A SHARED COGNITIVE USER TASK FRAMEWORK FOR ELEARNING STORYBOARD

NOR'AIN BINTI MOHD YUSOFF

FACULTY OF COMPUTER SCIENCE AND
INFORMATION TECHNOLOGY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2015

A SHARED COGNITIVE USER TASK FRAMEWORK FOR ELEARNING STORYBOARD

NOR'AIN BINTI MOHD YUSOFF

THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

FACULTY OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY
UNIVERSITY OF MALAYA
KUALA LUMPUR

2015

UNIVERSITI MALAYA

ORIGINAL LITERARY WORK DECLARATION

Name of Candidate: NOR'AIN BINTI MOHD YUSOFF (I.C No: 740811-05-5384)

Registration/Matric No: WHA040020

Name of Degree: Doctor of Philosophy

Title of Thesis: A shared cognitive user task framework for eLearning storyboard

Field of Study: Human-computer Interaction

I do solemnly and sincerely declare that:

i. I am the sole author/writer of this Work;
ii. This Work is original;
iii. Any use of any work in which copyright exists was done by way of fair dealing and for permitted purposes and any excerpt or extract from, or reference to or reproduction of any copyright work has been disclosed expressly and sufficiently and the title of the Work and its authorship have been acknowledged in this Work;
iv. I do not have any actual knowledge nor do I ought reasonably to know that the making of this work constitutes an infringement of any copyright work;
v. I hereby assign all and every rights in the copyright to this Work to the University of Malaya ("UM"), who henceforth shall be owner of the copyright in this Work and that any reproduction or use in any form or by any means whatsoever is prohibited without the written consent of UM having been first had and obtained;
vi. I am fully aware that if in the course of making this Work I have infringed any copyright whether intentionally or otherwise, I may be subject to legal action or any other action as may be determined by UM.

Candidate's Signature Date: **19th March 2015**

Subscribed and solemnly declared before,

Witness's Signature Date: **19th March 2015**

Name: **Professor Dr Siti Salwah Salim**

Designation: **Professor**

ABSTRACT

This thesis presents a framework which is aimed to achieve shared mental model (SMM) needed between instructional designers and subject-matter experts called as the eSCOUT (eLearning Storyboard for Shared Cognitive User Task). The eSCOUT is built to facilitate shared input, shared process and shared output. The shared input refers to the data process that derived from the knowledge and needs of instructional designer and subject-matter expert. The shared process refers to storyboard design process methodology which is designed to support agility and consists of three cognitive user task processes: pre-processing, processing and post-processing. Several types of shared visualizations techniques are proposed to support shared cognitive user task in these processing phases. At the pre-processing stage, collaborative mapping is used to support shared structural design of the storyboard requirement while at the processing stage; collaborative whiteboard is used to support shared storyboard design specifications. At the post-processing stage, both collaborative discussion and collaborative annotation are used to support shared reviews of the storyboard design. Finally, the shared output is the shared cognitive user task information generated in a form of shared data visualization. To implement the framework of the eSCOUT, a web-based system prototype is developed. Experimental study on shared mental model is carried out among users of real instructional design practices. Using paired groups of instructional designers and subject-matter experts, the result shows that effectiveness of the agile storyboarding process is perceived as 64.3% compare to efficiency capabilities of the process which is 50%. All the tools available (i.e. collaborative mapping, collaborative whiteboard, collaborative discussion and collaborative annotation) are perceived as different from what the users have experienced in other storyboard system. The findings also showed that both collaborative map and collaborative whiteboard are flexible in terms of sharing

the data and performing eLearning tasks as well as easy to learn the functionalities. Our evaluation study demonstrates high achievement of similarity and accuracy of the shared data visualization, in turn leading to the development of task mental model. Consequently, it also shows effectiveness and efficiency of the agility support in the storyboarding design process as well as high usability scores of the shared visualizations techniques.

ABSTRAK

Tesis ini membentangkan rangka kerja yang bertujuan untuk mencapai perkongsian mental model yang diperlukan antara pereka pengajaran dan pakar isikandungan yang dipanggil sebagai eSCOUT (Papan Cerita e-Pembelajaran untuk Perkongsian Pengguna Tugas Kognitif). eSCOUT dibina untuk memudahkan perkongsian input, proses dan output. Perkongsian input merujuk kepada proses data yang diperolehi daripada pengetahuan dan keperluan pereka pengajaran dan pakar isikandungan. Perkongsian proses merujuk kepada proses reka bentuk metodologi di dalam papan cerita yang direka untuk menyokong ketangkasan. Ia terdiri daripada tiga proses pengguna tugas kognitif iaitu pra-pemprosesan, pemprosesan dan pasca-pemprosesan. Beberapa jenis teknik perkongsian visualisasi dicadangkan untuk menyokong perkongsian pengguna tugas kognitif dalam fasa pemprosesan. Di peringkat pra-pemprosesan, pemetaan kolaboratif digunakan untuk menyokong perkongsian reka bentuk struktur yang diperlukan untuk papan cerita dan pada peringkat pemprosesan; papan tulis kolaboratif digunakan untuk menyokong perkongsian spesifikasi reka bentuk papan cerita. Manakala, di peringkat pasca-pemprosesan, kedua-dua perbincangan kerjasama dan anotasi kolaboratif digunakan untuk menyokong perkongsian ulasan untuk reka bentuk papan cerita. Akhirnya, perkongsian output adalah maklumat pengguna tugas kognitif yang dihasilkan dalam bentuk perkongsian visualisasi data. Bagi merealisasikan perlaksanaan rangka kerja eSCOUT, sistem prototaip berasaskan web dibangunkan. Kajian eksperimen perkongsian mental model telah dijalankan di kalangan pengguna sebenar didalam hal reka bentuk. Kajian penilaian ke atas pereka pengajaran dan pakar isikandungan yang disatukan sebagai satu pasukan reka bentuk menunjukkan bahawa, keberkesanan proses papan cerita yang tangkas memperlihatkan pencapaian 64.3% berbanding dengan keupayaan kecekapan proses iaitu 50%. Semua alat-alat yang

dicadangkan (iaitu pemetaan kolaboratif, papan tulis kolaboratif, perbincangan kerjasama dan anotasi kolaboratif) dilihat sebagai pengalaman berbeza daripada apa yang terdapat didalam sistem papan cerita lain. Selain daripada itu, kajian juga menunjukkan bahawa kedua-dua pemetaan kolaboratif dan papan tulis kolaboratif adalah fleksibel dari segi perkongsian data, serta mudah digunakan untuk menjalankan tugas dan fungsi dalam e-Pembelajaran. Hasil kajian ini menunjukkan bahawa wujud persamaan dan ketepatan perkongsian data visualisasi yang tinggi, seterusnya membawa kepada pembangunan tugas mental model. Di samping itu, keputusan juga menunjukkan keberkesanan dan kecekapan yang di berikan apabila menggunakan ketangkasan proses reka bentuk di dalam lakaran papan cerita dan juga skor kebolehgunaan yang tinggi yang diperolehi daripada teknik perkongsian visualisasi yang telah dicadangkan.

In the Name of Allah, the Most Gracious, Most Merciful.

By time.
Indeed, mankind is in loss,
Except for those who have believed
and done righteous deeds
and advised each other to truth
and advised each other to patience.

(The Quran, Surah 103: 1-3)

* *

As a true believer, this humble work is granted and made permissible from His blessings.

ACKNOWLEDGEMENTS

My deep appreciation, sincere and heartfelt gratitude are dedicated to:

The Dean of the Faculty of Computing and Informatics, Multimedia University, Cyberjaya, Associate Professor Dr. Ho Chin Kuan for his gracious support and motivation with my career and study.

My supervisor, Professor Dr. Siti Salwah Salim for her inspiration, patience, persistence and perseverance in coaching me towards the journey of research.

The following research grants which my supervisor and I received from:

1. Multimedia University Research Funding: Project ID - IP20110707004 for funding the investigation study,
2. Multimedia University Research Funding: Project ID - IP20120511020 for funding the experimental study, and
3. Exploratory Research Funding Scheme (ERGS), Ministry of Higher Education, Malaysia: Project ID - EP20120612006 for funding the eSCOUT frameworkl development and evaluation work

My colleagues at the Faculty of Computing and Informatics, Multimedia University, Cyberjaya, for their support and encouragement on my research work.

My research mates at the Human-computer Interaction lab who have brought in an enjoyable companionships and made my time such a great experience on knowledge and expertise.

My beloved parents Haji Mohd Yusoff and Hajjah Maznah, as well as parents-in-law, Haji Ahmad and Hajjah Faridah for their unconditional loves and concerns, especially during my moments of ups and downs.

Lastly but by no means the least, to both of my dear precious sweethearts; my darling husband Ariff and lovely baby Anas, you kept my spirit alive, always. Without your encouragement and understanding, it would have been impossible for me to complete this research. Yes sweetie... finally mommy has finished her PhD, which from this special moment, I am looking forward to devote and enjoy the time that I owe you, insyaAllah.

TABLE OF CONTENTS

CHAPTER 7 SYSTEM PROTOTYPE DEVELOPMENT AND EVALUATION 253

LIST OF FIGURES

LIST OF TABLES

LIST OF SYMBOLS AND ABBREVIATIONS

ACTA	:	Applied Cognitive Task Analysis Technique
API	:	Application Programming Interface
CoP	:	Community of Practice
CoVis	:	Collaborative Visualization
CTA	:	Cognitive Task Analysis
eSCOUT	:	eLearning Storyboard for Shared Cognitive User Task
HCI	:	Human-computer Interaction
ID	:	Instructional Designer
IPO	:	Input-Process-Output
ISI	:	Institute for Scientific Information
KM	:	Knowledge Management
MMU	:	Multimedia University Malaysia
MPU	:	Multimedia Production Unit
PUTQ	:	Purdue Usability Testing Questionnaire
SCO	:	Sharable Content Objects
SCORM	:	Sharable Content Object Reference Model
SDK	:	Software Development Kit
SME	:	Subject-Matter Expert
TMM	:	Task Mental Model

LIST OF APPENDICES

LIST OF PUBLICATIONS

Referred Journals

1. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2012). Investigating cognitive task difficulties and expert skills in eLearning storyboards using a cognitive task analysis technique. *Computers & Education, 58*(1), 652-665. Elsevier Science. doi: 10.1016/j.compedu.2011.09.009.

2. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). A Systematic Review of Shared Visualisation to Achieve Common Ground. *Journal of Visual Languages and Computing, 28, 83-99. (Open Access).* Elsevier Science. doi: 10.1016/j.jvlc.2014.12.003

3. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). Visualisation strategy and techniques for agile storyboarding: driven strategies towards shared mental models. *Computers & Education* – In preparation

4. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). eSCOUT: a shared visualization-based system of eLearning storyboarding supporting task mental models for design communication. *Computers & Education* – In preparation

5. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). eLearning storyboard framework for shared cognitive user task: a dual expertise evaluation. *IEEE Transaction in Learning Technologies* – In preparation

6. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). Classification in domain independent and dependent storyboard systems. *New Review of Hypermedia and Multimedia* – In preparation

7. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). Issues in instructional designers and subject-matter interaction using eLearning storyboards. *Educational Technology & Society* – In preparation

8. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). Agility support for eLearning storyboard design process. *Learning and Instruction* – In preparation

9. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2015). A shifting paradigm of shared mental model for human-computer interaction. *International Journal of Human-computers Studies* – In preparation

Lecture Notes in Computer Science

10. Nor'ain Mohd Yusoff & Siti Salwah Salim. (2014). *A review of storyboard tools, concepts and frameworks.* In Panayiotis Zaphiris & Andri Ioannou (Eds.), Learning and Collaboration Technologies. Designing and Developing Novel Learning Experiences (Vol. 8523, pp. 73-82): Springer International Publishing.

Conference Proceedings

11. Nor'ain Mohd Yusoff & Siti Salwah Salim (2014). *Social-based versus shared situation awareness-based approaches to the understanding of team cognitive research in HCI.* Proceedings of the 3rd International Conference on User Science and Engineering 2014 (iUSER2014). Shah Alam, Selangor, Malaysia (pp.281-286): ISBN: 978-1-4799-5813-9/14

Poster Presentation

12. Nor'ain Mohd Yusoff & Siti Salwah Salim (2014). *Shared mental model in human-computer interaction.* National Symposium on HCI (SymHCI) 2014. 8th Dec 2014. International Islamic University, Kuala Lumpur Malaysia.

Notes:
1. "In preparation" statuses are correct at time of printing.

CHAPTER 1 INTRODUCTION

This chapter provides the background of study, research problem and motivation which lead to the problem statement, research objectives and research questions. The scope and limitation of the research as well as the research methodology are also being emphasized.

1.1 Background of Study

The National Higher Education Strategic Plan is a strategic direction program towards long term objectives to empower higher education in Malaysia. To realize the educational transformation, the Ministry of Higher Education has identified 22 critical agenda projects which can be developed to achieve the need of urgency. ELearning policy is one of the critical agenda projects that refer to the initiative which provide a quality eLearning framework that fits the concept of 1Malaysia and New Economic Model. This policy is in line with the critical fields of eLearning presented by the National Information Technology Council and the needs of Economic Transformation Program in which more than 60% of the Entry Point Projects is using information and communication technology (PEMANDU: Performance Management & Delivery Unit, 2013).

One of the objectives in the eLearning critical projects is to provide appropriate infrastructure and user friendly eLearning avenue. Developing eLearning infrastructure is important as it provides online communication and interaction for the process of eLearning development. Such technologies are used by eLearning designers and developers for specific purposes, including design instructions and content development. To date, many instructional design tools and technologies are developed to support different stages of eLearning design development.

One of the stages is storyboarding process. Storyboarding process has some issues which are highly interdisciplinary which involve high participation from instructional designers and subject-matter experts. At this stage, design decision that requires communication within the instructional design team is crucial because the design generation affects the later production development of eLearning. Therefore, any corrections due to the shortcomings of a poor design development can be difficult to compensate. In addition to the demands for fast and efficient eLearning courseware available, eLearning companies and higher institutions have to stay competitive in a global market. It indicates that not only the resources and softwares are geographically distributed, but also the knowledge and expertise in the instructional design team. Experiencing this shifting of paradigm, the storyboarding process for eLearning design needs to adopt more pragmatic approach through the support of information technology. As such, providing suitable techniques and strategies for the storyboarding process to assist the instructional design team in distributed design environment is very important, where it becomes a promising area for further research.

1.2 Research Problem

Current eLearning development that occur in the instructional design strategies, tools, and technologies, require higher education institutions to be adaptive as well as responsive to the change and innovation. Therefore, exposure to new knowledge and skills need to be updated and provided to academic faculties in order to keep abreast with the demand of eLearning education. In order to achieve quality eLearning course production, instructional designer (ID) and subject-matter expert (SME) need to use one of the most common visual communication strategies which are called the eLearning storyboards.

This section discusses research problems in the scope that support ID-SME interaction in instructional design. In this section, research problems refer to research gaps that include issues or concerns studied by researchers (Brewer & Hunter, 2006; McLaughlin, 2013).

Looking at these spectrums, the urge for conducting this research is motivated by the following problems in research:

1.2.1 Little Emphasis to Support ID and SME Interaction

Based on preliminary studies, many literatures have reported their works in examining the design team as a whole, who includes ID, programmers, graphic designers, etc. Despite having noted as the two most critical roles in eLearning design team as well as denoted as the key players, the research about ID and SME interaction in particular is relatively very few.

The need of performance support for academicians as a part of instructional design team had also been addressed by Jury (2007). According to Jury (2007), elearning in corporation and academic environments are much different in terms of business drivers, audiences, performance outcomes, and functional requirements. In academic environment, course instructor, professor, or course designer are considered as the SMEs where they work together with the IDs as one team. Unlike the SMEs in academe, corporate eLearning designers may be members of the instructional design team but are usually not the SMEs. They are often considered as clients who provide the needs and contents to the IDs who work under their project funding. Parsons (2008) revealed that one of the greatest challenges in Malaysian higher education environment is educator's motivation and acceptance as well as their lack of time to involve in implementing the eLearning. In this thesis, the result shows special attention should be given to the educators in receiving adequate support from the "instructional designers, computer graphic artist, the relevant softwares... etc."(Parsons 2008, p.89). Another relevant study has been further investigated by Umar and Su-Lyn (2011). In their study on Malaysian instructional design practitioners, Umar & Su Lyn (2011) found that more effort should be conducted to support ID practitioners in the process of decision making. The study has found that by encouraging ID involvement in the decision phase, the importance of awareness concerning the relevancy and significance of the instructional design practice can be created.

Based on these studies, research should be conducted to support for SMEs motivation in implementing eLearning by finding ways to reduce their time constraint. On the other hand, research is also needed to find ways to assist ID in making decision making. It shows that much more research is needed to support educators (i.e. the SMEs) as well as the IDs to proliferate the future of instructional design practices in Malaysia.

1.2.2 Limited SME's Role in eLearning Content Design

While many initiatives have been done to assist ID with their work, there is a room for further research to bridge and promote the collaboration between ID and SME. A recent study by Razak and Palanisamy (2010) suggested that there is a need for "the creation of a platform to promote the collaboration between SMEs and IDs in developing content for multimedia learning objects, where the SMEs provide inputs on the content analysis and questions for learning activities while the IDs design presentations such as simulation, demonstration, and learning activities with feedback" (p. 1911). Future research could include the role of SME in content design and development of multimedia learning objects where interaction between ID and SME can be optimized during content design leading to storyboard development. By initiating and allowing SMEs to participate in elearning content design, it can lead towards flexible ways to represent their own design content (Griffiths & Blat, 2005).

1.2.3 Limited Choice of Storyboard Tools

The availability in computer-based ID tools intended to support the designer during the actual conceptualization and front-end instructional design is very limited. This type of family which is referred by Andrews (2001) as the pre-production/design tools has received very little attention among the tool developers. It leaves the instructional designers with limited choices to support pre-production instructional work that could be used to automate the needs assessment, learner analysis, objectives, learning architectures, and other design events at the front-end (Merriënboer & Martens, 2002). The next generation of more pre-production design tools such as the storyboard system should be garnered by system developers. In addition to the trend where more and more organizations are looking to novice developers and SMEs as course designers, the storyboard tools to support automated instructional design at the pre-production work is much needed in instructional design practices.

1.2.4 Little Work in Collaborative and Distributed Design

Despite of overwhelming interest in collaborative learning which is dedicated for student collaboration, the aspect of faculty or academic collaboration (i.e. SMEs) has been overlooked (Wang, Dannenhoffer, Davidson & Spector, 2005). Wang, et al., (2005) suggested that collaborative efforts by the academic members supported in distributed work environments should be increased. This is because much of the work is taking place in the context of distance and distributed environments where it requires considerable time, effort, and expertise for an academic member to collaborate with the IDs.

One of the challenges to design for computer-based learning environment is to recognize the importance of participatory and collaborative modes of designing. According to Häkkinen (2002), designing environments for learning is dependent upon descriptive knowledge which is derived from task analysis, problem solving and tested by teams of experts in complex domain. Zhang, Shaw, and Strobel (2006) have also noticed several limitation and capabilities to support instructional design for online delivery in content management systems. It is found that despite of many efforts conducted to automate design tasks for individual users, little attention has been paid to support the instructional design processes in collaborative and distributed ways. Based on this finding, Zhang, et al. (2006) suggested a computer supporting collaborative design that can support the construction of shared understanding and shared objects as well as able to support cooperation in articulating design process.

Picciano & Dziuban (2007) argue that blended learning approach which integrates communication technologies; people, locations and pedagogies are not only the useful approach to make decisions in achieving quality of learning environments. Further approach to support decision making should be initiated in a collaborative and distributed instructional design environment, who involve a group of faculty i.e. the SMEs along with instructional designers. By encourage more people shared in the process and disseminated the techniques for teaching, learning and evaluation, total faculty control of quality will be removed. Even though, the development time and initial costs can be longer, the quality control is shared and the eLearning courseware can be used by all SMEs teaching that subject.

This section discusses four research problems involving little emphasis in supporting ID and SME interaction in academe and work in distributed instructional design environment. Research problems are also found in pertaining to the limited effort in supporting the role of SME in eLearning design content and limited choice of storyboard tool to support front-end instructional design.

1.3 Research Motivation

Looking at these research problems, the urge for conducting this research is motivated by the following issues:

1.3.1 Shared Mental Model Research in Human-Computer Interaction

One type of cognitive architecture in domain of team work and collaboration that has received substantial research attention in Human-computer Interaction (HCI) is Shared Mental Model (SMM). SMM is derived from the root of mental model construct from the discipline of cognitive psychology (DeChurch & Mesmer-Magnus, 2010). SMM refers to “knowledge structure held by members of a team that enables them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of the task and other team members” (Cannon-Bowers, et al., 1993 p.228). One way to support SMM is by using technological visualization approach called as collaborative visualization (CoVis). In CoVis, a shared use of any forms of visual representations is required to enable any cognitive activities collaboration.

With regards to this research, aspects of shared knowledge have been identified in the design principles of multimedia between ID and SME (Razak, 2013). It shows the SMM is found between ID and SME, particularly in soliciting the agreed knowledge when designing multimedia instruction. The shared task knowledge required in eLearning storyboard which contains of task procedures, task strategies and task component relationships are crucial to the ID and SME in order to attain SMM of the task (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000). Ultimately, attaining SMM in this task work domain may lead ID and SME towards achieving their work goals and performance requirements (Mohammed, Ferzandi, & Hamilton, 2010).

SMM in HCI has been used to introduce the space of theoretical and empirical choices of the literature within the framework design and development (Payne, 2003).

According to Payne (2003), even though the research interest in SMM has become overwhelming in HCI, more emphasis on empirical and conceptual work pertaining to the team cognition and computer interaction are required. In response to this need, the aspects of SMM of the task in eLearning storyboard can be explored based on user study. Besides, there is also a need to investigate how shared visualization can be used in eLearning storyboarding process to support the SMM of ID and SME.

1.3.2 Shared Cognitive User Task Support for ID and SME

The role of cognitive task analysis is important in instructional design. According to Nekvinda (2011), task-based information is needed to be captured and completely analyzed to enable designers in utilizing strategic and tactical scaffolding techniques when presenting support instructional design content (p.138). A cognitive task is a group of unobservable, mental related activities which is directed toward a goal (Klein & Militello, 1998). Task that depends on cognitive aspects of expertise, such as decision making and problem solving is primarily valuable in order to perform effective and efficient task effectively (Crandall, Klein, & Hoffman, 2006).

With regards to this research, ID and SME need to put much effort on sharing cognitive task activities such as deciding on the storyboard content, organizing the structure for storyboard design, recalling the analysis requirements before storyboarding, and evaluating the storyboard design production. Moreover, working in a distributed instructional design project, having different domain knowledge, skills and expertise becomes additional barrier to achieve common ground in this distance communication. Difficulties in these tasks can hinder the development of SMM between them and later impeding the effective and efficiency process of storyboarding. Because of this, they suffer a substantial amount of time and effort to coordinate the tasks and activities in designing and developing an eLearning storyboard. The shared cognitive user task of eLearning storyboard, in particular the ID and SME is much needed because cognitive task that is shared among team could lead to better task performance, in terms of the accuracy, efficiency, quality of output, volume, timeliness (Cannon-Bowers & Salas, 2001).

1.3.3 Solidifying Instructional Design Process

An ID performs distinguishing and critical competencies which includes the ability to deal and communicate within the team (Liang, 2000). One of the biggest challenges confronting ID is to guide the SME through the design process (Gibby, Quiros, Demps, & Liu, 2002). Gibby et al. (2002) found that SME frequently needs assistance from ID practitioners in producing the “steps and tasks that a designer takes to get to the end product” (p.205). It includes helping SME is by making the right design decision based on the project needs, such as decision about informational and media presentation.

Iterative or agility process in making decision in designing instruction for both experts i.e. the ID and non-experts i.e. SME in instructional design is important (Jonassen, 2008). Due to the complexity of and ill-structured problem solving in instructional design process, the primary thinking process that ID and SME needs to employ is decision making that occurs in cycles. Due to the needs of agile in instructional design, a framework of an agile instructional development (AIDev) has been developed to support efficiency and foster pedagogical excellence (Bratt, 2011). Although this framework is targeted to scaffold new research by situating agile instructional development in a pedagogical context, the limitation of these strategies was derived from data gathered from learners and not the eLearning designers (Bratt, 2013). As such, this framework may not be effective or suitable to apply for eLearning design teams. Recommendations for future research should gather data requirements from eLearning designers such as IDs or SMEs to identify the strategies for an appropriate agile process which can support decision making between them.

1.3.4 Trends Towards Internally Developed eLearning Courseware

A study conducted by Mercer Management Consulting found that distributed learning today has maintained the traditional focus on training (Ismail, 2001). This means that there has been no effort to expand the vision to a broader use and possibilities afforded by eLearning. They further found that innovative enterprises now have moved beyond training to focus more on the eLearning context. One of the emerging trends that arise from these usage patterns is that internally developed eLearning courseware is becoming more important than off-the-shelf courseware.

In Malaysia, this way of eLearning initiatives has become one of the important focuses of the organization. For examples, the virtual University of Tun Abdul Razak (UNITAR) established its own content development department in 1996 to support the development for internally digital content. Multimedia University Malaysia (MMU) developed an in-house learning management system in 2000, now called as Multimedia Production Unit (MPU). The establishment of MPU is dedicated to take care of its internet-based programs and forming a team of ID to be the bridge between the SMEs and the information technology experts. Similarly, Open University Malaysia (OUM) has established a Center for Instructional Design and Technology in 2001 to enable the development of its own digital and print-based contents (Raja Maznah, 2004). These higher educational institutions have made an aggressive movement in putting their efforts to customize their own an internally developed content. Based on the trends of eLearning which have been discussed, it is important to investigate ways that can facilitate and support the instructional design work of ID and SME in achieving their own internally developed eLearning courseware.

This section discusses four issues involving the need for more SMM research in HCI, shared cognitive user task support for ID and SME, solidifying the instructional design process and trends towards internally developed eLearning courseware in academe.

These problems and issues have brought the concern that further research needs to be done to support ID and SME to collaborate in distributed instructional design environment, in particular to solidify instructional design process in creating internally developed eLearning courseware. Furthermore, there is also a great need to assist ID and SME in aspects of SMM of the task in eLearning storyboard using supporting strategies in HCI.

1.4 Problem Statement

From the research problem above, it is not known how the shared cognitive user task of ID and SME as design team in a distributed instructional design environment can be supported using shared visualization techniques. Moreover, it is also not known how the decision making at front-end instructional design can be supported in an agile process of eLearning storyboard.

Pursuing to the problem statement, this research tries to grasp the so-called shared visualisation techniques in HCI and how these techniques can be applied to support shared cognitive user task between ID and SME using the proposed eLearning storyboard framework called as the eSCOUT (**e**Learning Storyboard for **S**hared **Co**gnitive **U**ser **T**ask).

1.5 Research Objectives

The main objective of this research is to support shared cognitive user task between ID and SME using a proposed eLearning storyboard framework. In achieving the main objective, there are some specific objectives that need to be fulfilled, which are:

Objective 1: To identify the requirements of shared cognitive user task between ID and SME in eLearning storyboard.

Objective 2: To formulate a framework that can support the shared cognitive user task between ID and SME in eLearning storyboard.

Objective 3: To develop a system prototype that can demonstrate a logical view of the formulated eSCOUT framework.

Objective 4: To evaluate the aspects of shared cognitive user tasks using the system prototype.

1.6 Research Questions

Corresponding to the four research objectives, research questions are designed and each question is answered in the chapters as follows:

OBJECTIVE 1: To identify the requirements of shared cognitive user task between ID and SME in eLearning storyboard.

Chapter 2 – Instructional designer and Subject-matter Interaction

- RQ 1. Why supporting ID and SME interaction is required?
- RQ 2. What are required to support ID and SME interaction?

Chapter 3 – eLearning Storyboard

- RQ 3. What is needed in eLearning storyboard to support ID and SME interaction?

Chapter 4 – SMM and Shared Visualization

- RQ 4. How to support SMM for ID and SME interaction?

Chapter 5 – Empirical Studies in eLearning Storyboard

- RQ 5. What are the aspects of cognitive task difficulties in eLearning storyboard?
- RQ 6. How to solve the cognitive task difficulties?
- RQ 7. How the shared visualizations can be used to support shared cognitive user task of ID and SME?
- RQ 8. How agility can be driven in the eLearning storyboarding process to support shared cognitive user task of ID and SME?

OBJECTIVE 2: To develop a framework that can support the shared cognitive user task between ID and SME in eLearning storyboard.

Chapter 6– Framework Development

- RQ 9. What are the basis, structure and contents of the eSCOUT?
- RQ 10. How the shared cognitive use task can be supported in eLearning storyboard?
- RQ 11. How is the eSCOUT framework evaluated?
- RQ 12. How is the result of evaluation lead to revised eSCOUT development?

OBJECTIVE 3: To develop a system prototype that can demonstrate a logical view of the formulated framework.

Chapter 7 – System Prototyping Development and Evaluation

- RQ 13. How is the eSCOUT prototype system developed?
- RQ 14. How is the revised eSCOUT framework being mapped into the system prototype?
- RQ 15. How is the walking interface in the system prototype being described using a scenario?

OBJECTIVE 4: To evaluate the similarity and accuracy of shared data visualization which is derived shared cognitive user tasks.

Chapter 7 – System Prototyping Development and Evaluation

- RQ 16. What are the criteria used to evaluate the system prototype?
- RQ 17. How is the system prototype evaluation being conducted?
- RQ 18. How the result of the evaluation implicates the study?

1.7 Scope and Limitations

This research concentrates on investigating specific problems involving ID and SME interaction using eLearning storyboard in communicating the eLearning design content. The proposed eSCOUT framework is applicable to similar problems faced by ID and SME in other countries. However, to evaluate the eSCOUT framework, participating IDs and SMEs from the area of Kelang Valley, Kuala Lumpur, Malaysia are invited for testing and evaluation. As shown in Figure 1.1, this study focuses on two domains from automated instructional design and HCI.

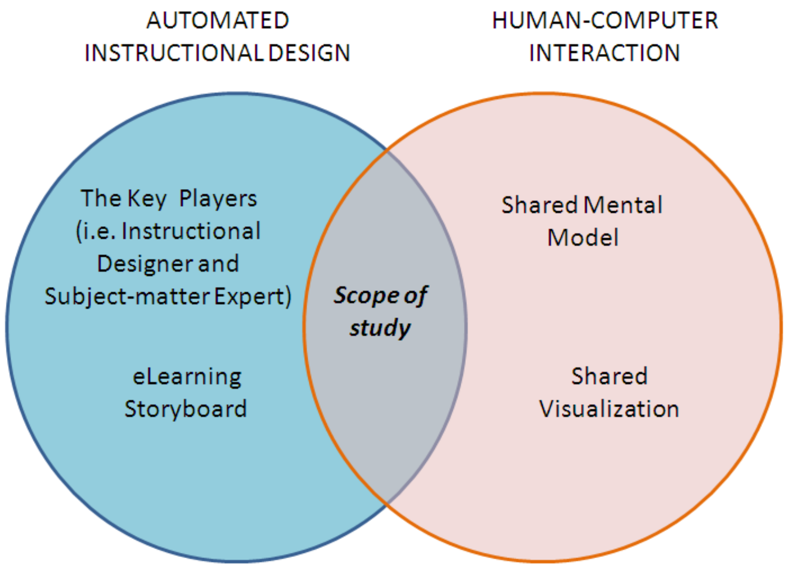


Figure 1.1: The scope of research

This study concentrates on the aspects of eLearning storyboard as one of the pre-production tools to support the key players in automated instructional design, i.e. the ID and SME (Andrews, 2001). In addition, the aspects of SMM and system technologies that provide knowledge values to the HCI research are concerned (Payne, 2003). The SMM in this study refers to the SMM of the ID and SME while shared visualization is chosen as the technique for system design.

It is important to emphasize that this research does not aim to offer collaborative design for learners or students, nor it is meant to achieve eLearning quality and standard. As we have mentioned in the research objective earlier, we aim to support shared cognitive user task using the proposed eLearning storyboard framework, involves participation of the key players in eLearning design team, i.e. the ID and SME. Thus, this research is aimed to assist the eLearning designers to collaborate and communicate, which can only be achieved when their SMM are developed.

1.8 Research Methodology

The research work is divided into three phases of study; Phase 1 is the literature reviews work, Phase 2 is framework development and Phase 3 is system prototyping development.

This research starts with conducting literature review to understand the concepts and issues pertaining to the scope of study. Using both narrative and systematic approaches in reviewing the literatures, three chapters of reviews are presented. First chapter represents the issues and challenges of ID and SME in instructional design study. Second chapter describes the importance to support ID and SME in eLearning storyboard as well as limitation in the existing storyboard tools, conceptual model and framework. It also includes the needed requirements to support ID and SME in eLearning storyboard. The third chapter reviews systematically available shared visualization strategies and techniques used to support SMM.

From the three reviews, two empirical investigations are conducted. The first study explores the aspects of cognitive task difficulties in eLearning storyboard using a specific cognitive task analysis technique called as Applied Cognitive Task Analysis (L. G. Militello & R. J. B. Hutton, 2000). In the second study, artefacts simulation of physical storyboards are used to examine shared visualization techniques as well as the drive of agility in supporting shared cognitive user task of ID and SME in eLearning storyboard.

The information from the literatures and investigation studies is collected and analyzed to which is important for the initial framework development of the eSCOUT. Using a specific method for early design development called as the Virtual Windows Method (Lauesen, 2007), the initial framework is evaluated by groups of academic experts and industrial practitioners. Consequently, the feedback from these groups is gathered and used for the enhancement of the revised eSCOUT framework.

The revised eSCOUT framework is translated into a logical form of system prototype. Specific criteria are used to evaluate the aspects of shared cognitive user tasks using the system prototype. This system prototype is evaluated using three ways of testing; cognitive walkthrough, usability evaluation and SMM measurement.

In this thesis, each research methodology is presented in the respective chapter to provide a reading flow in such an order that their logic is as easy for a reader to understand as possible. For example, chapter 5, 6 and 7 are presented in the order starting with introductory, research methodology, research procedures and design, data results and findings, discussion, recommendation as well as conclusion. The research flow and its corresponding research methods are summarized in Figure 1.2.

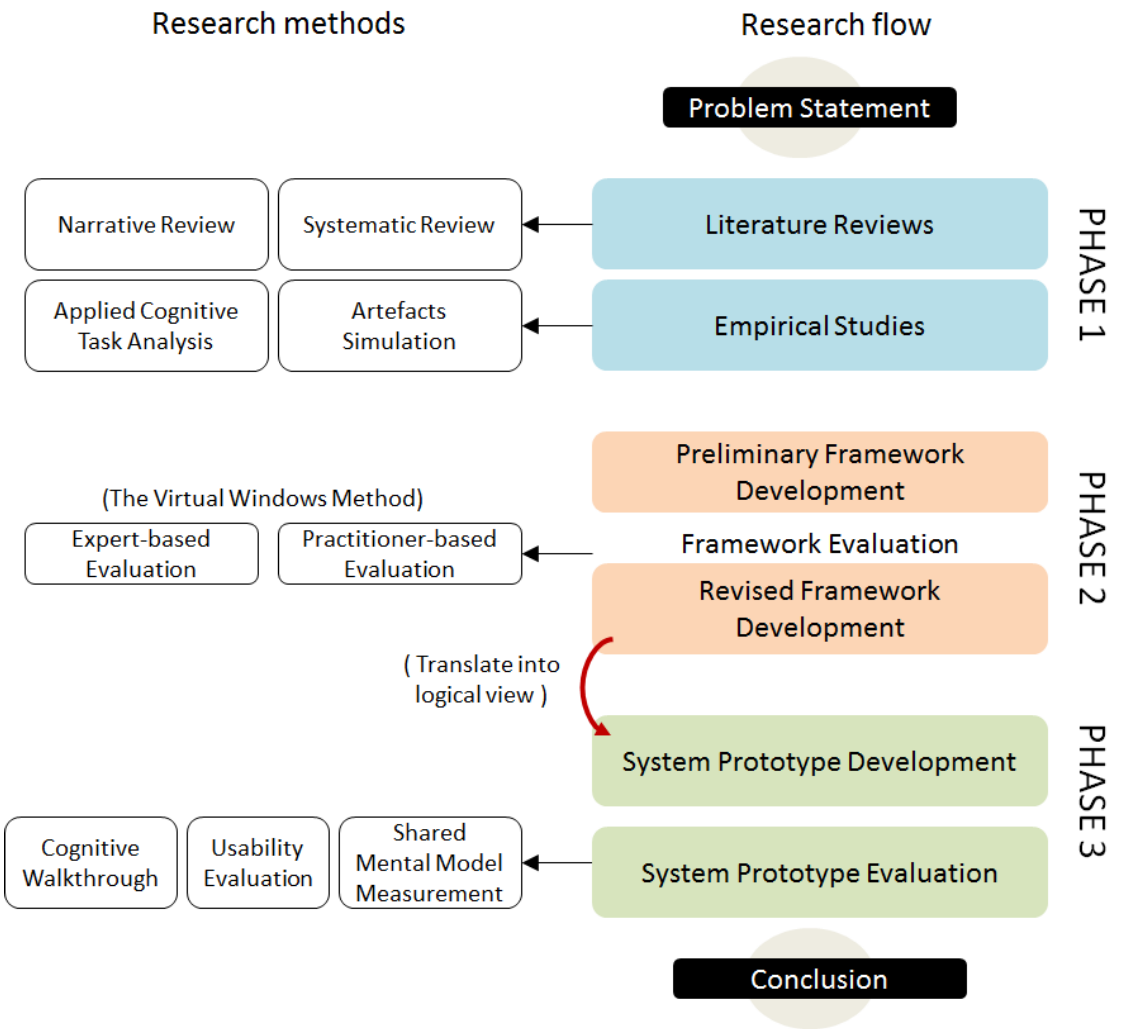


Figure 1.2: Research flow and its corresponding research methods

CHAPTER 2 INSTRUCTIONAL DESIGNER AND SUBJECT-MATTER EXPERT INTERACTION

This chapter describes two key players in instructional design; the ID and SME and issues surrounding the support for their interaction support. It consists of two parts. The first part reviews the ID and SME in online course development team and distinctions between them. The second part reviews four issues pertaining to their interaction support, which includes their roles in community of practices in instructional design, SMM, online course collaboration in distributed design and designer centeredness. Summary of the review is discussed.

2.1 Online Course Development Team

Online course development is a complex process which requires a high calibre online course of instruction. In order to produce quality course production, highly organized and concerted efforts are needed from many players.

An online course development team or the instructional design team comprises at least five key roles; subject-matter experts, graphic designer, web developer, programmer and instructional designer. According to Piskurich (2003), these people are grouped into two kinds of role; the core group and the transition group. Piskurich et al. (2000) emphasized that these two groups complement to each in such a way that the core group works need to work closely with the transition group to ascertain that the course production is founded on solid course design principles as well as smoothly integrated with the capabilities of the web environment.

The core group is the people who are responsible to design the basic principles of instruction and learning that follow the instructional design process. These people are normally members in eLearning development unit and who manage the project such as instructional designers, graphic designers and web developers. The transition group refers to those who involve extensively in the eLearning course development to provide information. They could be the clients who sponsored the eLearning projects, academic faculty members or subject-matter experts. Piskurich (2003) identifies two key players from each core and transition group who are significant to represent the participation of their roles; i.e. instructional designers (ID) and the subject-matter experts (SME). These key players need to utilize number of communication strategies in order to achieve the acceptance and participation as Community of Practices in instructional design, which is coined by Keppell (2004) as "legitimate participation".

In instructional design literature, the important of interaction between ID and SME in instructional design project had been given a great emphasis. Before this matter could be described, questions such as who is an ID, what does an ID do - should firstly be understood. Similarly, the same questions should be asked for defining SME. This explanation is presented in the next section.

2.2 Instructional Designer

Instructional design is defined as the "systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources, and evaluation" (Smith & Ragan, 2005 p.4). Therefore, an ID can be simply understood as a person who is responsible for designing the basic principles of instruction and learning that follow the instructional design process. They serve positions such as eLearning Manager, Information Manager, or Head Department of eLearning Unit (Keengwe, Kidd, & Kyei-Blankson, 2009).

According to Caplan & Graham (2008, p.258), an ID need to perform five common processes in instructional design which is constitute in a famous ADDIE model (which refers to Analysis, Design, Development, Implementation and Evaluation). IDs use this model as a guide and systematic framework to build effective online course. These processes are described briefly as follows:

- Analysis – the process to define what to be learnt
- Design – the process to define how learning would occur
- Development – the process to author and produce the material
- Implementation – the process to install the instruction in the real world
- Evaluation – the process to determine the impact of instruction

Even though this model is well adopted and commonly applied by IDs in their instructional design work, there are many evolutions of models which have been well said in the instructional design literature (refer to D. Andrews & Goodson, 1980 and Edmonds, Branch, & Mukherjee, 1994). It is worth to mention that is not the focus in this study. Kenny, Zhang, Schwier, & Campbell (2005) conducted a literature reviews to determine whether the IDs apply the ID model in their professional activities. Using 10 articles, Kenny, et al. (2005) have found that apparently, they do make use of any process-based ID models. However, they do not spend the majority of their time working with them nor do they follow them in a rigid fashion.

Gibby, et al., (2002) conducted an interview with eleven IDs working in various multimedia companies to determine their views of responsibilities and challenges for new media development. The result has found that responsibilities of IDs could be categorized into four sets of element: working with a client, working with SME, working with the design and working with other members in the team. In this interview, three biggest challenges associated to their responsibilities have been identified. The first challenge was working effectively with client and SME, which involve guiding them through the design process, describing the problems to be solved and helping them to make the right design decisions based on the project's needs. The second challenge was to balance multiple roles which include performing duties as project manager, engaging in activities such as script writing for video and audio scripts, writing programming code, writing technical documents, creating animations and graphics, and providing trainings. The third challenge was to adapt to the rapid technological changes and advances, which requires new technological tools to be used as a part of requirements. From this study, (Gibby, et al., 2002) have outlined four essential competencies for IDs:

- Communication skills – ID should able to communicate effectively with clients and SMEs.
- Knowledge in instructional design models and strategies – ID should be well-versed in different types of instructional design models and strategies for which to choose for case-specific process.
- Problem solving and decision making skills – ID should be able to perform multiple roles and responsibilities, steps into new roles when necessary and overcome barriers over datelines.
- Technology skills –ID should have basic knowledge of software tools used in instructional design work and be aware of newly available advanced tools.

In this section, it is understood that an ID, by profession is a professional in instructional design field with the ability to perform multiple roles and tasks associated with their professional field.

The term SME is a broad definition that can be explained in different domains. The Oxford English Dictionary defines the term “subject matter” as “the matter operated upon in an art, a process, etc.; the matter out of which something is formed”. The term “expert” is defined in this online dictionary as “One who is expert or has gained skill from experience” ("Online Oxford English Dictionary,"). From these two definitions, an SME is a person who can be described as an expert or has gained skill from the matter out of something is formed such as in an art, process or others.

2.3 Subject-Matter Expert

In the view of instructional design practice, an SME is referred to as "the qualified person who provides information about content and resources relating to all aspects of the topics for which instruction are to be designed" (Smith & Ragan, 2005 p.4). Anderson, Rourke, Garrison and Archer (2001) said that an SME "knows a great deal more than most learners and is thus in a position to scaffold learning experiences by providing direct instruction" (p.2). The SMEs can be any academic expert such as professors (Power, 2009) and knowledge presenters (AMA Handbook of ELearning: Effective Design, Implementation, and Technology Solutions, 2002).

There is not much literatures specifically details out the roles of an SME in instructional design. Probably, researchers in instructional design may need to carry out future studies to determine the SME's roles from the context of expertise using the proposed Farrington-Darby & Wilson (2006)'s framework. Despite of this, many studies are found in improving the instructional design process involving ID and SME participation. This issue has become important in this field because SMEs are still needed by the instructional designer to "specify the knowledge that must be acquired to be able to perform at the required level of mastery" (Lee, 1994 p.33). As mentioned earlier, the challenges of ID relies on participation from SMEs to collaborate any kinds of materials such as information or design, in order to achieve the right design decisions based on what is needed in the project.

In earlier discussion, the roles of an ID have been described, while the roles of an SME in this field have not been much emphasized. Despite of this, the distinctions between them have been drawn and found in the literature. The next section presents the difference between ID and SME.

2.4 Instructional Designer vs. Subject-matter Expert

Lee (1994) has delineated three reasons to distinguish an SME from an ID. Firstly, it is due to the unconscious thinking that can be performed by SMEs. The SMEs has been found reaching the highest level in learning process. By providing an example using Bloom's taxonomy model, Lee (1994) stated that level of knowledge that SMEs has attained is found in the psychomotor domain, in which the physical and mental capabilities to perform a task has integrated. When the knowledge has reached the automatic stage, the SME is able to understand how to perform the required tasks without consciously thinking about the required skills and actions. This high attainment level of knowledge is the advantage that a SME has, but that IDs probably might not.

The second reason is the difference between knowing and communicating knowledge. Using an analogy, Lee (1994) argued that a highly knowledgeable teacher knows best about the content of a course, but not necessary able to communicate the knowledge to students. For example, the missing element would be the ability to put the content into a structured order for people to learn. This kind of mistakes can be detected by the IDs who are well trained in instructional design. Elements such as principles of learning, assessment, learning theories are all effective instruction possessed by an ID, but that SMEs might not.

The third reason is the knowledge about the allocation of project resources. In an organization where the SMEs are available such as academic faculties, an ID is needed in the project to find the subject matter among the academics and organize it into a meaningful way for teaching purpose. However, Lee (1994) said organizations who conduct training services, what is needed are the SMEs as the internal consultant. Here, the SMEs should not be treated as IDs to design instruction. An ID has better knowledge capabilities in allocating project resources in designing instructions that a SME might not. Due to the unique combination of skills possessed by ID and SME, Lee

(1994, p.33) shows the capabilities required from each of them in order to diverge expertise differences, as shown in Table 2.1.

Table 2.1: Lee (1994)'s distinctive uses for divergent expertise

SME	ID
▪ Serves as a reality check for assessment outcomes ▪ Provide technical content for course ▪ Review and validate the technical accuracy of content and procedures	▪ Interpret assessment data ▪ Organize material according to principles of learning and events of instruction. ▪ Write the content

The role of the ID and SME in formative evaluation of instructional materials had been investigated by Saroyan (1992), as a part of the Saroyan-Farivar (1989)'s thesis work. In this study employed three IDs and three SMEs (i.e. professors) using think-aloud method to delineate the processes of formative evaluation performed by both ID and SME. Two issues are found in this investigation.

Firstly, the SMEs use their evaluation on heuristics directed by the domain, while the IDs use instructional design model and recommended heuristic to evaluate. The study shows that the SMEs use sequential approach and that their view is linear, narrow and does not encompass the evaluation of the text as a whole. In contrast, the IDs use comparative approach which enables them to evaluate the text in locally and globally.

Second issue refers to the roles assumed by the SME and ID. Saroyan (1992) has delineated two roles. Firstly, the SME limits their comments to their domain, while the IDs extend their comments beyond their area of expertise to the issues related to content, presentation and pedagogy during the formative evaluation. Secondly, the SMEs evaluate the test in the formative evaluation at their face value, while the IDs consider their own performance on the test as a mean to evaluate the pedagogical value of material. Saroyan (1992) distinguished the assumed role of SME as "naïve learner" role as they perceive the material and task as an end, by putting little emphasis for pedagogical impact. On the other hand, Saroyan (1992) assumed role of IDs as "naïve learner" role where these group perceive the material as a means of learning. The IDs are seen to invoke strategies which are can likely generate effective revisions. This study provides insights about the scope and limitation of comments generated by IDs and SMEs during formative evaluation. The study suggests that the inclusion of both participation of ID and SME is more likely to produce contended and superior results, which may reduce duplication of effort, increase efficiency and yield a mutually acceptable instructional materials.

This section presents two studies that distinguished the roles of an ID and SME in the instructional design work. Having said that these groups are heterogonous in terms of their unique expertise and skills, the divergence of these expertises in terms of their knowledge would lead to effectiveness and efficiency in instructional design work. Some behavioral strategies have been provided by Moller, (1995) and Yancey (1996) to walk the path for the IDs towards successful steps in gaining information from the SMEs.

2.5 ID and SME Roles in the Community of Practice

Communities of practice (CoP) is coined by Wenger (1998, p.6) to describe a concept of social learning in communities which the person belonged to. Due to the important roles of ID and SME for the CoP in instructional design, researchers such as M. Keppell (2001), Hashim, Kadir, Alias, & Hassan (2009) and Razak and Palanisamy (2010) have developed some methods as parts of efforts to support the ID and SME in instructional design work. Their methods are described in this section.

2.5.1 Method for Content Production Process

M. Keppell (2001) developed an eclectic approach called "Content Production Process" as a part of M. J. Keppell (1997)' thesis work. This method is aimed to elicit and conceptualize unfamiliar content knowledge from the SME in order to achieve efficient and effective instructional design leading to online and multimedia project. This method uses combination of interviews techniques such as Informal Conversational interview, Ethnographic interview and Teach back interview, to probe SME's thinking and ideas which lead to generic questions. The final phase is to use concept mapping as the strategy to scaffold the intellectual knowledge, conceptualize the content into a form of map, and communicate the focus on pertinent information from the SME.

2.5.2 Method for Learning Object Development Process

Hashim, voice over script for the multimedia lesson. The storyboard is passed to the multimedia Kadir, Alias, & Hassan (2009) developed a learning object development process flow to assist the development of engineering learning object for the "Sistem Pengurusan eLearning" or SPeL learning management system in the context of Technical University of Malaysia (UTeM), Malaysia. There are four key processes; producing learning design, storyboarding and multimedia authoring and development. The first process starts with lesson chunking where the SME break down the lesson/subject into independent learning units. In the next process where storyboarding is concerned, the ID plan the lesson flow, layout and navigation design, placement of appropriate multimedia elements as well as producing developers a fully functional multimedia learning object using multimedia authoring software, which will be packaged using the sharable content object reference model (SCORM) standard. Later the multimedia lesson will be reviewed by both ID and SME, and will be uploaded. In this process, it shows that the SME is highly involved in the whole learning object development in a linear manner.

2.5.3 Method for Multimedia Learning Object Design

Razak and Palanisamy (2010) developed Multimedia Learning Object Design Guidelines (M-LODGE). The purpose of M-LODGE can be used by ID to guide SME in the process of content analysis and produce design plan for multimedia learning objects. The guidelines which is shown in Figure 2.1, is a form of flow chart depicted to project six steps in content analysis document.

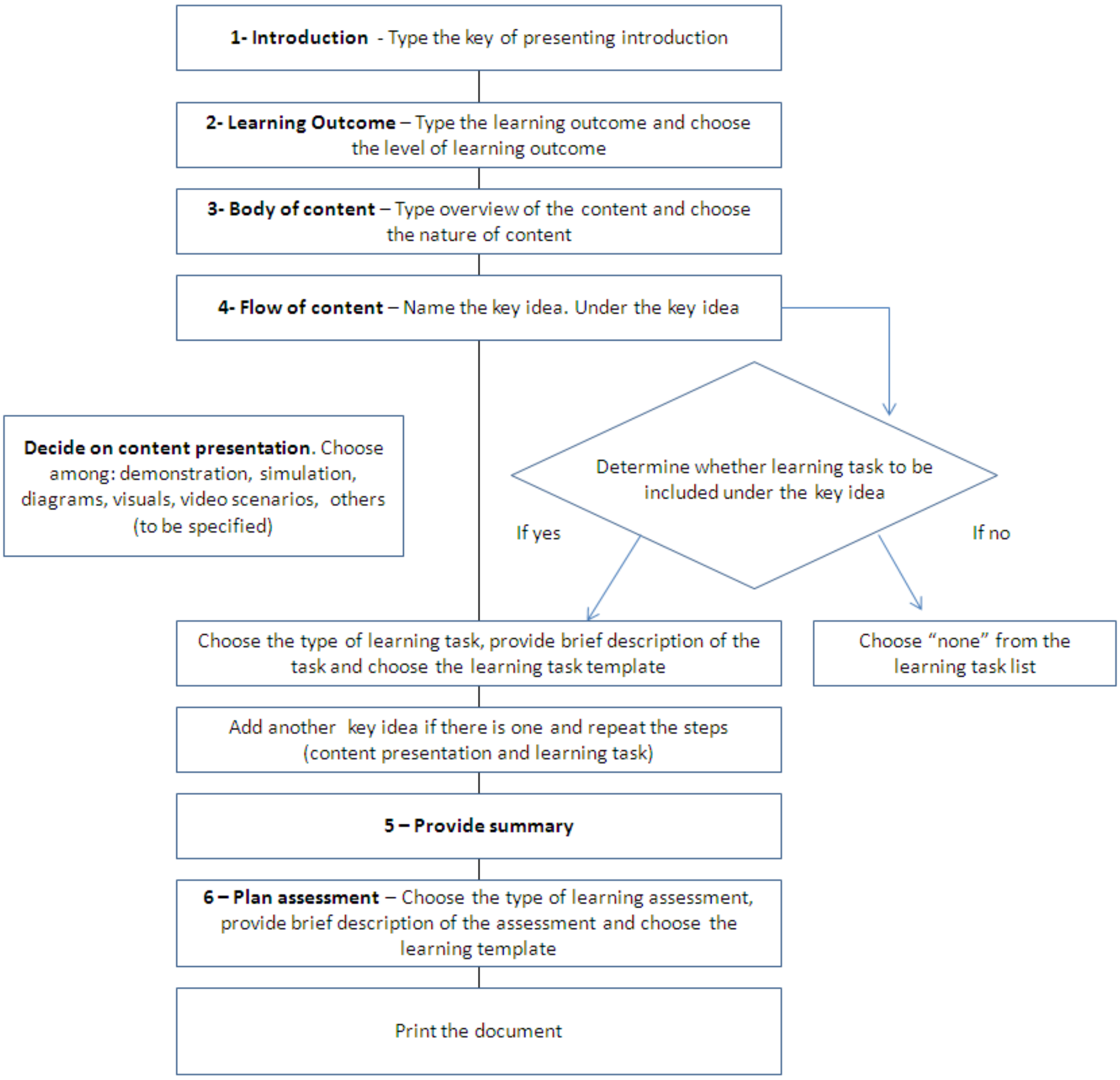


Figure 2.1: Razak and Palanisamy (2010)'s flow chart for content analysis document

2.5.4 Discussion

This section discusses selected literatures that describe methods developed to support ID and SME as a part of CoP in instructional design. The three related studies show different processes and strategies. M. Keppell, (2001)'s CPP method has been tested using a series of interview with several IDs and SMEs. This process appeared to be useful to the ID where its structure facilitates the interview with SME effectively using particular interview techniques and mapping strategies. Razak and Palanisamy (2010)'s content analysis document process has been evaluated by five instructional designers using focus interview. This process is proven to be effective due to its capability to assist IDs task to become more organized and structured. It is also proven to be efficient because the ID can communicate effectively with the SME about the content analysis document in which, later it saves their time in creating storyboard. While the above two processes have been evaluated by the real practitioners in instructional design, Hashim, et al., (2009)'s learning object development process has not found to be tested.

There are two significant findings which can be synthesized from these literatures. Firstly, ID and SME's activities have been explicitly delineated using several processes and supported using specific techniques. One of the significant techniques is the concept mapping which is used in M. Keppell, (2001)'s CPP method. The use of concept mapping technique provides insight into how to conceptualize the eLearning storyboard content into a form of map which may enable to focus on pertinent information from ID and SME before storyboard can be processed.

Secondly, ID and SME's activities for producing design plan for multimedia learning objects in Razak and Palanisamy (2010)'s M-LODGE are depicted in linear steps. In contrast to Jonassen (2008), the decision making in instructional design needs to be conducted in a cyclical process or agile. This is emphasized due to the nature of instructional design which is complex and ill-structured. Interestingly, Razak (2013) has found the existence of SMM in ID and SME from an investigation study conducted with a group of multimedia design experts. The SMM of ID and SME and the importance of agility process in making decision for instructional design is discussed more in the next section.

2.6 Shared Mental Model in ID and SME

Literature shows that design team such as engineering design team (Goldschmidt, 2007) and software development team (Scozzi, Crowston, Yeliz Eseryel, & Qing, 2008) recognize the importance of having SMM. As a part of instructional design team, ID and SME also have their own SMM which is described by Razak (2013) and Jonassen (2008).

2.6.1 Shared Knowledge and Ideas

A cognitive task analysis study has been conducted by Razak (2013), which involve twelve experts IDs. This study has focused on soliciting the knowledge of agreement on the multimedia design principles using Delphi methods. The finding has found ID and SME are the two multimedia design experts who share the most knowledge and ideas in the principles application of multimedia design, than the others (refer ID and SME highlighted in Figure 2.2.). Apart from this finding, the ID and SME have been categorized under design team apart of other categories such as management and technical teams. In this design team, ID and SME are separated according to their roles. The IDs produces or oversees the production of a set of documents that communicate effectively with the rest of the team, while the SME creates a design of the program that leads to the most effective learning by the target learners.

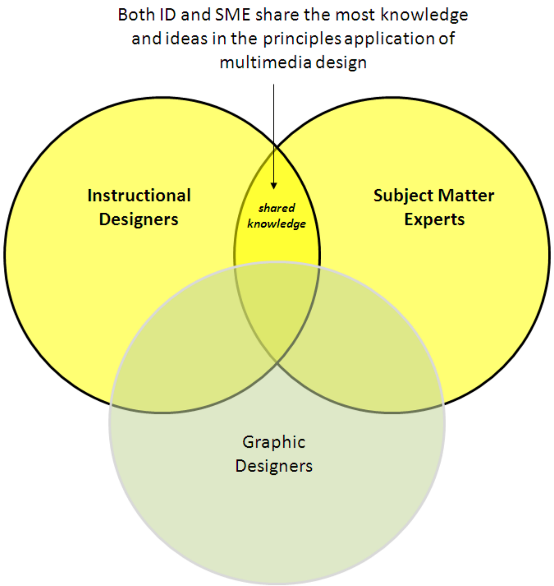


Figure 2.2: Razak (2013)'s SMM of multimedia design experts showing ID and SME share the most knowledge and ideas in designing instructional media

2.6.2 Shared Decision Making and Agile Process

Due to the existence of SMM, shared decision making in designing instruction for both experts (i.e. ID) and non-experts (i.e. SME) in instructional design has been emphasized by Jonassen (2008). Despite of the importance of sharing decision making between them, the decision making also needs to be conducted in a cyclical process or agile. According to Jonassen (2008), agility practices in making shared decision are needed due to the complexity and ill-structured kinds of problem solving in instructional design. In addition, the constraints that are introduced at every step of the instructional design process require ID and SME to make shared decision in agile ways so that the constraints can be satisfied.

Motivation towards a work on agility in instructional design process has been conducted by Bratt (2011). In Bratt (2011)'s Agile Instructional Development (AIDev) framework, the aim is to support efficiency and foster an excellent pedagogy by situating agile instructional development. Bratt (2013) emphasized that this AIDev is targeted to scaffold new research in a pedagogical context rather than a software development context. However, the strategies in AIDev were derived from data gathered from learners and not from design team (Bratt, 2013). As such, this agility process in this framework may not be effective or suitable for the ID and SME use in making decision.

2.6.3 Discussion

The section pertains to the implicit relationship between ID and SME to form SMM. Studies by Razak (2013) and Jonassen (2008) emphasized the importance of having SMM in ID and SME to perform instructional design work. Both studies show that ID and SME who have distinctive roles and knowledge in their own expertise need to have a shared understanding about certain aspects of their task, in order to collaborate successfully. It is due to a situation, where the ID is an expert in instructional design, but can be a novice in the subject-matter. Conversely, the SME by literally is an expert in his or her subject matter, and probably can be a novice in designing instruction.

According to Crandall, Klein and Hoffman (2006), experts and novices can be distinguished based on five cognitive elements such as mental model, perceptual skills, sense of typicality, routines, and declarative knowledge. As an expert in eLearning storyboarding, the ID has richer mental model, more proficient which enable him/her to notice cues and patterns or difficulties than novice (i.e. the SME). This explains the exploration of SME's challenges and errors in the design and process of eLearning storyboard can be investigated by probing into ID's knowledge.

The existence of SMM has been identified in ID and SME with regards to the sharing of knowledge and ideas in the application of multimedia design, which leads to the importance of shared decision making between them. An alternative perspective on agility in decision making has also been emphasized in the primary thinking process of all designers, including ID and SME. While the existing work to support agile process for instructional design has been conducted for learners, there is a need to extend the focus to the design team in particular ID and SME for user requirements.

2.7 Collaboration in Distributed Instructional Design

While many researchers discussed the importance of collaboration among design team members in online course development as seen in examples conducted by Brahler, Peterson, & Johnson, (1999), Xu and Morris, (2007) and Hixon, (2008), few studies have been emphasized on the aspect of distributed design.

An experience based on collaborative project between Syracuse University and a multi-national corporation is reported by Eseryel and Ganesan (2001). This finding found that there is a need of communication, cooperation, group facilitation and group-model building process between the instructional design team (i.e. ID) and the development team (i.e. SME). Interestingly, this study suggests that a communication technology support is needed in a web-based computer supported collaborative work systems to support distributed group design process in their working environment.

This issue motivates researchers to conduct solutions surrounding distributed instructional design. For example, Spector (2002) developed a conceptual framework to improve the planning, implementation and management of instructional systems in a distributed instructional design environment. Spector (2002) uses knowledge management approach to support the knowledge management activities. One of its significant components is DocuShare. DocuShare is a web-based document management system which provides functionalities such as adding, posting, changing, searching, and retrieving information in a secure and controlled environment. Spector (2002) claimed that the DocuShare is simple yet a powerful tool that allows sharing of documents and flexible access via the Internet to existing documents. It is also claimed using the DocuShare, the involving team members such as ID and SME can be supported in sustaining collaborative efforts overtime and across projects which Spector (2002) refers to the distributed design environment.

This section pertains to the works that support distributed instructional design. It is learnt that besides of functionalities that are found from Spector (2002) work on knowledge management systems, more support for collaborative effort is needed in research for the distributed instructional design team. Besides of knowledge management, Lang, Dickinson and Buchal (2002) reported four other broad categories of support that are needed by any distributed design team such as design method, collaboration, team work, and design representation. For a design team, ID and SME need to be supported in terms of design method and design representation.

Hevner, March, Park and Ram (2004.p.77) said that information technology artifacts are broadly defined as constructs (i.e. vocabulary and symbols), models (i.e. abstractions and representations), methods (i.e. algorithms and practices), and instantiations (i.e. implemented and prototype systems). On the other hand, design method is a support for design activity that can transform available information from an expressed need to a solution, while design representation is a support of representative forms such as artefacts, prototypes, process plans, etc that can served as an instantiation catalysts for further development and evolution (Lang, Dickinson & Buchal, 2002). In this research context, design representation support refers to the system platform of an eLearning storyboard which is instantiated from the instructional design activities, while design method support refers to the design process in the eLearning storyboard. As a design representative in a distributed design environment, the eLearning storyboard should be able to present and manipulate any types of shared forms in a shared design workspace, prevent inconsistency and support divergence to support cognitive synchronization of the design artefact and the design process.

2.8 Designer Centeredness Support

While many works have been emphasized to support community of learners in developing online course, the role of eLearning designers has been less examined. According to Shea (2007), there are two important elements for a successful instructional quality. First is the "learner centeredness" that supports the needs of cognition, interaction, and experiences of the learners. The other element is the role of community, collaboration, and cooperation which is essential for producing desired learning outcomes. In this research study, we refer it as the "designer centeredness". In order to support designer centeredness, the application of communication technologies, modalities, people, temporalities, locations, and pedagogies should become the units of analysis for making decisions about how to ensure instructional quality (Shea, 2007). At the same time, the integration between the learner centeredness and designer centeredness could increase better support in developing online course. In this research context, many ways can be applied to support designer centeredness in particular for the ID and SME including the use of communication technologies in eLearning storyboard.

2.9 Summary

This chapter reviewed the issues in supporting ID and SME interaction in the context of instructional design. From the discussion of the literatures, some information has been synthesized and concluded as follows:

- ID and SME are heterogeneous in nature. As a part of a CoP in instructional design, ID is identified as an expert in instructional design but can be a novice in the subject-matter while SME is a novice in instructional design but is an expert in his or her subject matter. Despite of their unique expertise and skills, the divergence of their expertise in terms of knowledge is needed to reach common goal in designing instruction.

- The use of concept mapping technique can be used to conceptualize the eLearning storyboard content into a form of map which may enable to focus on pertinent information from ID and SME before storyboard can be processed.
- ID and SME develop SMM when they share knowledge and ideas in multimedia design. As such, it is important to support their SMM using an agility practice in making shared decision.
- In order to support collaboration for the distributed design team, ID and SME need design method and design representation. As a design representation for ID's and SME's use, a system platform of eLearning storyboard contains design method that supports the agile design process activity.
- While much focus has been centered on how to support learners, the focus to support designers has been often neglected. As such, this research introduces the concept of designer centeredness support.
- It concludes three needed requirements to support ID and SME interaction: design representation (i.e. eLearning storyboard that support collaboration), design method (i.e. agility) and design-centeredness support (i.e. designers' community).

Figure 2.3 shows achievement of research questions, summary of chapter 2 and its connection with chapter 3.

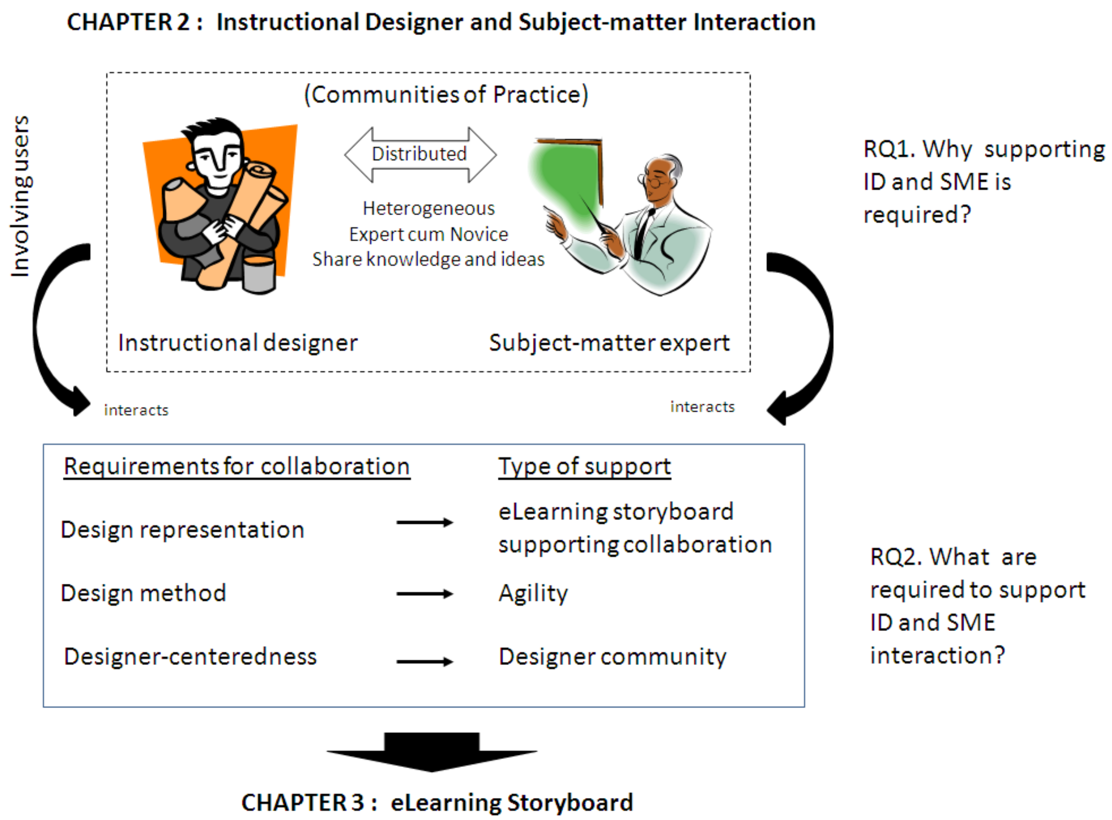


Figure 2.3: Achievement of research questions and connection from chapter 2 to chapter 3

CHAPTER 3 ELEARNING STORYBOARD

This chapter reviews storyboard for eLearning. It consists of three parts. The first part reviews definitions of storyboard in general and its importance to different industries. The second part introduced the eLearning storyboard, its differences with media storyboard, architecture, design process and roles. The final part reviews and analyse existing storyboard tools, concepts and frameworks. Summary of the review is discussed.

3.1 Defining Storyboard

In general, storyboards can be defined in many ways:

- “A series of sketches that are used as a planning tool to visually show how the action of a story unfolds” (Tumminello, 2005 p.11)
- “An illustrated view, like a comic book, of how the producer or director envisions the final version of a production will look” (M. Simon, 2007)
- “An outline or a draft line of a production made up of consequential pictures” (Cristiano, 2005)
- “Script is a verbal plan for a story, while storyboard is a plan for visualization of that story”(Glebas, 2009)
- “Storyboards are series of sketches that indicate how sequences of events should take place. They are similar to cartoon panels because they have pictures with captions explaining the scenes and any possible dialogue”(Pardew, 2004, p.3)

To summarize the definitions, a storyboard is found to be a technique for illustrating and outlining an interaction between a person (people) and a product(s) in narrative format, which includes a series of drawings, sketches, or pictures and words that tell a story. Another name for storyboard is “narration”. According to Wong and Khong (2007, p.276) narration board is a “valuable design tool to the design team as it provides a common visual-based medium to share the common understanding of future design developments”. The visual-based elements are important to the designers because it assist them in visualizing and developing ideations for future design solutions.

3.2 Significance of Storyboard in Different Industries

Storyboards are used in many kinds of industries. Some of the significant uses of storyboards have been provided by Tumminello (2005, pp.13):

- *Advertising campaigns* – the storyboards are used to sell campaign strategies to clients or for use in focus group. These storyboards which reflect campaign ideas are highly detailed and include only key frames.
- *Video games* – the storyboards are used to create each scene of the game, including cinematic and full-motion video sequences that introduce a story and act as the user’s reward for excelling in game play.
- *Multimedia* – the storyboards are used to sketch each of the screens along with notes about the content of particular images, the functions of specific button and how the video and sound is to be presented. These storyboards assist in developing CD-ROMs for education or training.
- *Web design* – the storyboards are used for the development of web design in defining and grouping elements such as graphics, animations, videos and illustrations. These storyboards assist the development team to understand the structure of a site and how that information is presented.
- *Industrial and governmental videos* – the storyboards are used to present ideas to clients when creating industrial and/or governmental videos. These storyboards promote effective decision making, help to set strategies and solve problems.

3.3 Media vs. eLearning Storyboard

The use of storyboard which purposely used in developing eLearning course originally comes from the combination of the film, video world, software engineering and education. The so-called as “eLearning storyboard” comprises documentation for eLearning courses which includes prescriptive interaction components such as animation, sound, pictures, text, and graphics (Chapman, 2008). Another kind of storyboard is the media storyboard.

Brandon (2004) provides the similarities and differences between the media and eLearning storyboard as shown in Table 3.1. Both types of storyboard share common characteristics in terms of team production, visual elements, audio productions, creativity, and cost. However, both of the storyboards are different in terms of the linearity, purpose, and ways of interaction.

For media storyboard, it always follow the sequence, serves to create awareness and interest through clear communication message and most of the multimedia elements are non-interactive. In contrast, an eLearning storyboard involves branching based on learner responses, serves to obtain particular institutional goals to develop new skills or knowledge, facilitate communication between team members and provide a thorough visual representation of a final instruction. In eLearning storyboard, the multimedia elements are interactive because it involves feedback from learners who interact through questions and practices.

To sum up, an eLearning storyboard signifies as a blueprint to eLearning design, which it provides the details from the designers that are needed by the multimedia developers in order to produce an eLearning application on time and within budget (Brandon, 2004). Besides, the used of storyboard in eLearning storyboard also saves time, money, communication and helps in problem solving (Pardew, 2004).

Table 3.1: Similarities and differences between media and eLearning storyboard

	Media Storyboard	ELearning Storyboard
	Similarities	
Team Production	Both involve production with a team.	
Visual elements /audio production	Both involve production of visual elements and audio.	
Creativity	Both are important in creativity.	
Expensive	Mistakes in either one are expensive to fix.	
	Differences	
Linear	▪ Most products are linear and one follows another in a fixed sequence.	▪ Most eLearning involves branching based on learner responses that each learner may experience a different path through a course.
Purpose	▪ Most multimedia and a lot of video and film are made for the purpose of creating awareness and interest via a clearly communicated message.	▪ ELearning is created in order to obtain particular business goals as the result of people developing new skills or knowledge. ▪ Facilitates communication between team members ▪ Provide a thorough visual representation of the final instruction
Way of Interaction	▪ Most multimedia and all video and film products are non-interactive.	▪ Interactive because eLearning is defined by questions, and practice. There is a feedback from the learners.

3.4 Architecture of eLearning Storyboard

According to Brandon (2004), an effective eLearning storyboard can only be achieved if it is only built by its own. It can be designed developed using Microsoft office application such as Word, Excel, Access and PowerPoint. Alternatively, it can also be designed using HTML or Flash.

An effective storyboard also means it should be provided with a robust hybrid of instructional design, graphic visualization, and software engineering features. Brandon (2004) stresses that the most useful storyboard integrates instructional methods and media elements in a graphical way, where all of the details included in the individual

Web pages or screens are addressed. In order to support the creation of an effective storyboard, Brandon (2004) provides a typical storyboard organization that support frame-based eLearning. This frame-based eLearning storyboard is divided into four sections, where each section contains different needed elements and their purposes, are described in Table 3.2:

- The header section: It refers to the information and administration details
- The display section: It refers to the instructional content seen or heard by the learner
- The navigation section: It refers to the options and instructions given to the learner
- The interactivity section: It refers to the logic application of interactivity such as how the learner and the application communicate.

Table 3.2: Brandon (2004)'s storyboard organization

Categories of Section	Purpose	Elements	Description
HEADER	To identify information and administration details	1. Date	Storyboard creation / latest revision date
		2. Storyboard Number	Unique number assigned to the screen or frame
		3. Version	Version number that reflects revisions between SME reviews cycles
		4. Revision	Revision number that reflects revisions between SME reviews
		5. Writer	The designer / author of the storyboard
		6. Reviewer	The person assigned to review the storyboard
		7. Review Date	The date of the current storyboard was reviewed
		8. Course Title, number	The one that appear on the course title screen. A unique number identifies the course to which the storyboard belongs
		9. Module Title, number	The one that appear on the module introduction screen. A unique number identifies the module within the course.
		10. Lesson Title, number	The one that appear on the lesson introduction screen. A unique number identifies the lesson within the course.
		11. Screen Title, number	The one that appear on the screen itself. A unique number identifies the screen and its position within the lesson.
DISPLAY	To display instructional content or voice-over scripts to learners	12. Monitor	Graphic showing what the learner sees on the monitor
		13. Scripts / Notes	Scripts for narration, notes for the developer / programmer
		14. Monitor image details	Where to find graphic, if one exists
		15. Logo / branding	Notes concerning use of logos or branding on this screen
		16. Font, bullets, text position	Notes concerning typographic treatment
NAVIGATION	To give options and instruction to the learners	17. Navigation Controls	Indicate which controls are available and which screen each goes to
		18. User Instructions	Specific instructions to appear on screen for the learner.

INTERACTIVITY	To allow interactive communication and logic to the learners	19. Rollovers 20. Hotspots 21. Items and Logic 22. Number of tries 23. Feedback	Location and text for any rollovers Location and result for any hot spots on screen. Response items, right/wrong/none and result of selection How many tries does the learner get on the question Feedback for learner when maximum tries are exceeded, number of next screen

3.5 Design Process in eLearning Storyboard

To date, there are few researches on storyboarding design process have been found specifically for eLearning storyboard. While most researches in storyboard have been focusing on design process for designing product (Van der Lelie, 2006) and system interface design (Truong, Hayes, & Abowd, 2006), this section reviews their works including Marie and Klein (2008)'s and Donahue (2005)'s related reports on eLearning storyboard.

Van der Lelie, (2006) described the five phases of the product design process in storyboard. Each design process is accompanied with its own design activities, purpose, visualization style and the form it will produced. Van der Lelie (2006)'s product design process in storyboard focuses on different visualization style for each design cycle. Van der Lelie (2006)'s storyboard design process for product design is shown in Figure 3.1

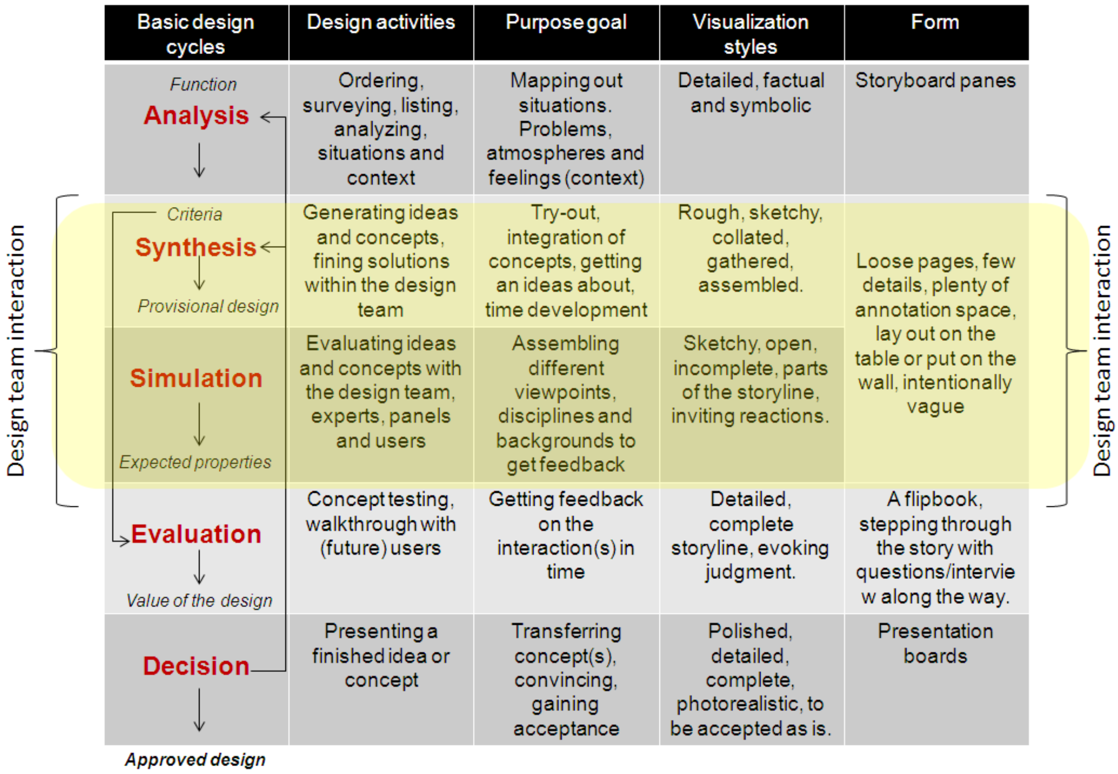


Figure 3.1: Van der Lelie, (2006)'s five phases of design process in storyboard for product design

Van der Lelie, (2006)'s storyboarding design process practices agility in five phases of storyboarding; analysis, synthesis, simulation, evaluation and decision. Throughout the design process, design teams interact is reported in synthesis and simulation phase (refer Figure 3.1). Ideas and concepts are generated from the design team to evoke comments, judgment or acceptance in these the processing phase. Interestingly, Van der Lelie, (2006) storyboarding design process is influenced by the visualisation style used in relation with the design phase and the intended goal.

Truong, Hayes and Abowd (2006) provide five significant attributes of storyboards for demonstrating system interfaces in HCI. These attributes can be significant for designing interfaces within the processing of eLearning storyboard. The attributes provided by Truong, Hayes and Abowd (2006, pp.15) as follows:

- *Level of detail* – It refers to how many objects and actors might be presented in a particular frame, level of photorealism and display of the entire scene or only details of the interface.
- *Inclusion of text* – It refers to text either through tagline narrations for each pane or within individual frames as speech, thought bubbles, or labels and signs which represents in the real life environment. The designers can also choose to depict the story entirely using visual elements without text.
- *Inclusion of people and emotions* - Storyboards can include renditions of human characters to build empathy for potential users, display motivation, or convey other intangible elements.
- *Number of frames* – In a single storyboard, number of panels presented in can be between 1 and more than 20 frames. 3 and 6 frames are regards as minimum size to show single activity. However, multiple features and activities are usually shown in multiple storyboards.

- *Portrayal of time* - Designers can explicitly indicate time passing within a storyboard or use transitions that convey changes over time.

Marie and Klein (2008) reported a detailed design guideline for developing storyboards that lead to faster client approval and fewer edits during the design and development process. The detailed design is categorized into three design process activities. First design activity refers to analysis of five requirements of eLearning development; content gathering and analysis, high level design, detailed design, storyboarding and web-based training modules i.e. alpha, beta and final phases. Second design activity refers to the detailed design development which includes the following steps: identifying learners, gathering and analyzing contents, developing instructional objectives, identifying instructional strategies and identifying the flow of the content. This detailed design document needs to be approved before continuing to the next step. Apparently it becomes a guideline for the storyboarding process. Final design activity refers to the storyboard template which are reviewed and compared in terms of its alignment with the detailed design storyboard development. Marie and Klein (2008)'s guidelines can be significant for structuring design process activities in the development of an eLearning storyboard framework. Since design documents are the core and longest activity for developing eLearning storyboards, Donahue (2005, pp.4) offers six strategies to assist designer's task, as follows:

- Graphic themes must be consistent and clear with the interface before the early phase in design process.
- Combination of instructional methods can be used to provide information in the eLearning course, such audio, graphical illustrations and case studies
- Interactivity for course development should be agreed.
- Testing or evaluations of the course should be included

- Constraints of course development such as scaling or deemphasize extraneous or non-critical information from SMEs need to be emphasized.
- A preliminary course plan to structure the format, sequence and presentation of specific content need to be developed. This high-level outline may include the breakdown of course objectives and content into modules, recommended interactivity to support the contents and length estimation for each modules, and a flow chart to visualize complex interaction or branching.

From these reviews of literatures, four important findings are identified. Firstly, Van der Lelie, (2006) has shown agility practices and visualization strategies in storyboarding design process as well as interaction in design team is found in synthesis and simulation phase of storyboarding design process. Secondly, Truong, Hayes and Abowd (2006) provided three attributes which can be significant for designing interfaces within the processing of eLearning storyboard. Thirdly, Marie and Klein (2008)'s report on the detailed design guideline for developing storyboards can be used to structure design process activities in the development of an eLearning storyboard framework. Finally, Donahue (2005)'s strategies for design document activities can be used to assist design team in documenting content for eLearning storyboard.

3.6 Roles of eLearning Storyboard

A storyboard in the context of eLearning course development is used to document the eLearning design. It provides the content in a visual format which is customized based on the needs of ID and SME. As being practice in instructional design field, the ID needs to provide the detail in storyboard that is needed by the SME in order to produce an effective eLearning (Okur & Gümüs, 2010). In this section, there are two roles of eLearning storyboard identified in the literature. First as an instructional design tool and secondly as a communication tool.

3.6.1 An Instructional Design Tool

Storyboard assists in instructional design process. This storyboard which is used for developing eLearning contains scenarios and their processes include descriptive elements, purpose about assignment and components. These components can be animation, sound, picture, text, graphic and interaction. Each component describes the kind of interaction it should behave during the actual implementation, where the amount and positions of these components are also being planned in storyboarding. When the scenarios and descriptive components have been completed, the storyboard will be passed to the multimedia developers to translate the requirements into a form of multimedia courseware (Okur & Gümüş, 2010).

Brandon (2004) provides several steps that lead to the creation of eLearning storyboard. As shown in Figure 3.2, the production storyboard is created in the instructional design process before it ends and being handoff to the multimedia development team. Each of these steps is meant to reduce the possibility of mistakes or to preserve the integrity and value of the eLearning design.

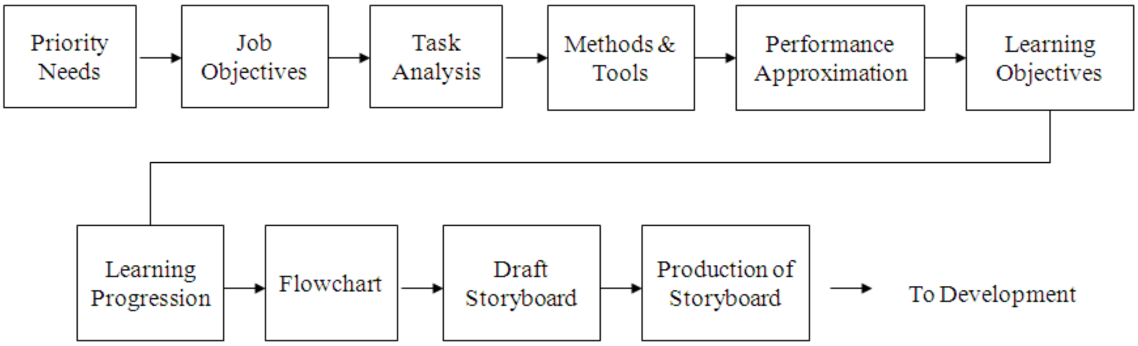


Figure 3.2: Brandon (2004)'s steps of eLearning storyboard creation

Briefly, Brandon (2004) steps are described as follows:

- The priority of business needs are identified
- The job objectives (in terms of outcomes and accomplishments) are outlined to resolve the needs.
- The tasks of a learner are being analyzed to accomplish each outcome.

- List out available methods and tools to accomplish each outcome.
- The approximations are identified to help the learners develop the needed skills in a learning setting.
- Formal learning objectives can be defined
- Formal learning objectives are organized into learning progressions
- A flowchart is created to set up the sequence of learning activities
- Draft storyboards are created to provide a basis for reviewing the course plan with SMEs.
- Draft storyboards are transformed into production storyboards that will guide the developers. These production storyboards can also serve as a checklist for the final summative evaluation before release.

3.6.2 A Communication Tool

In general, the eLearning storyboard is used to communicate eLearning design which "provides the details from the designers that are needed by the developers in order to produce an eLearning application on time and within budget" (Brandon, 2004). Brandon (2004) stated that the eLearning storyboard provides a communication channel between at least three disciplines contributing to the final product; instructional design, graphic design and technology. There are three significances of storyboard in producing effective eLearning through the support of communication (Brandon, 2004):

- Storyboard documents eLearning design completely.
- The brainstorming which accompanies work on storyboard may assist the creative process and result in a better design
- Storyboard provides an important basis for project management, control and communication.

In achieving communication using storyboard, examples of work have been demonstrated by Haesen, Meskens, Luyten and Coninx, (2010) and Malizia, Bellucci, Diaz, Aedo and Levialdi (2011).

Haesen, et al. (2010) demonstrated principles and techniques which are derived from comics can facilitate supports communication in storyboarding. The approach called as COllaborative MultIdisciplinary user-Centered Software engineering (COMuICSer) formalizes the way that storyboards are created and at the same time preserving creative aspects of storyboarding to provide greater involvement of all team members and end-users in engineering processes. Malizia, et al. (2011) demonstrated the principle of back-channel communications in emergency management in their emergency storyboard system (eStoryS) where it provides combinations of tools including storyboards in mash up application.

3.6.3 Discussion

There are two identified roles of eLearning storyboard. Firstly, it is used to assist in designing instruction which contains scenarios, their processes and descriptive multimedia components. Secondly, it is used to assist in communicating the eLearning design between designers in order to produce an eLearning application on time and within budget.

3.7 Storyboard Tools, Concepts and Framework

The purpose of this section is to review and analyse existing storyboard tools, concepts and frameworks. It begins by describing sixteen storyboard systems and groups them into two types of software classification tools and models. The next section focuses on eight storyboarding concepts and frameworks which have the potential to become functional tools in future. This is followed by analysis with regard to three requirements that ID and SME interaction: collaboration, agile design process and designer-centeredness support.

Following Wang, Shen, Xie, Neelamkavil, and Pardasani (2002), these tools are classified into domain- independent and domain-dependent tools. These software classification tools and storyboard models are not confined to any particular domain and cover a wide spectrum.

3.7.1 Domain Independent Tools

The domain-independent tools of storyboards are tools that support specific but general-purpose tasks. They are divided into three sub-categories: the sketch-based approach, authoring approach, and SCORM approach.

3.7.1.1 Early sketch design approach

The sketch design approach is treated as a domain-independent tool as it can provide functionalities to assist designers to sketch user interfaces and web pages.

Landay and Myers (2001) developed SILK (Sketching Interfaces Like Krazy), a storyboard that allows designers to sketch user interfaces easily by recognising the designer’s ink strokes. Using SILK, designers can quickly sketch an interface using an electronic pad and stylus, which can recognizes widgets and other interface elements as the designer draws them. As oppose to the paper-based sketching, designers are able to can exercise these elements in their sketchy state. The SILK’s usability has been evaluated which found to be effective in terms of supporting designing task, design communication and performance.

Bailey, Konstan, and Carlis (2001) developed DEMAIS (Designing Multimedia Applications with Interactive Storyboards), a sketch-based, interactive multimedia storyboard tool that uses a designer’s ink strokes and textual annotations as an input design vocabulary. Designers can perform this vocabulary where the tool transforms the static sketch into a working example. DEMAIS is able to facilitate experience-based exploration which means exploring an idea through a working example. This tool is targeted for the early stages of multimedia design, when a designer’s ideas are still rough and evolving. It helps a designer to rapidly explore the behavioral dimensions of the design space early in the design process.DEMAIS has been evaluated (Bailey & Konstan, 2003) and is found to be effective for helping designer to explore and communicate behavior in early multimedia design.

Newman, Lin, Hong, and Landay (2003) developed DENIM (Design Environment for Navigation and Information Models), an informal website design tool that supports designers in sketching input, allows design at different levels of granularity, and unifies the levels through zooming.

Newman, Lin, Hong, and Landay (2003) developed DENIM (Design Environment for Navigation and Information Models), an informal website design tool that supports designers in sketching input, allows design at different levels of granularity, and unifies the levels through zooming. Designers are able to interact with their sketched designs as if in a Web browser, thus allowing rapid creation and exploration of interactive prototypes. This tool is targeted for prototyping in the early stages of design but not for the creation of finished Web sites. DENIM has been evaluated and is found to be useful in terms of the functionality and usable in terms of the basic interactions, to facilitate replication, incremental modification, testing, and distribution which are needed in the practice of early phase of design.

3.7.1.2 Authoring approach

In the context of instructional design, an authoring tool supports non-programmers in assembling media objects and pre constructed scripting code to build instructional learning applications (Chapman, 2008). The authoring approach is treated as a domain-independent tool to support users or designers in authoring any aspects of objects and processes required to reach a specific objective.

Harada, Tanaka, Ogawa, and Hara (1996) developed ANECDOTE to support designers to edit the different aspects of the scenario using multiple editing views, and help them to create the final application seamlessly from the prototype scenario. Designers can choose from different authoring styles (such as hypermedia/linear, graphical textual, etc.) to construct the scenario framework. ANECDOTE is targeted to support the early-design phase and the whole development process of multimedia applications. There is no specific evaluation study conducted to demonstrate the usability of ANECDOTE. However, the paper indicates that results from some sample applications by professional designers, the aspects of authoring design principles, are found favorable and useful.

Midieum, Byung-soo, and Jun (2005) developed the AR storyboard (augmented reality-based interactive storyboard authoring tool) to support intuitive interfaces for scene composition and camera pose/motion control. It is targeted to non-experienced designers to compose 3D scenes for a storyboard using interfaces in his/her real environments at the pre-production stage of film making. AR Storyboard composes of a computing system, a PC camera, and a set of “Item blocks”. This “Item block” refers to a character or other stage object. As item blocks are placed within the camera view, the composed scene of corresponding 3D models is rendered in Augmented Reality view. The designer is able to capture, store, and edit the scene images to create a storyboard. As designer’s desktop space replaces the stage, item blocks replace characters and stage properties; he/she is able to create storyboards in a simulated screen-filming environment. There is no evaluation study conducted to demonstrate the usability of AR storyboard available in the literature. Thronesbery, Molin, and Schreckenghost (2007) developed the ConOps (Concept of Operation) storyboard to help designers to create, communicate, and refine concepts of operation information. ConOps is targeted to provide effective task that can support the difficulties of designer to understand end user tasks and software engineering principles. Using ConOps, designers can make use of XML to represent ConOps information that permits the defining XML style sheets to format the data that has met documentation requirements of specific domains (Carroll

Thronesbery, Schreckenghost, & Molin, 2009). There is no evaluation study conducted to demonstrate the usability of ConOps available in the literature.

3.7.1.3 SCORM approach

SCORM (Sharable Content Object Reference Model) is a technical specification that governs eLearning content creation and delivery (Bohl, Scheuhase, Sengler, & Winand, 2002). The SCORM approach is treated as a domain- independent tool as it helps designers to create eLearning content that complies with SCORM specifications. Ting et al. (2005) developed the eStoryboard authoring tool which is intended to provide designers with functionalities such as creation of HTML documents, Flash editing, and inserting images and, at the same time, generating outputs in flash format to produce a SCORM-compliant document. This tool support designers to create SCORM learning contents, generate multiple lesson plans, and subsequently predict learner's performance from the generated lesson plans. The eStoryboard employs artificial intelligence techniques in authoring tools that enable automatic SCORM content planning and organization, and allow prediction of learner's acquisition of contents, which are referred to Artificial Intelligence Planning and Bayesian Reasoning. The eStoryboard has been evaluated in terms of user feedback and it was found satisfactory in reducing the effort in sequencing course content and also easy to use. Yang, Chiung-Hui, Chun-Yen, and Tsung-Hsien (2004) developed the Visualized Online Simple Sequencing Authoring Tool (VOSSAT) to help designers to edit existing SCORM-compliant content packages which can be embedded as a module on the Content Repository Management System (CRMS). Using a learner-centered and web-based approach, VOSSAT is designed to support teachers to add their instructional ideas in more practical usage for eLearning. There is no evaluation study conducted to demonstrate the usability of VOSSAT available in the literature. Table 3.3 shows a summary of domain-independent tools and their implementation technologies.

Table 3.3: Summary of systems/tools on domain independent tools and their implementation technologies

Name of System/Tool	Key Features	Implementation Technologies
SILK (Landay & Myers, 2001)	To support sketching for user interfaces.	Common Lisp. The Garnet toolkit.
DEMAIS (Bailey, Konstan, & Carlis, 2001)	To support the early stages of multimedia design.	Java language, Java Media Framework (JMF) and Java Speech Markup Language
DENIM (Newman, Lin, Hong, & Landay, 2003)	To support early-phase information and navigation design of websites.	Java 2. The SATIN toolkit
ANECDOTE (Harada, Tanaka, Ogawa, & Hara, 1996)	To support the early-design phase and the whole development process of multimedia applications.	-unspecified -
AR Storyboard (Midieum, Byung-soo, & Jun, 2005)	To support non-experienced designers using interfaces in real environments at the pre-production stage of film-making.	- unspecified -
ConOps (Thronesbery, Molin, & Schreckenghost, 2007)	To provide effective task that can support the difficulties of designer to understand end user tasks and software engineering principles.	- unspecified -
eStoryboard (Ting et al., 2005)	To create SCORM learning contents, generate multiple lesson plans, and predict learner performance from the generated lesson plans.	Artificial Intelligence Planning and Bayesian Reasoning.
VOSSAT (Yang, Chiung-Hui, Chun-Yen, & Tsung-Hsien, 2004)	To assist designers in editing the existing SCORM-compliant content packages for learning processes.	- unspecified -

3.7.2 Domain Dependent Tools

The domain-dependent tools of storyboards are tools that are hard-wired with theories and models in an instructional design that cannot be altered. These tools use underlying philosophical models and theoretical underpinnings (Gustafson, 2002). They can perform various functions for different kinds of learning solutions. They are divided into two subcategories: the learning theories approach and instructional design model approach.

3.7.2.1 Learning theories approach

The learning theory approach is treated as a domain-dependent tool as it supports the intended application of learning theories which inform the designer about the flow of the modules and ensures that all aspects of the intended course have been covered.

Hundhausen and Douglas (2000) developed SALSA (Spatial Algorithmic Language for StoryboArding) as a teaching approach in which students use the simple art supplied to construct and present the algorithm to their instructor and peers for feedback and discussion. SALSA is developed using a high-level, interpreted language to program the low fidelity algorithm visualization for storyboards called as spatial algorithmic language. There is no evaluation study conducted to demonstrate the usability of SALSA available in the literature.

Lee and Chong (2005) developed OntoID (Automated Eclectic Instructional Design) to support the design phase through the explication of different techniques in the learning theory categories such as foundation (behaviorism), learning strategies (cognitivism) and teach transfer (constructivism). OntoID is targeted to provide strong pedagogical guidance through the provision of educational models and techniques founded on learning philosophy. Using OntoID, designers can select any technique from any method in these categories to fulfill different learning needs. The OntoID has been evaluated in terms of user feedback and it was found useful in reducing the design and development time compared with the creation of storyboard which required numerous discussions among the instructional design team.

Deacon, Morrison, and Stadler (2005) developed Director’s Cut to support students as designers in the production of multimodal texts which enable the understanding of conventions and processes. Using experiential learning theory, this tool supports students in creating their own video sequences from a set of clips in order to promote creativity. Consequently, this tool supports CoP for lecturers and tutors around the development of socio-cultural approaches to ICT in teaching and learning. It initiates understanding and generating intersections of media types and modes of expressive communication between students and staffs in the context of South African university. The Director’s Cut has been evaluated based on the observation of the lecturers. It was found that this tool is effective in terms of generating imaginative video clips among students.

Mustaro, Silveira, Omar, and Stump (2007) developed a schematic storyboard for learning object development to support the instructional design team throughout the model schemes molded in a linear process according to the five processes in ID: analysis, design, development, implementation and evaluation as well as Gagne’s nine events (Gagne, 1985). There is no evaluation study conducted to demonstrate the usability of this schematic storyboard available in the literature.

Igbrue and Pathak (2008) developed the Multiple Intelligence Informed tool to support both novice and experienced IDs in designing storyboard assessments suitable for multiple intelligences in eLearning. This framework is targeted to guide IDs in creating the Multiple Intelligences informed eLearning content during the storyboarding process. There is no evaluation study conducted to demonstrate the usability of this Multiple Intelligences framework available in the literature.

3.7.2.2 Instructional design model approach

The instructional design model approach is treated as a domain-dependent tool as it supports the design of a particular instruction.

Hodis, Schreiber, Rother, and Sussman (2007) developed eMovie to support designers in making molecular movies in 3D structures. It is targeted to provide a ‘guided tour’ of structures and conformation changeswhich gives guidance and direction to filming. Using eMovie, designers can create lengthy molecular animations using the plug-in for the open-source molecular graphics program called PyMOL which enables both novice and expert designers to produce informative and high-quality molecular animations. There is no evaluation study conducted to demonstrate the usability of eMovie available in the literature.

Furini, Geraci, Montangero, and Pellegrini (2010) developed STIMO (STIll and MOving storyboard) to help designers to produce on-the-fly, still and moving storyboards. Using STIMO, designers can customize the length of the storyboard and specify the time they are willing to wait in order to have the storyboard.STIMO has been evaluated and it is found efficient in producing storyboards with computational speed and quality which is suitable for on-the-fly production, however, it is efficient in terms for the on-the-fly usage.

Table 3.4 shows a summary of domain-independent tools and their implementation technologies.

Table 3.4: Summary of domain-dependent tools and their implementation technologies

Name of System/Tool	Key Features	Implementation Technologies
SALSA (Hundhausen & Douglas, 2000)	To support designers in constructing rough and unpolished low-fidelity visualisations.	spatial algorithmic language
OntoID (Lee & Chong, 2005)	To provide strong pedagogical guidance through the provision of educational models and techniques founded on learning philosophy.	XML technology
Director's Cut (Deacon, Morrison, & Stadler, 2005)	To support students in creating their own video sequences from a set of clips in order to promote creativity.	- unspecified -
Schematic Storyboard tool (Mustaro, Silveira, Omar, & Stump, 2007)	To support the instructional design team throughout the model scheme development and production of learning objects in storyboard.	- unspecified -
Multiple Intelligence Informed tool (Igbrue & Pathak, 2008)	To guide IDs in creating the multiple intelligences informed eLearning content	- unspecified -
e-Movie (Hodis, Schreiber, Rother, & Sussman, 2007)	To support designers with guidance and direction in the form of structures and conformation changes in filming.	open-source molecular graphics program
STIMO (Furini, Geraci, Montangero, & Pellegrini, 2010)	To support the production of on-the-fly video storyboards.	Farthest Point-First (FPF) clustering algorithm

3.7.3 Conceptual Models and Frameworks

In addition to the above domain-independent and domain-dependent tools, the following storyboarding concepts and framework have the potential to become functional tools in future.

Baek (1998) developed a knowledge management system-based environment to support the knowledge management activities of multimedia designers. This framework is based on knowledge management approach designed to create a new collaborative design environment in which multimedia designers could freely share their knowledge on the web. The knowledge management system-based design environment consisted of three intelligent agents which are implemented using Java script and Cold Fusion. The agents are referred to the user agent, knowledge agent and knowledge manager. The system has been evaluated and it is found to be usable for multimedia systems design, in terms of its support in creating, securing, and retrieving knowledge. This framework is targeted for social interaction of group members who are not distributed.

Jakkilinki, Sharda, and Ahmad (2006) developed the MUDPY (multimedia design and planning pyramid) to guide designers through the various phases of a multimedia project in a systematic fashion by allowing them to create a project proposal, specify the functional requirements, decide on the navigational structure and create a storyboard. The tool is targeted to streamline the process of creating a multimedia system by providing a clear pathway for planning, designing and developing. This tool is developed using Protẽgẽ 2000, an ontology editor which can provide graphical development for ontology editing and knowledge acquisition. There is no evaluation study conducted to demonstrate the usability of MUDPY ontological framework available in the literature.

Dohi, Sakurai, Tsuruta, and Knauf (2006) developed the Dynamic Learning Needs Reflection System (DLNRS) storyboard tool to support the formal process of representing, processing, evaluating and refining didactic knowledge. It is found more powerful in managing education than general artificial intelligence knowledge representations such as frames due to its syntax characteristics that are driven by the particular nature of didactic knowledge. The DLNRS tool is targeted to support the didactic knowledge that can be represented by storyboard and used for supporting dynamic learning activities of students. There is no evaluation study conducted to demonstrate the usability of DLNRS storyboard tool available in the literature.

Choo Wou (2007) developed the ILC-CMAS Model (Intuitive Life Cycle-CMAS Model) to assist the process of content development and the storyboarding management process for multimedia software development. It is a fully web-based application that consists of two modules, the content creation and management. The content creation module comprises five sub modules which are storyboard template for content writing, a quality control standard tool to maintain quality of the created content, a multimedia database for storing multimedia data, drawing tool and search tool. The management module consists of management tools used for assigning tasks and duty to each of the employees and workload planning for the employees. This model is targeted for experts of Smart Schools, organization and universities involved in the development of multimedia software and courseware. The usability of ILS-CMAS model has been evaluated and it is found to be efficient and effective to assist the process of content development and the storyboarding management process for the multimedia software development. ILS-CMAS is a fully web-based system that supports windows, Macintosh or UNIX operating system to encourage collaboration and cooperation activities, however, no available technologies implementation are being mentioned in the literature.

Bulterman (2007) developed a framework to support usercentered control of media within a collection of objects that are structured into a multimedia presentation. The control mechanism within the multimedia presentation in the storyboard providing ways in efficiently selecting content, assisting the location and recommending media objects. The user-centered multimedia control framework has been evaluated in terms of the various aspects of presentation authoring and language structuring, and is found efficient in controlling multimedia presentation. However, the responses from the end-users indicate less motivated to the use of this framework as potential media consumers.

Kleinberger, Holzinger, and Müller (2008) developed MEMORY (Multimedia Module Repository) to provide designers with a technological base for implementing eLearning applications that make extensive use of continuous media, especially video. This system supports continuous media with adaptive multimedia processes in order to achieve efficiency in search, selection, rating and usage. MEMORY is implemented using Python programming language, C++ and Java. It is also implemented using CORBA as a communication middleware. MEMORY has been evaluated and is found to be efficient in terms of searching and retrieving lecture information such as video recordings of lectures and background material, audio recordings, slides, and additional information of various types for students preparing for exams.

Wan (2007) developed the Content Storyboard Application System Framework to monitor subject-matter experts in performing storyboarding activities. This framework supports SMEs to construct the eLearning content storyboards based on Gagne's Nine Learning Events (Gagne, 1985). Within this framework, two main components are available, the Learning Principle module and the Storyboard module. The Learning Principle module holds the rules for content generation with accordance with an actual instructional design principle. Design principles rules are kept in a data store and can be manipulated to cater for multiple design principle. The Storyboard module uses the instructional design rules in order to create the content templates or content screens. This module generates a typical storyboard that consists of multiple content screens that has been organized in proper sequence as determined by the instructional design rules from the Learning Principle module. The framework is implemented using PHP programming language and MySQL. The framework has been evaluated and is found to be effective in monitoring SME performing storyboarding activities.

Wahid, Branham, Harrison, and McCrickard (2009) developed the concept of Collaborative Storyboarding to help in aggregating designers' expertise in the storyboarding process, and it offers the opportunity for a group of designers to make progress toward creating a visual narrative for a new interface or technology. Using Collaborative storyboarding, designers can work together to explore ideas, differentiate between options, and construct a common solution using three phases model, which are referred to exploration, differentiation, and construction. The PIC-UP tools which is developed based on the concept of Collaborative storyboard has been evaluated and is found effective in terms of sharing and appropriating features for storyboards, support design learning, tailor to both experienced and inexperienced users, and facilitate communication with others involved in design projects.

Table 3.5 shows a summary of conceptual models and frameworks and their implementation technologies.

Table 3.5: Summary of conceptual models and frameworks and their implementation technologies

Name of System/Tool	Key Features	Implementation Technologies
Knowledge-based system (Baek, 1998)	To support multimedia designers in sharing their knowledge on the web.	Java script and Cold Fusion
MUDPY (Jakkilinki, Sharda, & Ahmad, 2006)	To streamline the process of creating a multimedia system by providing a clear pathway for planning, design and development.	Protẽgẽ 2000
DLNRS storyboard tool (Dohi, Sakurai, Tsuruta, & Knauf, 2006)	To support the didactic knowledge that can be represented by storyboards and used for supporting dynamic learning activities of students.	- unspecified -
ILC-CMAS Model (Choo Wou, 2007)	To support experts of Smart Schools, organizations and universities involved in the development of multimedia software and courseware.	- unspecified -
User-centered multimedia control. (Bulterman, 2007)	To support user-centered control of multimedia that assist in locating or recommending media objects.	- unspecified -
MEMORY (Kleinberger, Holzinger, & Müller, 2008)	To support continuous media with adaptive multimedia processes in order to achieve efficiency in search, selection, rating and usage.	Python programming language, C++, Java, CORBA
Content Storyboard Application System Framework. (Wan Adli Ridzwan, 2007)	To support SME in constructing eLearning content storyboards based on Gagne's Nine Learning Events.	PHP, MySQL
Collaborative storyboarding (Wahid, Branham, Harrison, & McCrickard, 2009)	To facilitate shared understanding among designers.	- unspecified -

3.7.4 Analysis of Storyboard Tools, Concepts and Framework

This section analyses the storyboard tools, concepts and frameworks based on the three requirements for supporting ID and SME interaction, which are concluded in Chapter 2 earlier; collaboration, agile design process and designer-centeredness support. The storyboarding tools, concepts and frameworks are discussed in comparison whether they support these requirements.

3.7.4.1 Collaborative vs. non-collaborative

The literature contains no description of collaborative effort by tools from the domain independent category and only one tool, i.e. Director's Cut (Deacon et al., 2005) from the domain-dependent category mentions this collaborative environment. The collaborative design environment has been identified in many conceptual models and framework research: Baek (1998)'s knowledge-based system, Choo Wou (2007)'s ILC-CMAS Model, Wan Adli Ridzwan (2007)'s Content Storyboard Application System Framework and Wahid, Branham, Harrison, et al. (2009)'s Collaborative Storyboarding.

3.7.4.2 Agile design process vs. linear

The literature identifies only one tool from the domain independent category which implemented iterative process whereas none is identified from the domain-dependent category. The ConOps tool which is developed by Thronesbery et al., (2007) describes a concept of operations that requires iteration to support creative design activity. Researchers such as Dohi et al. (2006), Choo Wou (2007), and Bulterman (2007) implement an iterative process method in their conceptual models and frameworks.

3.7.4.3 Designer-centeredness vs. learner-centeredness

In the literature, many researchers have concentrated on the designer-centered approach. All the sketch-based tools (Landay & Myers, 2001; Bailey et al., 2001; Newman et al., 2003) were designed to support designers. An authoring tool that supports designers' work was demonstrated by Harada et al. (1996), and both Midieum et al. (2005) and Thronesbery et al. (2007) designed tools for authoring storyboards to support learners. All the SCORM-compliant based tools (Ting et al. 2005; Yang et al., 2004) support designers in developing learning content which is compliant with SCORM requirements. The same support can be found in the eLearning theory-based tools (Hundhausen & Douglas, 2000; Lee & Chong, 2005; Deacon et al., 2005; Mustaro et al., 2007; Igbrue & Pathak, 2008). Instructional model-based tools (Hodis et al., 2007; Furini et al., 2010) are designed purposely for learners, however. Researchers such as Jakkilinki et al. (2006), Choo Wou (2007), Wan (2007) and Wahid et al. (2009) demonstrated storyboarding concepts and frameworks which are intended to support designers' work. Figure 3.3 shows the classification of the available storyboard tools and frameworks in several categories for quick reference.

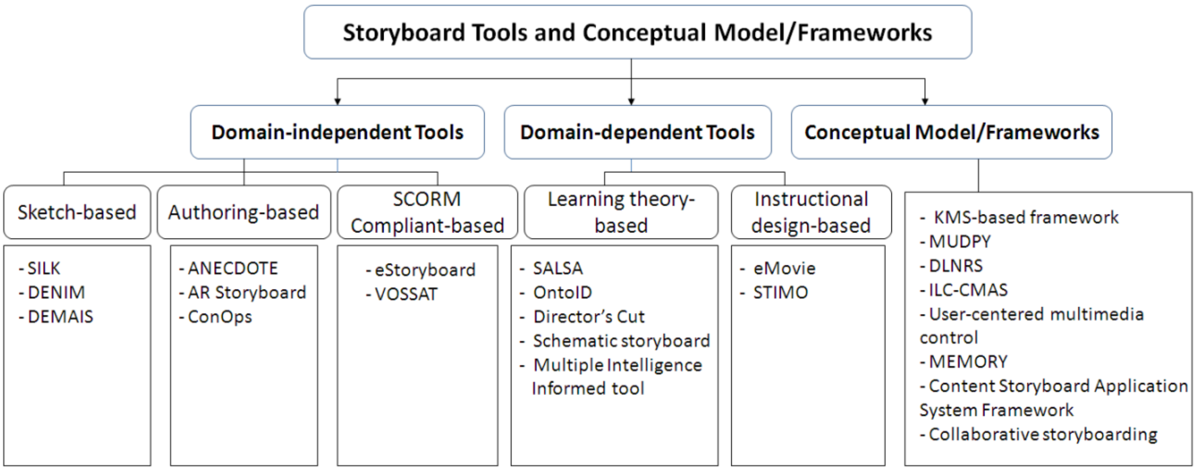


Figure 3.3: Storyboard tools, conceptual models and framework

3.7.5 Discussion

This section discusses and analyses the available storyboard tools which are categorized in two types: domain-independent and domain-dependent tools. Existing conceptual models and frameworks have also been identified and presented. From the analysis of all the tools, concepts and frameworks, it can be concluded that less research has been done on collaborative environments and iterative processes, but much has focused on supporting designers at work. It is also evident that the existing storyboard systems have some limitations in terms of giving the distributed instructional design team opportunity to engage in these cognitive task-related activities.

In this review, two important roles that are needed in eLearning storyboard.

Firstly, social support is important because of the need to shift the paradigm of storyboarding away from the individual user practices to social practices. According to Häkkinen (2002), better tools should be designed to encourage participatory and collaborative modes of designing among designers.

Secondly, agility support is important to move away from linear process. Douglas (2006) suggests that computer-based instructional design tools should move towards an agile design process in order to be more effective in adapting to the designers' activities. Current practice in instructional design is interpreted by Häkkinen (2002) as "nonlinear, cyclical and iterative process" (pp.466), therefore, the need for agility is important as it enables changing requirements and allows flexibility in reaching common understanding among the design team. By following agility process, design can be more adaptive where instructional design team can play their roles better (Häkkinen, 2002). Software designers should find initiatives and effort to design and develop computer-based instructional tools that provide agility, tightly linked design-analysis-redesign cycles, that can move toward artifact improvement (Bratt, 2011, Jonassen, 2008).

Interestingly, Douglas (2006) said that instructional system software can be more effective if its components have well defined functions to perform under adaptive and people-oriented rather than predictive and process-oriented. It explains that such feature that allows adaptive design is needed in eLearning storyboard, which can be provided using agility process.

Apart from these two important roles, the important components in an agile eLearning storyboard can be better defined by considering the shared cognitive aspects that are needed to support ID and SME interaction who are using this system. Cognitive task activities are commonly shared between the designers. They used to share on cognitive activities such as deciding on the storyboard content, organizing the structure for storyboard design, recalling the analysis requirements before storyboarding, and evaluating the storyboard design production. According to Cannon-Bowers & Salas (2001), when these cognitive activities are shared, they develop SMM resulting in better task performance and effective communication.

This section discusses and identifies some of the important issues to warrant the need of an agile storyboarding design process methodology. As suggested by Häkkinen (2002), Douglas (2006), Jonassen (2008) and Bratt (2011), future needs of software applying agile design process to assist designers' role is essential and recommended. Besides of the social and agility support, this study sheds light on the importance of SMM that is needed to support ID and SME interaction.

3.8 Summary

This chapter reviews the architecture, roles of storyboards and available storyboard systems/tools, conceptual models and frameworks. From the discussion of the literatures, some information has been synthesized and concluded as follows:

- E-Learning storyboard has its own architecture that differentiates from other kind of storyboards.
- E-Learning storyboarding design process consists of three main design activities: analysis, design document and design template. It is found that design document is the core and longest design activity that requires strategies to assist the task of design team.

- E-Learning storyboard performs roles in assisting instructional design process and communication among team designers.
- Available storyboard tools, concepts and framework have been developed using different approaches and offer different kinds of support.
- Storyboard system that can assist collaborative tasks for the instructional design team should be able to function as a communication tool as well performing design instruction. However, what is more needed in supporting ID and SME interaction is the functionality to adapt changes in the design process. As such, this research introduces the concept of agile storyboarding process.
- E-Learning storyboard needs social and agility support for ID and SME interaction. In addition to these needs, SMM is also important to support the shared cognitive aspects between them.

Figure 3.4 shows achievement of research questions, summary of chapter 2, 3 and connection to chapter 4.

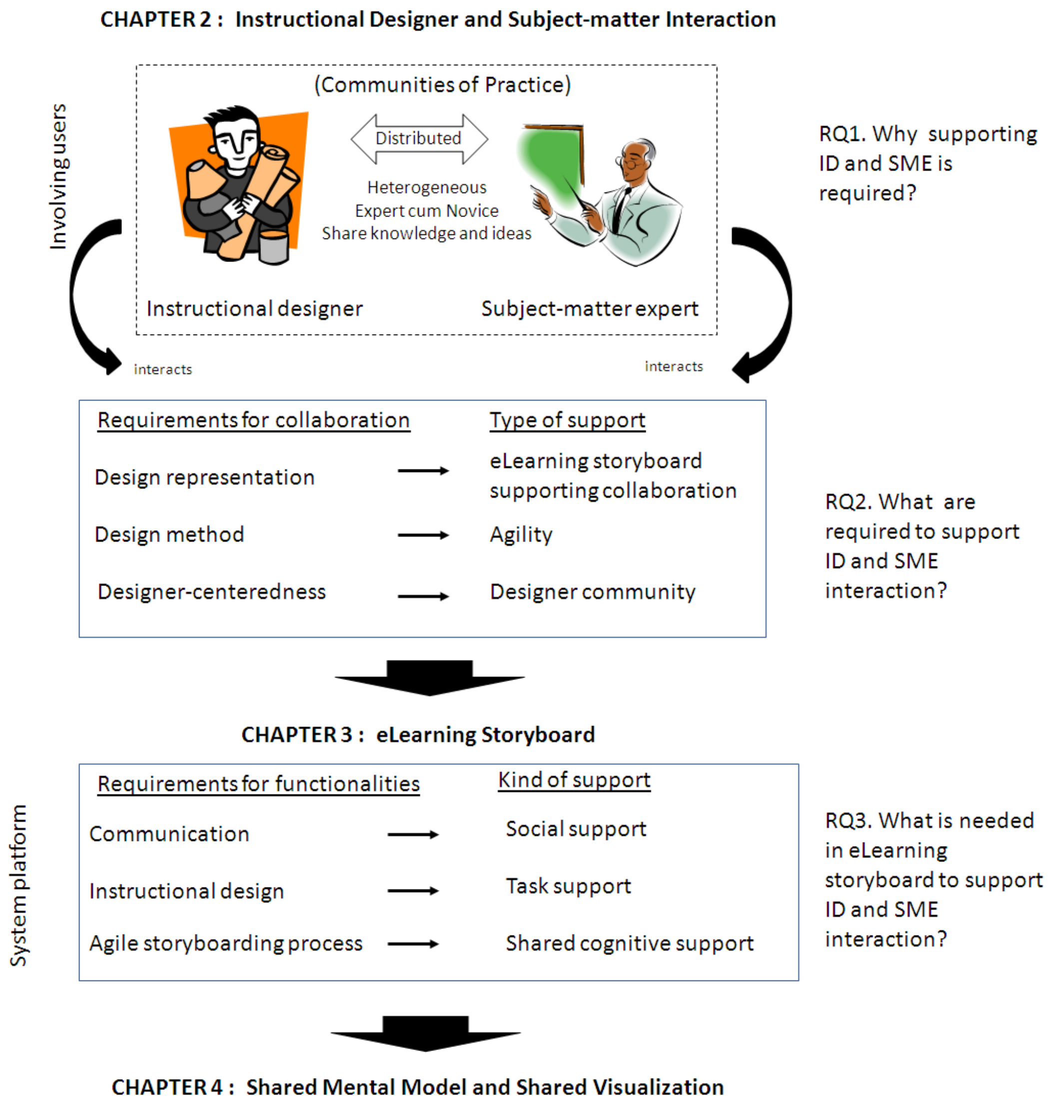


Figure 3.4: Achievement of research questions and connection from chapter 2, 3 to chapter 4

CHAPTER 4 SHARED MENTAL MODEL AND VISUALIZATION

This chapter reviews SMM and shared visualization. It consists of three parts. The first part reviews theoretical concept of SMM. The second part discusses the evaluation in SMM, and the final part presents a systematic review of shared visualization for SMM. Summary of the review is discussed.

4.1 Team Cognitive Research in Human-Computer Interaction

In HCI, team cognitive research is characterized as the study of a team as an information-processing unit (Salas, Cooke & Rosen, 2008). In order to understand the cognitive processes of the team that they want to study, HCI researchers learn from cognitive models that describe the fundamental concept.

Yusoff and Salim (2014) reported two types of approaches in studying team cognition; socially shared cognitive approach (SSC) and shared situation awareness approach (SSA). SSC is a shared cognitive approach views “how dyads, groups and larger collectives create and utilize interpersonal understanding” (Thompson & Fine, 1999, pp. 3). On the other hand, SSA refers to “degree that team members possess the same awareness of shared situation awareness requirements, within a volume of time and space, as well as the comprehension of their meaning and projection of their status in the near future” (Endsley, Bolte, & Jones, 2003, pp.13].

SMM is a type of information-processing model which is developed underlying the SSC approach (Yusoff and Salim, 2014). This model views that group members have a separate and independent memory structures. It suggests that group member who is able to access to other member’s memory stores can effectively expand their storage and retrieval, thus leading to development of group interaction. Conversely, SMM has also seen to support awareness situation. For example, works by Haig, Sutton and

Whittington (2006) shows a SMM development to support situation awareness among clinicians as well as work by Entin and Entin (2000) who found team situation awareness in SMM using simulated military missions. Hence, the SMM can be used to support both SSC as well as SSA.

Using an underlying input-process-output (IPO) framework, the greatest focus of concern on team cognitive research in HCI has been on enhancing communication and collaboration among team members as well as optimizing the performance of the team as a whole. The theoretical concept of SMM is discussed further in next section.

4.2 Theoretical Concept of Shared Mental Model

SMM refers to "knowledge structure held by members of a team that enables them to form accurate explanations and expectations for the task, and in turn, to coordinate their actions and adapt their behavior to demands of the task and other team members" (Cannon-Bowers, et al., 1993, pp.228). SMM develops when team members interact and that converge the individual team member's mental model, resulting in similar to, or sharing with, that of their team member's mental model. The terminology SMM has also been introduced in many ways, for example, team mental models and compatible mental model (McComb, 2008). Throughout this thesis, the two terms SMM and shared cognition are being used interchangeably to describe essentially the same concept.

4.2.1 Properties of Shared Mental Model

SMM consists of two properties; similarity and accuracy (Mohammed, Ferzandi, & Hamilton, 2010). Similarity in SMM refers to "sharedness" or the "degree to which members' mental models are consistent or converge with one another and does not signify identical mental models" (Mohammed, et al., 2010, pp. 880). Examples of SMM studies focusing on similarity are the study on similarity of knowledge structures between two members (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000), the effect of cross-training for the similarity of teammates' team-interaction model

(Marks, Sabella, Burke, & Zaccaro, 2002) and the effect of similar mental models for high-performance team (Zou & Lee, 2010). On the other hand, accuracy in SMM refers to the “true score” or “similarity of knowledge ratings about other members and one’s own corresponding self-ratings” (J. A. Espinosa, 2001, pp.2103).

The studies in sharedness or similarity have given more emphasis than the accuracy in the literature even though some studies attempted to study both properties are also found (Mohammed, et al., 2010). For examples; Burtscher, Kolbe, Wacker and Manser, (2011) investigate how the similarity and accuracy and two forms of monitoring behavior i.e. team vs. systems interacted to predict team performance in anesthesia, and Resick, Dickson, Mitchelson, Allison, and Clark, (2010) examined the relationships between team cognitive ability and personality composition in relation to the similarity and accuracy of team task-focused mental models.

4.2.2 Importance of Shared Mental Model

According to Cannon-Bowers and Salas (2001), constructing SMM is important due to three reasons:

- Firstly, SMM provides an explanatory mechanism that helps to understand team performance. It explains the effectiveness of teams’ interaction with one another without the need to communicate.
- Secondly, SMM construction can be valuable to predict variable in teams such as identifying potential performance problems and providing insight into how the problems can be fixed.
- Thirdly, SMM can diagnose problems such as identifying poor communication that may derive from lack shared of knowledge.

Due to the importance of SMM, the application of SMM can lead to three outcomes (Cannon-Bowers & Salas, 2001):

- First, SMM could lead to better task performance, such as in terms of the accuracy, efficiency, quality of output, volume, timeliness. This outcome is defined as task-specific.
- Second, SMM leads to better team processes, which in turn lead to better task performance such as more efficient communication, more accurate expectations and predictions, consensus, similar interpretations, and better coordination. This outcome is defined as task-related.
- Another expected outcome from SMM is referred to motivational outcomes. This includes cohesion, trust, morale, collective efficacy and satisfaction with the team. However, (Cannon-Bowers & Salas, 2001) stresses that the motivational outcomes have a looser association with task performance than the previous two.

Cannon-Bowers and Salas (2001) argued that there is a need to clarify which kind of outcomes that is expected from the SMM so that the types and aspects of shared cognition can be determined. The types and aspects of shared cognition are explained in the next sections.

4.2.3 Types of Shared Mental Model

Types of SMM refer to what cognitive processes are shared. There are four types of cognitive categories on what is shared in team (Cannon-Bowers & Salas, 2001):

- *Task-specific Knowledge* - This type of shared cognition allows the team members to coordinate without the need to communicate overtly and act on knowledge without discussion. The nature of knowledge being shared is highly task-specific, which involves specific procedures, sequences, actions and strategies to perform a task.
- *Task-related Knowledge* - This type of shared cognition allows team members to have common knowledge about task-related processes such as what it is, how it operates and its importance, which contribute to the team's ability to accomplish the

task. In contrast to task-specific knowledge, it is not task-specific, but it can hold variety of similar tasks.

- *Knowledge of Teammates* - This type of shared cognition allows team members to understand each other in terms of their preferences, strengths, weaknesses, and tendencies in order to maximize performance. It views that team learns the distribution of expertise within the team over time. It is also a task-related knowledge but not necessarily task-specific.
- *Attitude or Beliefs* - This type of shared cognition allows team members to have similar attitudes and beliefs that lead to effective decisions. It involves the notions of shared beliefs and cognitive consensus. This shared cognition type covers a broad category of knowledge, where it does not related to task-specific or task-related.

These four types of SMM are categorized into two major content domains; task-work, and team-work (Mathieu, et al., 2000). Task work domain refers to the work goals and performance requirements, while the team work domain refers to the interpersonal interaction requirements and skills of other team members (Mohammed, et al., 2010). The integration between the two major domains and four types of SMMs are presented in Table 4.1.

Table 4.1: Mathieu, et al. (2000)'s major domains and Cannon-Bowers, et al. (1993)'s types of SMMs

Major Domain	Types of Model	Knowledge Content	Description	Stability of Model Content
Task-work what needs to be accomplished	Technology / Equipment	Equipment functioning Operating procedures System limitations Likely failures	Likely to be the most stable model in terms of content. Probably requires less to be shared across team members.	High
	Job / Task	Task procedures Likely contingencies Likely scenarios Task strategies or techniques Environmental constraints Task component relationships	In highly proceduralized tasks, members will have shared task models. When tasks are more unpredictable, the value of shared task knowledge becomes more crucial.	Moderate
Team-work how work needs to be accomplished	Team Interaction	Roles/responsibilities Information resources Interaction patterns Communication channels Role interdependencies Information flow	Shared knowledge about team interactions drives how team members behave by creating expectations. Adaptable teams are those who understand well and can predict the nature of team interaction.	Moderate
	Team	Teammates' knowledge Teammates' skills Teammates' abilities Teammates' preferences Teammates' tendencies	Team-specific knowledge of teammates helps members to better tailor their behavior to what they expect from teammates.	Low

4.2.4 Aspects of Shared Mental Model

Aspects of SMM refer to how cognitive processes are shared. There are four different categories of ways of how cognition is shared in team (Cannon-Bowers & Salas, 2001):

- *Shared vs. Overlapping* - This refers to situations where two or more team members need to have some common knowledge but should not be redundant.
- *Similar vs. Identical* - This refers to the need to hold similar or identical knowledge. Team members need to hold similar attitudes and beliefs in order to draw common interpretations that can drive towards effective performance. For example, surgeon and nurse working together in an operation theater are not expected to have identical knowledge, but portions of their knowledge bases are needed to be shared (Undre, Sevdalis, Healey, Darzi, & Vincent, 2006). This category of shared cognition is associated with the task that must be common among members.
- *Compatible vs. Complimentary* - This refers to team who possess specialized roles and knowledge that is crucial to task performance. A multidisciplinary team where each member possesses specialized expertise to solve a problem may have dissimilar knowledge, however still can lead them to complementary behavior.
- *Distributed* - This refers to the knowledge that is distributed across members. This aspect of shared cognition is applied in many high performance teams, such as military combat teams, where the systems and tasks are complex and difficult. Therefore, if the team members' knowledge is specialized and distributed, team members need to coordinate their knowledge effectively in order to achieve SMM.

4.2.5 Discussion

This section discusses properties, types and aspects of SMM. It is found that SMM contains two types of properties that refer to similarity and accuracy of knowledge. The types of knowledge can be either the specific task, related task as well as the knowledge of their team members and their attitude or beliefs. It also explains that SMM works in a shared or overlapping, similar or identical, compatible or complimentary, and distributed situations.

Apparently, SMM of the ID and SME can be described based on Badke-Schaub, Neumann, Lauche and Mohammed (2007)'s framework of SMM in design teams. As shown in Figure 4.1, this framework shows how the SMM begins. Starting with current situation where design members, namely A, B, and C perceive the reality based on one or more of these elements; active perception, memory, knowledge and/or needs. These elements differ substantially between the design members as each has their own knowledge, experiences or expertise, which lead to the development of individual mental model. The SMM develops when the design members exchange their models in communication which involves either one of the five context models; task, process, team and competence. The presence and features of any one of these models may affect team performance. In addition, expectations from the design members on skills and abilities may also contribute towards team performance.

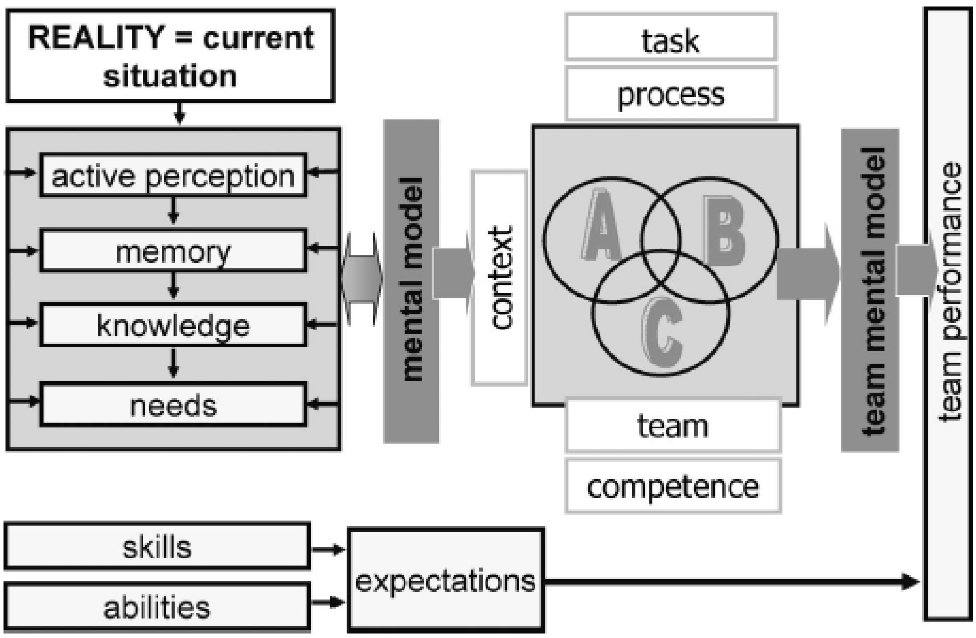


Figure 4.1: Badke-Schaub, et al. (2007, pp.10)'s framework on SMM development in design teams

Based on Badke-Schaub, Neumann, Lauche and Mohammed (2007)'s framework, SMM in ID and SME can be described under the aspects of team, process and task. It is assumed that ID and SME should at least have a SMM about the team members whom they are working. For example in ID-SME interaction, by relying on the difference of resources available and expertise held by them will likely lead to better communication than design teams who do not. It is assumed that ID and SME who have a SMM of the process in solving a storyboarding design problem, such as applying similar techniques to structure a procedure, will likely perform better than design teams who do not. Finally, it is also assumed that ID and SME, who have a SMM of the task in designing an eLearning storyboard, will likely achieve better solutions and agreement.

In this research, however, we focus on the task aspects of SMM in ID and SME, or can be referred to the "shared cognitive user task". This term defines shared cognition that belonged to the specific tasks in eLearning storyboard that are important to the intended users i.e. ID and SME. Consequently, it also covers the shared cognition of the process when performing those specific tasks in eLearning storyboard.

Based on these focus, the perceived reality derived from each design members should also contains the elements of knowledge and/or needs which lead to the development of individual mental model. Consequently, as Badke-Schaub, Neumann, Lauche and Mohammed (2007) said, the SMM develops when the design members exchange their models with others.

As mentioned by Mathieu, et al. (2000), the Task Mental Model (TMM) contains knowledge of the task procedures/process and task strategies/techniques. As such, in a highly proceduralized task in designing eLearning storyboard, design members will need to share particular task knowledge in order to achieve TMM. This research evaluates TMM based on the degree of agreement that they achieve based on the design contents produced by applying similar techniques in the eSCOUT. Consequently, it also evaluates both properties of SMM i.e. similarity and accuracy of those design contents using the same techniques in the eSCOUT, in terms of the degree of agreement. Next section reviews the evaluation methods in SMM.

4.3 Evaluation in Shared Mental Model

This section describes two types of evaluations in SMM; SMM measurement and cognitive task analysis.

4.3.1 Shared Mental Model Measurement

Shared knowledge can be measured in two ways (Cannon-Bowers & Salas, 2001). Firstly is by assessing the structure of team member knowledge and secondly is to measure the content of team member knowledge. Mohammed, et al. (2010, pp.884) refers the structure as "how concepts are organized in the minds of participants" whereas content is the "knowledge that comprises cognition". It is stated that assessing the team knowledge structure is more straightforward, however in practical ways it is rather very difficult. On the other hand, measuring contents has been seen as more possible to conduct.

4.3.1.1 Steps to measure Shared Mental Model

DeChurch and Mesmer-Magnus (2010) further have described steps to measure SMM, which involves three aspects of characteristics: elicitation method, structure representation, and representation of emergence. These three characteristics are needed as they can show the operationalization of SMM. They are as described as follows:

(a) ***Elicitation Method***

It refers to the technique used to determine the components or content of a mental model. Techniques include:

- Similarity ratings - Participants are presented with a grid and they will be requested to consider each pair of task nodes and report their perceptions of the relation between the two nodes.

- Concept maps – Participants are asked to elicit contents and place the actions into a meaningful organizational scheme.
- Rating scales – Participants are asked to elicit the content of the model and respond to questions about the task on fixed-response formats such as strongly agree to strongly disagree.
- Card sorting tasks – Participants are asked to sort numbers of cards and categorize or list them based on their understanding of the structure and relationship.
- Interactively elicited cause mapping - Participants are asked to provide data through questionnaires and/or interviews using interactive ways.
- Text-based cause mapping – Participants are asked to provide post hoc analyses of data such as systematic coding of documents or transcripts.

(b) ***Structure Representation***

It refers to the organized knowledge structures corresponding between how the knowledge content is represented in the mind and how the knowledge representation can be modeled by the researcher (DeChurch & Mesmer-Magnus, 2010). Techniques include:

- Pathfinder – This technique is used to produce appropriate psychological scaling based on the underlying structure between concepts. It provides algorithm that can transform raw paired comparison ratings into a network structure where these concepts are represented as nodes, while the relatedness of the concepts are represented as links.
- UCINET - This technique is developed by Borgatti, Everett and Freeman (2002) to support social network data analysis. It comes with a complete software package for data visualization[1].

[1] http://www.analytictech.com/

- Multidimensional scaling – This technique uses geometric models to represent proximity data spatially. It is used to identify unknown underlying dimensions in organizing cognitive stimuli.
- Concept mapping/card sorting - as described.

(c) ***Representation of Emergence***

It refers to representation technique used “to reveal the structure of data or determine the relationships between elements in an individual’s mind” (Mohammed, Klimoski, & Rentsch, 2000, pp. 129). Techniques include; concept mapping, pathfinder, UCINET, interactively elicited cause mapping, text-based cause mapping and Euclidean distance.

Of all the techniques described in each steps for measuring SMM, Mohammed, Klimoski and Rentsch (2000) recommended only four techniques because they encompassed both elicitation and representation. These techniques are referred to as pathfinder, multidimensional scaling, interactive elicited mapping and text-based cause mapping.

Next section describes cognitive task analysis as another type of evaluation in SMM.

4.3.2 Cognitive Task Analysis

Cognitive task analysis (CTA) focuses on the difficulties in cognitive structures such as knowledge-based and representational skills as well as processes such as attention, problem solving and decision making (Stanton, Salmon, & Walker, 2005). The aspects of cognitive structures and processes in the CTA can provide a description of the knowledge and thought processes that are required at the expertise level (Schraagen, Militello, & Ormerod, 2008; Seamster, Redding, & Kaempf, 1997). They can also lead to a process for designing, developing and evaluating a better human–computer interface intended to amplify and extend the human ability to make good decisions (Crandall, et al., 2006).

Most studies in CTA are concerned with expertise (Klein & Militello, 2001, p.180). Cognitive study is designed to elicit the knowledge and wisdom acquired (Crandall et al., 2006, p.134). For example, during CTA interviews, interviewers will appreciate the nature of expertise when responses and feedback received are probed in detail. Some related expertise studies that have been conducted using CTA include experienced air warfare coordinators unpacking their expertise and coaching skills for the development of shipboard-based on-the job training for the Navy (Pliske, Green, Crandall, & Zsambok, 2000), certified cytotechnologists detecting questionable cells and making sense of the clinical picture for the process documentation of tissue biopsies and cell samples for pathology (McDermott & Crandall, 2000) and army ranger squad or platoon leaders describing the required skills for clearing buildings in urban combat settings for the development of training software (J. K. Phillips, McDermott, Thordsen, McCloskey, & Klien, 1998).

Cooke (1994) found more than 100 types of CTA methods and techniques. Due to the growing number of CTA methods, extensive CTA reviews by Stanton et al. (2005), Schraagen et al. (2000) and Wei and Salvendy (2004) offer a broad exploration of the difference among these methods and techniques in a number of ways. Stanton et al. (2005) present five selected CTA methods based upon their popularity and the application used, while Schraagen et al. (2000) described a comprehensive review of reviews and classifications to guide researchers interested in exploring and applying the CTA techniques. On the other hand, Wei and Salvendy (2004) classify the CTAs into four broad families, namely: 1) observation and interview 2) process tracing 3) conceptual techniques and 4) formal models. This CTA family classification is meant to guide researchers, who aim for particular outputs, to select appropriate techniques.

4.3.3 Discussion

This section describes SMM measurement and CTA. It discusses the procedures and available techniques in guiding researchers to conduct evaluation and analysis for SMM. In this research context, specific evaluation and analysis is used for investigation and evaluation studies.

The investigation study which is presented in Chapter 5 uses the application of CTA. This study takes the expertise study approach in CTA to discover the cognitive tasks and skills of expert designers that SMEs may acquire for eLearning storyboard development. In this study, a specific technique called as the Applied Cognitive Task Analysis (ACTA) developed by Militello and Hutton (1998) is adopted, and described further in Chapter 5.

The evaluation study which is presented in Chapter 7 uses the application of SMM measurement. This study evaluates the TMM as well as the similarity and accuracy properties based on the degree of agreement that they achieve based on the design contents produced by applying similar techniques in the eSCOUT. In this study, interactively elicited cause mapping is adopted, which involves only two steps to measure SMM i.e. elicitation and representation of emergence.

Next section discusses the roles of shared visualization for SMM.

4.4 Significance of Shared Visualization

One way to externalize the individual mind is through the representation of visualization. Many studies have also demonstrated that visual representation that is shared among the users can lead to the development of SMM. Visualization is referred to as “a method of computing…offers a method for seeing the unseen, enriches the process and unexpected insights” (National Science Foundation's Visualization, 1987). According to McGrath et al., (2012), visualization is a graphical representation of data to aid human cognition. These two definitions explain that visualization that is shared can enrich the process as well as the unexpected insights performed by many users.

The application and effect of visualization to shared cognition have been studied by many researchers in the domain of cognition and design studies. For example, the effectiveness of visual representation for the purpose of externalizing and communicating the design process has been demonstrated by Goldschmidt (2007). In this study, two experiments are conducted to clarify how the visual representations have created a SMM of a new bicycle accessory meant to carry a backpack. The result shows that in order for all team members to arrive at a shared task model, it is necessary for them to see the design entity eye to eye in order to progress.

Other studies which had demonstrated the important of visual representation includes; collaborative knowledge construction via visual graphical representation (Suthers, 2005), reducing the effort of explicit communication via shared white boards in emergency department (Xiao, Schenkel, Faraj, Mackenzie, & Moss, 2007), and understanding different kinds of video representation and analysis via the use of video story (McNeese, 2004).

Arias, Eden, Fischer, Gorman and Scharff (2000) said SMM can be visualized through the use of external artifacts. External representation can be used to make the knowledge available to all members explicitly as well as able to transcend the cognitive limitation across individual minds. This externalization is important as it creates what is vaguely resides in one's mental efforts. Other words, artifact represents an externalization which can be communicated visually to the users.

Next section describes the significant role of using artifact as a visual externalization.

4.4.1 Role of Artifact for Visualization

Artifact that is used as a tool for cognitive activities is called as the "cognitive artifacts". According to Visser (2006), cognitive artifact comes in two forms:

- Internal cognitive artifacts or mental cognitive artifacts (i.e. mental representation) – Examples; such as rules of thumb, mnemonics, shopping lists, and other kinds of procedures.
- External cognitive artifacts – There are two types; physical such as buildings, cars or garments or any results from mental representations and symbolic such as software, route plan, drawings, mock-ups or any results that symbolize the mental representation.

Visser (2006) explains that due to the nature of the mental cognitive artifacts that are less vague in terms of ideas or images that designers have "in their heads", the use of external cognitive artifact to visually externalize the emergence of mental cognitive artifacts are needed. Figure 4.2 shows the emergence process of external artifact to represent the visual externalization of internal cognitive artifact.

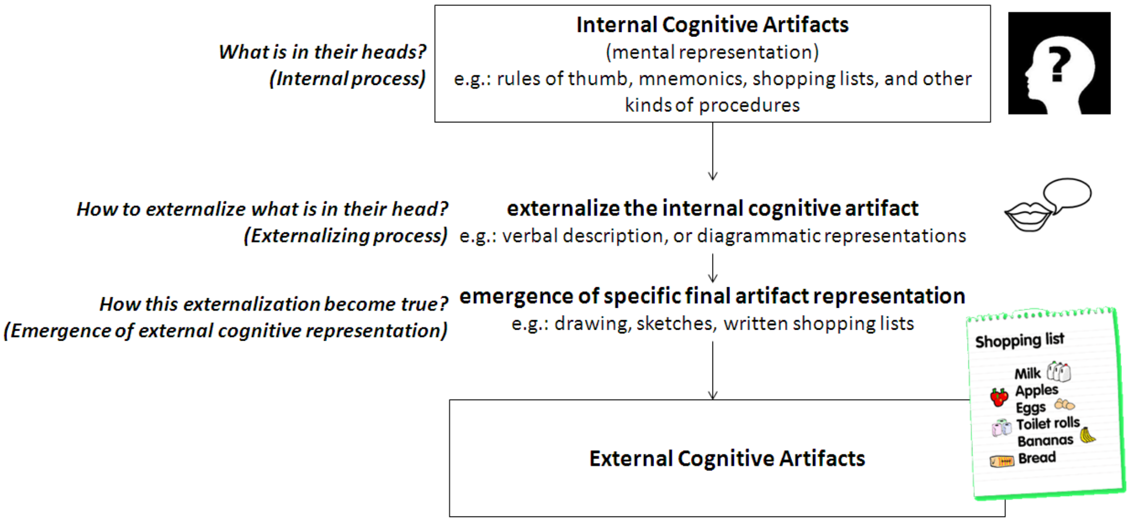


Figure 4.2: The emergence process of an external cognitive artifact

A research example of using external cognitive artifact is conducted by Nemeth, Cook, O'Connor and Klock (2004) to study communication and information sharing among healthcare providers. In this study, external cognitive artifacts which are related to operating room or scheduling are used such as the availabilities sheet, master schedule, graph and board. This study finds that better computer-supported cognitive artifacts can benefit patient safety by making teamwork processes, planning, communications, and resource management more resilient.

4.4.2 Shared Visualization for Shared Mental Model

Eduardo Salas, Nancy J. Cooke and Michael A. Rosen (2008) suggested that SMM can be improved using technological development and implementation. One of the technological visualization approaches towards SMM is CoVis. CoVis is referred to as "the shared use of computer-supported, interactive, visual representations of data by more than one person with the common goal of contribution to joint information processing activities" (Isenberg et al., 2011, pp.312). CoVis is an approach that emphasis the shared use of interactive visual representations, which could be in a form of joint viewing, interacting with, discussing, or interpreting the presentation.

According to Isenberg, et al. (2011), one of the important aspects in CoVis is the focus on cognition and results. It emphasizes that CoVis is not concern about the creation of a "product" i.e. the shared representation, but the focus should involve unique cognitive activities i.e. shared cognition. Besides, Isenberg, et al. (2011) also emphasizes the need to support social interaction process around the data. It concerns on the ability for a team to build each other's insights, in turn they could reach a common understanding of the datasets. Examples of social interaction include arriving at a common understanding of the data and enhance knowledge construction by making use of interaction of data.

Next section describes user interaction in shared visualization.

4.4.3 User Interaction in Shared Visualization

Brodlie, Duce, Gallop, Walton and Wood (2004) provide four aspects relate to how users interact when participating in visualization systems. The four aspects are:

- Joining/leaving – shared visualization systems should have facility to allow users to join and leave at any time.
- Floor control – Shared visualization systems should offer different levels of access to a session for individual users such as allowing editing, or sharing or both editing and sharing authority.
- Privacy – Shared visualization systems should allow users to work privately and at the same time, still remain in the conference. This is to protect some information and at the sometime can share other information.
- Global view - Shared visualization systems should be able to allow users to view the network editor of other users in order to reassure that they understand what other user is doing.

4.4.4 Distributed Design in Shared Visualization

Distributed design is understood as a design environment which is directed to the division or spread of resources such as design artifacts, design knowledge or design team. Distributed design can be operated in either synchronous or asynchronous mode. Synchronous mode in distributed design enables real-time communication and collaboration in a "same time-different space" environment; whereas, asynchronous mode enables the communication and collaboration in distributed design to be operated over a period of time through a "different time-different space" mode.

Both modes of distributed design have their own advantages and disadvantages for ID and SME. For synchronous mode, ID and SME can connect at the same time and able to engage with each other instantly. However, ID and SME who work in different time zones often experience conflicting schedules which can create communication challenges. For asynchronous mode, ID and SME can connect together at their own convenience and own schedule. It enables ID and SME to involve in design participation from multiple time zones as well as allowing collective knowledge to be more easily shared and distributed. However, it lacks of immediate engagement and participation for some ongoing communities of practice.

4.4.5 Discussion

This section discusses the significant role of artifact, importance of shared visualization for SMM and what aspects of interaction that users can perform in shared visualization systems.

In this research, artifact is used for experimental study. The experimental study which is presented in Chapter 5 uses the application of storyboarding artifact. Storyboarding artifacts which are related to eLearning storyboard design are used as external cognitive artifacts to visually externalize the internal cognitive artifacts inside the “ID’s and SME’s heads”. This study is aimed to identify what are the internal cognitive artifacts that represent the mind of ID and SME and how the internal cognitive artifacts can be represented.

In order to assist work in investigation study, the analogy of cognitive process in SMM and CoVis shown in Table 4.2 is analyzed. As seen in CoVis process, data within the mind of users is acquired, represented and emerged using a form of visual representation (Isenberg, et al., 2011). Similarly, SMM process also show the data or knowledge from the mind of individual or group is elicitated, represented in a structure form and finally emerge to form SMM (DeChurch & Mesmer-Magnus, 2010).

Table 4.2: Analogy of shared cognitive process in SMM and CoVis

Major processes	SMM	CoVis
Input	Knowledge elicitation from the mind of individual / group	Data acquisition from the users
Processing	Structure representation	Data representation
Output	Emergence of representation	Emergence of visualization

These processes do not show how the role of artifact can be used for each process. As such, we come out with a cognitive data process of SMM using the role of artifact. Based on these two processes, the role of artifact can be used to map with each of the major process in order to understand what cognitive data can be acquired as an input, how the cognitive data can be externalized as a process, and what form of visualization can display the emergence of that cognitive data. From the previous review, we have mentioned the focus on elements of knowledge and/or needs which can lead to the development of individual mental model derived from Badke-Schaub, Neumann, Lauche and Mohammed (2007)'s framework. The cognitive data process of SMM using the role of artifact as follows:

a) **Cognitive Data Acquisition** is the input process to identify internal cognitive artifact that represents the data from knowledge and needs of users.

b) **Cognitive Data Process** refers to how that internal cognitive artifacts being processed.

c) **Cognitive Data Emergence** is the output process which displays the emergence of that cognitive data in a form of visualization. It can be referred as the Visser (2006)'s symbolic form of external cognitive artifact.

Looking the importance of shared visualization for SMM, review study is needed to understand what strategy or techniques being applied in shared visualization to achieve SMM. Reviews should also include how these strategies and techniques being used in shared visualization. Next section presents a systematic review study of shared visualizations focusing on SMM.

4.5 A Systematic Reviews of Shared Visualization

This section presents a systematic review of shared visualization for SMM. It begins by discussing related works and research design. Result and analysis of the study is discussed.

4.5.1 Related Works

The concept of a SMM in HCI is derived from the field of teamwork and collaboration (Payne, 2003). Following the publication of an article by Payne (2003), there has been much interest in SMMs in the context of computer technology, particularly in the area of HCI. However, until now there is no substantial research review related to the use of systematic literature reviews in shared visualisation and which above all, focuses on developing a SMM.

Isenberg et al. (2011) provided a detailed review on five real world examples of scenarios in which CoVis tools were used. The study urged researchers to extend their investigations into CoVis. One of the specific challenges found in the research space intersecting collaborative work and visualisation is the visual representations aspect to support the process of social interaction to reach a common understanding in terms of dataset.

Grimstead, Walker and Avis (2005) reviewed 42 CoVis systems, which were grouped and compared in terms of four application areas: collaborative problem-solving environments, virtual reality environments, multi-player online games and multi-user enabling of single user applications. The study concludes that a CoVis system that needs to support many simultaneous users must be scalable if it is designed to maximise the use of distributed resources and network facilities.

In summary, these studies only describe the importance of shared cognition or shared application in CoVis systems. However, none of them analysed the shared visual representation for building a SMM, although this is one of the major aims for CoVis systems.

4.5.2 Research Design

This systematic review follows the guidelines given by Kitchenham and Charters (2007) that have been used in the software engineering field, as well as in other domains, including computer education (Arimoto and Barbosa, 2012) and business process measurement (González et al., 2010). Kitchenham and Charters's guidelines (2007) state that a literature review should be systematic and minimise researcher bias. Two protocols are necessary: firstly, a set of research questions that captures the rationale for and objectives of a review should be developed; secondly, a search strategy that details search terms, library databases and study selection criteria. The process by which papers and data for this review were extracted is further described.

4.5.2.1 Research questions

The main purpose of this systematic literature review is to present research on using shared visualisation to achieve a SMM. This review aims to identify the shared visualisation strategies and techniques that can facilitate the development of SMM; it addresses the following specific research questions:

- RQ1: What is the trend in SMM studies of shared visualization, focusing on two types of spatial collaborative environment approaches, socially shared cognition (SSC) and shared situation awareness (SSA)?
- RQ2: What and how is the strategy being applied in shared visualization?
- RQ3: What and how is the technique being used in shared visualization?

▪ RQ4: What is the technology being implemented in shared visualization?

Figure 4.3 gives an overview of how the four research questions link to one another to give a comprehensive view of the review topic.

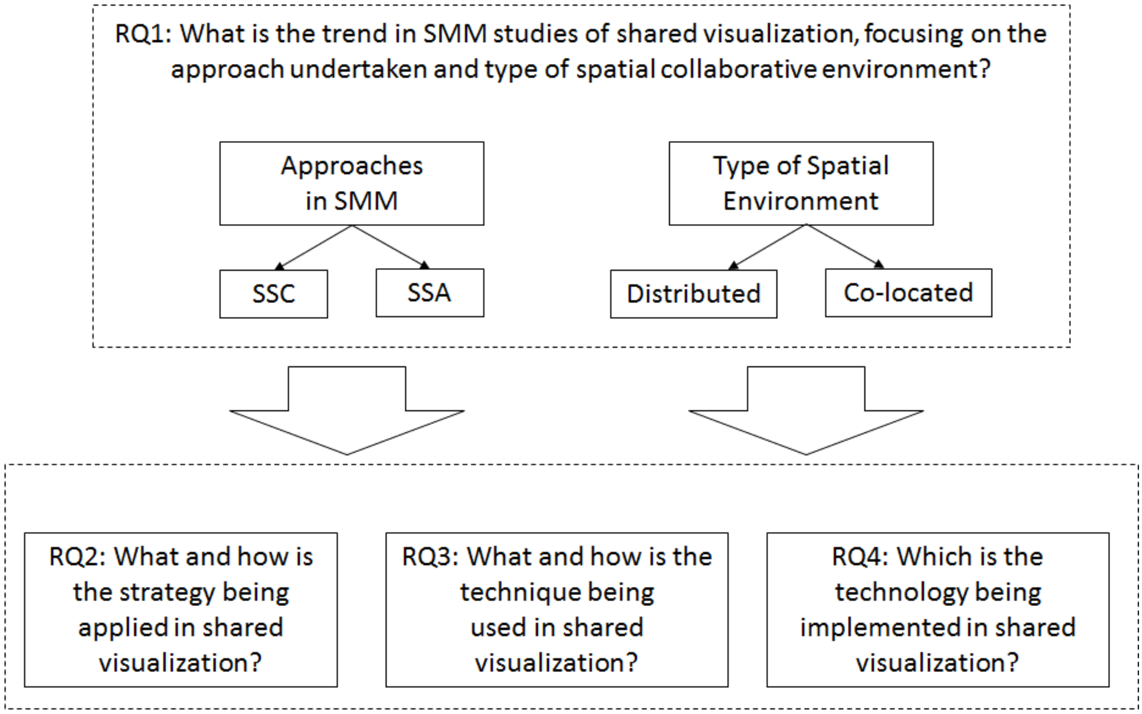


Figure 4.3: The relationship between the four research questions

4.5.2.2 Searching strategy

In this study, specific keywords were used to search for the relevant literature. Although the term "shared visual representation" had been used above, the term "shared visualisation" was preferred in the literature search as it is more specific than "shared visual representation", which may refer to any visual representation that can potentially be shared. Although there has been a considerable amount of cognitive and design research on shared visualisation, there is also a long list of shared cognition research in the fields of group cognition and collaborative design. The term "shared visualisation" is therefore used in this review to refer to a particular visualisation that is explicitly designed for sharing information.

*(a) **Search terms***

Databases were searched using the search string constructed from these keywords:

(Shared visualisation AND (SMM OR shared cognition))

If this search produced no hits, the terms "SMM" and "shared cognition" were removed from the search string.

(b) ***Library databases***

To encompass a broad set of relevant papers, the search covered popular databases in the field:

1. Science Direct[2]
2. ACM Digital Library[3]
3. IEEE Explore Digital Library[4]
4. ISI Web of Knowledge[5]
5. Scopus Online[6]
6. Taylor and Francis Online[7]
7. Springer Link[8]

These digital libraries were selected for their compatibility with the Endnotes bibliographic tool (Hull et al., 2008).

---

[2] http://www.sciencedirect.com/
[3] http://dl.acm.org/dl.cfm
[4] http://ieeexplore.ieee.org/Xplore/home.jsp
[5] http://apps.webofknowledge.com/UA_GeneralSearch_input.do?product=UA&search_mode=GeneralSearch&SID=R2ZP9MMddFqMHl9m4vk&preferencesSaved=
[6] http://www.scopus.com/source/browse.url?zone=TopNavBar&origin=searchbasic
[7] http://www.tandfonline.com/
[8] http://link.springer.com/

The numbers of initial hits for the various search strings used are presented in Table 4.3.

Table 4.3: Initial search results for seven databases using the search string

Digital Database Libraries	Keywords and Hits (Shared visualization AND SMM)	(Shared visualization AND shared cognition)	(Shared visualization)	Collective papers
Science Direct	5	1	-	6
ACM digital library	3	0	-	3
IEEEXplore	0	0	5	5
ISI	0	0	1	1
Scopus	0	0	5	5
InformaWorld	1	0	-	1
Springer Link	0	1	-	1
Total				**N=22**

(c) Studies selection

The inclusion and exclusion criteria used are described in this section.

Inclusion criteria - The initial hits are filtered according to the inclusion criteria as follows:

- Publication date: between 2000 and 2013 inclusive
- Research domain: science technology or computer science
- Publication type: journals, proceedings and transactions
- Article type: full text and reviews
- Subject: directly addresses one or more of the research questions
- Language: English

Exclusion criteria - This review focuses on strategies, techniques and technological implementation of shared visualisation for SMMs, so the following papers are excluded:

- Papers under five pages in length
- Papers drawn from workshops, presentations, opinions and viewpoints
- Redundant papers

▪ Replication studies

The Endnotes version X4 was used to detect and eliminate redundant papers. When similar studies with different first authors were found, only papers that were most recent, general and relevant to the research questions were included. The search strategy and results are shown in Figure 4.4.

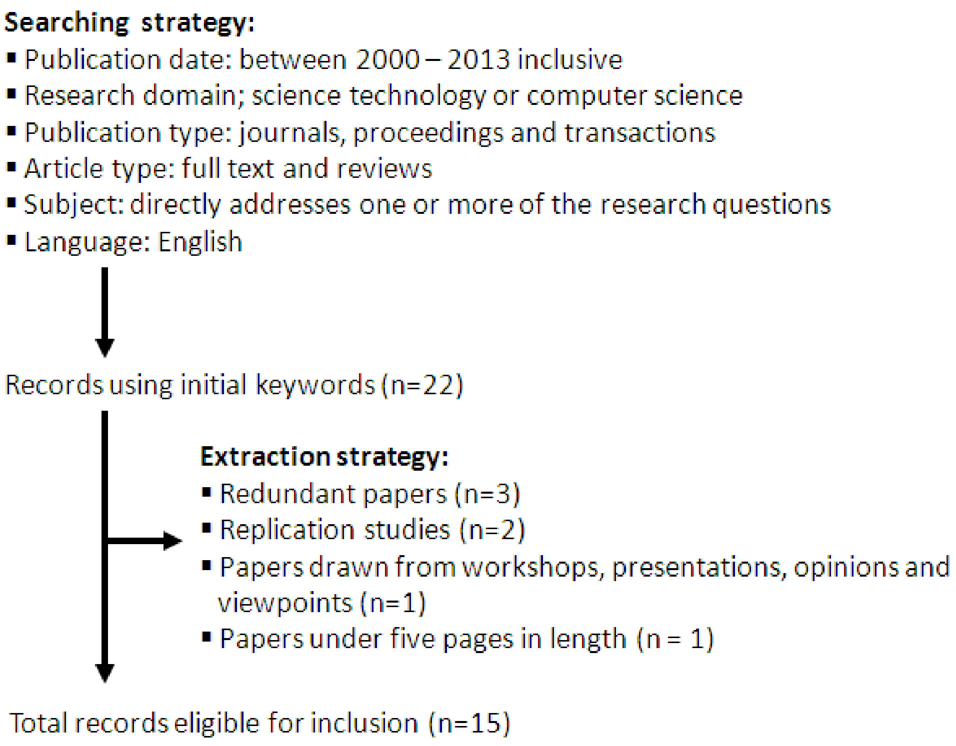


Figure 4.4: Flow of searching and extraction strategy

4.5.2.3 Papers and Data Extraction Process

Publications were extracted using the Endnotes version X4, which can automatically document references for each paper. Kitchenham and Charters (2007) do not provide very clear guidelines on the process of data extraction. We opted to use the Adobe® Reader® XI version 10.0.5 for data extraction. Papers were analysed using the "Find" tool and data were extracted on the basis of keywords such as "visual" and "visualisation". Following this, the Microsoft Excel version 7 was used for data entry and coding; the data were classified by system name, year, research field, key features, methodology, type of spatial environment, descriptions of strategy, techniques and technological implementation. The Microsoft Excel's "AutoFilter" was used to filter subsets of data based on this classification.

The results of this analysis are presented in the next section.

4.5.3 Result and Analysis

A total of 15 studies discussed strategies and techniques of shared visualisation for shared cognition. Citations for these 15 papers were sorted in ascending order of publication date and are included in Appendix A. A short overview of the studies is given before the detailed presentation of results relating to each research question.

4.5.3.1 Categorization based on Applied Research Method

The investigated papers were categorised according to two types of research (Shahrokni and Feldt, 2013). Experimental reports and evaluation paper were included in the category of "development and evaluation papers". Philosophical papers and solution proposals were also considered as a single category. This classification resulted in the following categories:

- Solution proposal paper: report of findings based on the theoretical studies, experimental research or other related work.
- Development and evaluation paper: report on the development of a tool, model or framework supported by evaluation.

Figure 4.5 shows that of 15 papers, 40% are solution proposal papers and 60% are development and evaluation papers.

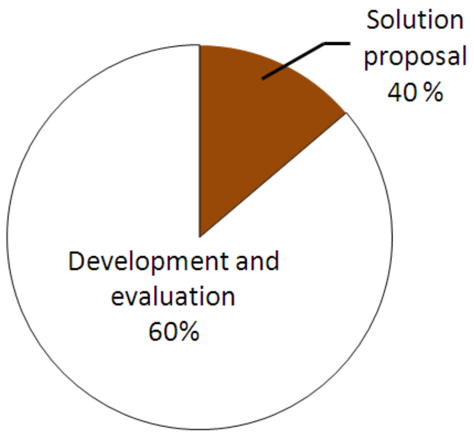


Figure 4.5: Classification of inspected publications according to type of research

These papers were investigated with reference to the strategies and techniques of shared visualisation. The following sections consider the specific research questions in more detail.

4.5.4 Research Question 1

RQ1: What is the trend in SMM studies of shared visualisation, focusing on the approach undertaken and type of spatial collaborative environment?

4.5.4.1 SSC vs. SSA approaches.

The inspected papers were published between 2000 and 2013. Figure 4.6 shows that over this 13-year period, there was an increase in publications focusing on SSA approaches to shared visualisation whilst the use of the SSC approach showed no consistent trend. The increase in SSA research may reflect a growing interest in SSA concerning shared visualisation research. This is due to an increasing demand for systems and tools to support decision making in critical situations and judgment under uncertainty (Bachour et al., 2010; Haeyong et al., 2010;Balakrishnan et al., 2010; Loll and Pinkwart, 2013;Engelmann et al., 2009; Bergstrom and Karahalios, 2012;Wu et al., 2013).

Between 2006 and 2008, the number of SSC studies decreased; a possible reason was that researchers had changed their focus to other areas such as collaborative design, collaborative learning and knowledge management. Examples of these studies are those by Germani et al. (2012), McGrath et al. (2012), Thouvenin et al. (2005), Ogi et al. (2003), Grandhi et al. (2011), Greenspan et al. (2000), Maceachren and Brewer (2004) and Abla et al. (2010).

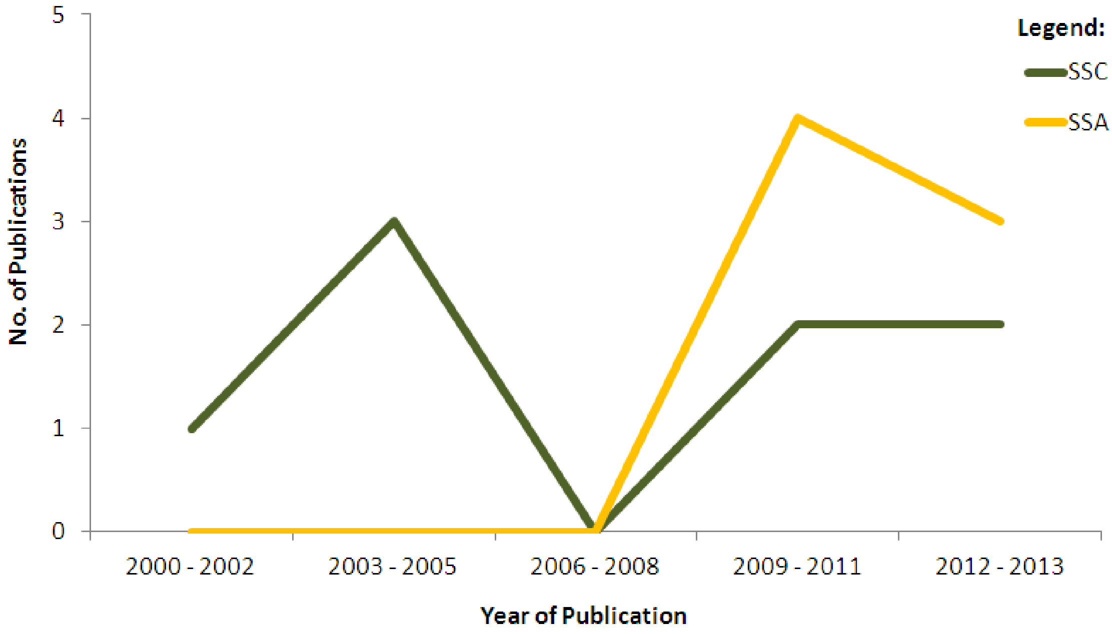


Figure 4.6: The trend in engaged research in SCC and SSA by 3-year intervals

4.5.4.2 Distributed vs. co-located environment

Figure 4.7 shows the trend in research on distributed and co-located environments. There was a continuous growth in research on both types of spatial collaborative environments. However, it shows that there was slightly more interest in distributed environments between 2006 and 2008, e.g. Germani et al. (2012), Ogi et al. (2003), Balakrishnan et al. (2010), Loll and Pinkwart (2013), Engelmann et al. (2009), Wu et al. (2013), Maceachren and Brewer (2004), and Abla et al. (2010). This was potentially due to the expansion of cloud computing services led by giant corporations such as Google TM and Microsoft TM.

Similarly, there was also a steady growth in research on co-located environments; for example, studies by McGrath et al. (2012), Grandhi et al. (2011), Bergstrom and Karahalios (2012), Haeyong et al. (2010), Bachour et al. (2010), Greenspan et al. (2000) and Thouvenin et al. (2005). The requirement for seamless interaction and integration across hardware devices was the likely key factor for research in this field. Research into both types of spatial environments has expanded and prospects for future research are promising.

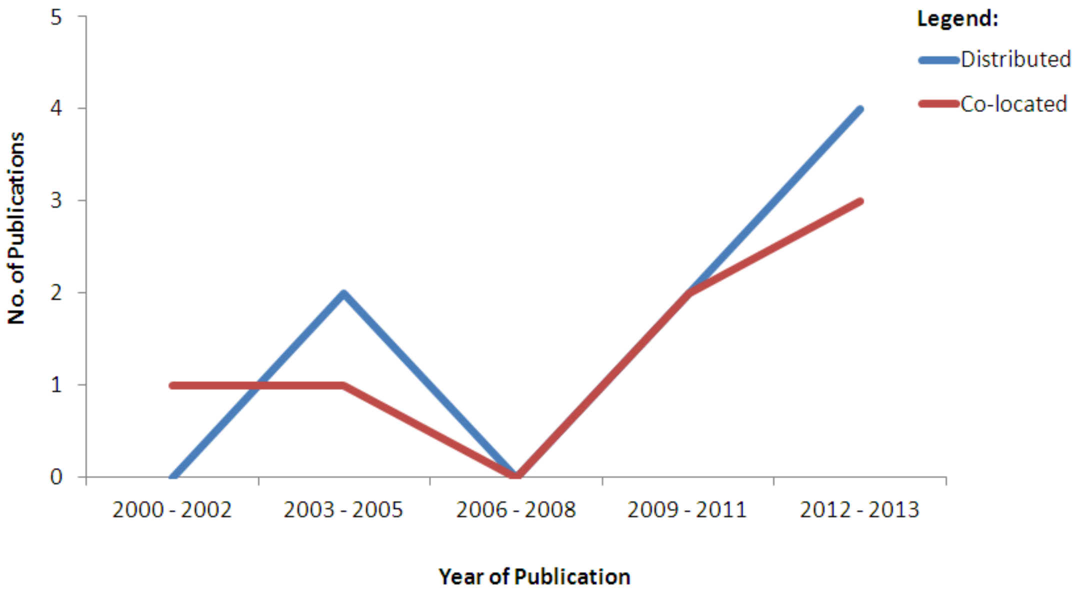


Figure 4.7: Trends in research on distributed and co-located environments

Similarly, researches in co-located as seen in McGrath, et al. (2012), Grandhi, et al. (2011), Bergstrom and Karahalios, (2012), Haeyong, et al. (2010), Bachour, et al., (2010), Greenspan, et al. (2000), and Thouvenin, et al. (2005) proved an equally emphasized in shared visualization study which has seen a growing steady. The needs of seamless interaction and integration in terms of hardware devices are probably inspired researchers to provide better solutions. These two types of spatial environments are simultaneously pursued to deepened competencies and expanded as a promising future research.

4.5.5 Research Question 2

RQ2: How are visualisation strategies applied in shared visualisation?

In this context, “visualisation strategy” refers to the methods used to achieve a SMM for users. Our analysis identified five types of visualisation strategies, which are presented below.

4.5.5.1 Shared visualization

Shared visualisation is a type of visualisation strategy used to visualise content, activity (e.g. a work process) or artefacts for multiple users. It can be used to increase team cohesiveness by providing unambiguous information to support a SMM (Swaab et al., 2002). It helps co-located working groups to communicate more effectively by externalising the communication process (DiMicco et al., 2007).

The use of a shared visualisation strategy has been demonstrated by Greenspan et al. (2000), Ogi et al. (2003), Wu et al. (2013) and Engelmann et al. (2009). In PhoneChannel, Greenspan et al. (2000) combined asymmetric visual data with symmetric audio data, which allowed PhoneChannel’s users to access the Internet on a digital-cable subscriber’s television as long as the two are connected; the TV user could view the data sent on a designated channel. The Remote Presentation System (Ogi et al., 2003) used a special tool called IVISOR to provide visualisation functions for flow data fields such as streamlining, particle tracing, contour lines, surface layer rendering, and creating animations that can be used in the shared virtual world. CIVIL (Wu et al., 2013) used maps as a medium for visualising a work process in order to enhance the awareness and sense-making abilities of groups. KIA (Engelmann et al., 2009) developed activity visualisation to aid information sharing, sense-making and decision-making in small emergency management teams consisting of domain experts.

4.5.5.2 Shared coordination

Shared coordination is a visualisation strategy used to coordinate two or more elements in shared visualisation for multiple users. It can be used to support implicit coordination, which is necessary for a team developing a SMM to improve task performance and enable interaction across social transparencies needed in a virtual collaborative work system (Lowry et al., 2013; Stuart et al., 2012).

The use of a shared coordination strategy has been demonstrated by Grandhi et al. (2011), Balakrishnan et al. (2010), Engelmann et al. (2009), Maceachren and Brewer (2004) and Wu et al. (2013).

In Telling Calls, Grandhi et al. (2011) implemented negotiated interaction commitment; this is a specific kind of coordination where two parties establish a shared understanding, which enables conversational engagement. Telling Calls was designed to allow both caller and receiver to review information sent or received, to provide common ground for coordination or reengagement; a call history feature was developed to store information sent or received in the same visualisation. In the Remote Collaborative System, Balakrishnan et al. (2010) used visualisation of shared annotations and hypotheses to overcome coordination costs and cognitive biases.

KIA (Engelmann et al., 2009) provided two coordination strategies based on verbal and nonverbal feedback as well as directory updating. Verbal or nonverbal feedback was used to support coordination of content and process in communications, whilst directory updating was used to support information allocation and retrieval coordination to improve team performance. Both coordination strategies aimed to establish common ground and transactive memory system dimensions. GeoVE (Maceachren and Brewer, 2004) supported coordination of perspectives, in particular cases of conflict using split screen views. In other words, GeoVE enabled users to understand what others were doing and used voice communication to discuss perspectives in a remote collaboration.

CIVIL (Wu et al., 2013) used coordinated maps and activity visualisation to aid decision-making as well as improve group activity awareness.

4.5.5.3 Shared multiple representation

Shared multiple representation is a visualisation strategy used to provide two or more coordinated representations in the form of a visualisation to multiple users. It can be used to support complex decision-making and analytical reasoning (Boshuizen et al., 2002; Cox, 1996).

Shared multiple representation strategies have been demonstrated by Germani et al. (2012), McGrath et al. (2012), Haeyong et al. (2010), Engelmann et al. (2009), Wu et al. (2013) and Abla et al. (2010).

Co-ENV (Germani et al., 2012) used integrated multiple collaborative functionality. A multidimensional viewpoint encompassing three collaborative tasks—job, team and cognitive performance enabled a design team to specify co-design activities and quantify each aspect of the collaboration. BEM (McGrath et al., 2012) removed decoupled work and placed it in private views on mobile devices such as smart phones or tablets, so that the collaborative view could be used exclusively for shared work. This allowed users to make a clear distinction between coupled and decoupled activity. The developers were able to address real-estate constraints related to managing private views on a shared display, and alleviate concerns about combining multiple private views in a shared view.

VizCept, (Haeyong et al., 2010) used a visual analytical tool called Jigsaw to provide multiple views to illustrate connections between automatically generated entities in multiple documents. This tool enabled interoperable views and changes in one view were seamlessly reflected in the other views. The multiple views feature allowed the user to explore connections between entities and documents within a data set. Haeyong and colleagues also designed the SIMILE timeline widget (2010). This tool visualises concepts as events on a timeline, with the document that connects them to the associated timepoint. Concepts that are associated with multiple documents appear in multiple locations in the visualisation. The SIMILE timeline widget also supported various collaborative features such as colour coding of concepts according to the user who identified them, along with variable thicknesses and labels for edges in the global concept map to express different users' interest in a particular semantic relationship. VizCept was also designed to allow multiple simultaneous messages and requests to be processed seamlessly without significant delay. Concepts, relationships and notes are sent back to the server, where they are combined to create a unified data source that is available to all users of the various views.

KIA (Engelmann et al., 2009) was a collaborative integration tool that supported collaborative learning using multiple external representations to enable simultaneous consideration of both individual and collaborative processes. Learners could assign multiple representations independent of one another, and the collaborative integration tool visualised knowledge awareness information for each learner. The tool displayed corresponding assignments for learners side-by-side and visualised information about group knowledge, such as which part of the learning material was covered by at least one group member.

CIVIL (Wu et al., 2013) used a multi-view and role-based approach to support personal and shared activities. This system used distinct views for role-specific and shared information to help team members selectively share role-specific or unique contentwith teammates. The system was able to limit the cognitive load on a team member whilst also offering a personal space for analyses. The personal (role-specific) and shared (team) map views served different purposes. The personal map view displayed role-specific information and allowed individuals to analyse data privately and explore various options before deciding what information and knowledge to share with others.

At team level, using different role-specific views at the same time enabled multiple team members to explore and analyse data in parallel, making collaboration more efficient. The team (shared) map, the view common to all team members, was used to display shared information and examine general relevant objects collectively. Information from personal (role-specific) workspaces could be transferred to the shared space, i.e. there was capacity to transfer information from role-specific maps to shared maps.

DIIII-D (Abla et al., 2010) was a centralised gateway for multiple software services, which provided researchers with a unified interface for multiple functions including experiment status monitoring, data analysis and communication needed during fusion experiments. The system offered a presentation tier that did not execute complex computations but simply filtered and displayed visual data in accordance with user requests. Multiple synchronous presentation methods were supported.

4.5.5.4 Shared mirroring display

Shared mirroring display is a visualisation strategy used to facilitate reflection by informing users what each member of the group has done. It provides an unbiased, third person, real-time visual perspective for multiple users. Shared mirroring display can be used to support computer-mediated collaboration and learning (Dehler, 2007), support interaction regulation in collaborative problem solving (Jermann and Dillenbourg, 2008) and small group collaboration (Reithmeier, 2013).

Shared mirroring has been demonstrated by Bachour et al. (2010) and Bergstrom and Karahalios (2012). Reflect (Bachour et al., 2010) used basic representations to display to users the actions they had taken, i.e. the amount of speech they had produced, without offering either advice or interpretation of the state of the interaction. The mirroring strategy was used simply to show users the current state of the conversation; it was up to them to decide what needed to be done. The system did not provide any judgment of the interaction, nor was it meant actively to promote a more balanced collaboration.

Conversation Clock (Bergstrom and Karahalios, 2012) used visualisation for an ongoing conversation in a shared surface. The Conversation Clock showed which member of the group was speaking at any given time and allowed users to access a snapshot of the conversation history every time they looked at the surface. The social mirror developed by Bergstrom and Karahalios (2012) introduced group dynamics and social computing into research on real-time visualisations. This pilot study showed that some people accepted some significantly distorted visualisation as an accurate representation of conversation.

4.5.5.5 Shared boundary objects

Shared boundary objects is a visualisation strategy used to enable integration of knowledge across boundaries for multiple users. It can be used to support creativity in a distributed collaborative design process involving groups belonging to different Communities of Practices (Zhu et al., 2011) and to achieve shared understanding through negotiation in heterogeneous problem solving (Koskinen and Mäkinen, 2009). Maceachren and Brewer (2004) used theories of boundary objects to develop a framework in which visual representation mediated group work. In GeoVE, visual displays for geocollaboration fulfilled several functions: shared objects to talk about: to depict selected information, provide geo context, and enable information integration; shared objects to think with: to develop, clarify and support structuring of arguments; and shared objects to coordinate perspectives and actions: to compare perspectives, related participants' knowledge domains, link perspectives across scales and enable joint activity.

These visual representations of geospatial information provided a display space where team members could share and integrate information, compare perspectives and negotiate approaches and solutions to problems. Maps and components of maps served as effective external representations of boundary objects. Table 4.4 provides a brief descriptive summary of visualisation strategies and systems.

Table 4.4: Types of visualization strategy, systems and their strategic descriptions (continued….)

Types of visualization strategies

Shared visualization: It is a type of visualization strategy undertaken by researcher to visualize the content, activity (i.e. work process)or artifacts to multiple users.

Author(s)	System Examples	Description
Greenspan, et al. (2000)	Phone Channel	- Audio-visual is shared among users
Ogi, et al. (2003)	Remote Presentation System	- Interactive visual interface of 3D are visualized and shared
Wu, et al. (2013)	CIVIL	- Work process and artifact are visualized and shared.
Engelmann, et al. (2009)	KIA	- Activity is visualized and shared

Shared coordination: It is a type of visualization strategy undertaken by researcher to coordinate two or more elements in a shared form of visualization to multiple users.

Author(s)	System Examples	Description
Wu, et al. (2013)	CIVIL	- Maps and activity visualization are coordinated to aid decision-making and group activity awareness.
Grandhi, et al. (2011)	Telling Calls	- Negotiating interaction commitment is applied to allow conversation engagement
Balakrishnan, et al. (2010)	Remote Collaborative System	- Visualizing annotations and hypotheses sharing are coordinated to overcome coordination costs and cognitive biases.
Engelmann, et al. (2009)	KIA	(1) grounding by verbal or nonverbal feedback is used to support coordination of content and process in communication (2) directory updating is used to support information allocation and retrieval coordination
Maceachren and Brewer (2004)	GeoVE	- Split screen views are used to support coordination of perspectives for a particular cases of conflict

Shared multiple representations: It is a type of visualization strategy undertaken by researcher to provide two or more coordinated representations in a form of visualization to multiple users.

Author(s)	System Examples	Description
Germani, et al. (2012)	Co-ENV	- A multiple viewpoint to enable the identification of co design activities typology
McGrath, et al. (2012)	BEM	- Users are allowed to make a clear distinction between coupled and decoupled activity, able to address real-estate constraints of private views on a shared display, and alleviate concerns of combining multiple private views on the shared view and quantify each aspect of the collaboration
Haeyong, et al. (2010)	VizCept	(1) Jigsaw allows a user to explore the various connections between entities and documents within the data set in a multiple view (2) SIMILE timeline widget allows concepts that are associated with the multiple documents to be appeared in multiple locations in the visualization
Engelmann, et al. (2009)	KIA	(3) Multiple simultaneous messages and requests are being processed seamlessly
Wu, et al. (2013)	CIVIL	- A collaborative integration tool that supports collaborative learning with multiple external representations which provides a simultaneous consideration of both individual and collaborative processes.
Abla, et al. (2010)	DIIII-D	- Multi-view and role-based design to support personal and shared activities - Multiple software services to provide researchers with a unified interface which can be supported synchronously.

Shared mirroring display: It is a type of visualization strategy undertaken by researcher to provide an unbiased and third person real-time perspective of visual information to multiple users.

Author(s)	System Examples	Description
Bachour, Kaplan and Dillenbourg (2010)	Reflect	- It is used to simply show the users a reflection of their current state of the conversation, and allows no judgment to the quality of the interaction.
Bergstrom and Karahalios (2012)	Conversation Clock	- It allows the users to get a snapshot of the conversation history every time it is projected onto some shared surface.

Shared boundary objects: It is a type of visualization strategy undertaken by researcher to enable integration of knowledge across boundaries to multiple users.

Author(s)	System Examples	Description
Maceachren and Brewer (2004)	GeoVE	Maps and components of maps are served as effective external representations of boundary objects in which its visual representation acts as a mediator of group work. The visual displays for geocollaboration provide the functionalities to shared objects to talk about, shared objects to think with, and shared objects to coordinate perspectives and actions

4.5.6 Research Question 3

RQ3: What and how is the visualisation technique used in shared visualisation?

In this context, a visualisation technique refers to visualisation tools used to provide shared visualisation in order to achieve a SMM among users. Our analysis of the reviewed studies identified four types of visualisation techniques.

4.5.6.1 Collaborative annotation

Collaborative annotation is the practice and method of creating and managing metadata collaboratively to annotate and categorise content; it is a feature of many Web 2.0 services where it is also known as “social tagging” (Kim and Kwon, 2009). It can be used to support collaborative analysis of digital video in distributed groups (Ploetzner et al., 2005), open-ended discourse with transparent groupware (Miettinen et al., 2006) or merely used to share, classify and elaborate documents (Lortal et al., 2006).

In this study, we explore collaborative annotation strategies used by Germani et al. (2012), Thouvenin et al. (2005) and Wu et al. (2013).

CO-ENV (Germani et al., 2012) used annotation in the collaborative phase of an advanced conceptual design task to support evaluation of individual contributions of the design team and decisions about future work. Users could be supported bidirectionally and actively with collaborative meeting tools.

MATRICS (Thouvenin et al., 2005) applied the shared annotations technique in a virtual environment that allowed direct interaction with remote 3D objects within the virtual model, knowledge integration and management in design tasks and collaboration or cooperation around the objects. The 3D annotation options could be used to provide a contextualised comment in the 3D space.

CIVIL (Wu et al., 2013) developed three types of annotation tools: annotation sorting table, annotation aggregation chart and annotation timelines chart. These annotation tools were used to cluster and aggregate information. Users could integrate relevant information from different sources as well as cluster and aggregate inputs from individuals, in order to review and analyse information.

4.5.6.2 Collaborative concept mapping

Concept mapping is a technique developed in the 1960s by Professor J.D. Novak from Cornell University to represent knowledge graphically. In concept mapping, a graph consists of a number of nodes and links. The nodes represent concepts and the links represent the relationships among the different concepts (Novak and Gowin, 1984). Concept mapping has been used in knowledge representation as well as teaching and learning applications due to its effectiveness in externalising thoughts in the form of concepts and relationships. In this context, collaborative concept mapping can be described as a technical process in which two or more users engage in collaborative or developmental activities where knowledge is represented as graphs, nodes and links in a shared visualisation.

Collaborative concept mapping has proven its ability to support learning (Simone et al., 2001), construction of group memories (Hoppe and Garner, 2002) and management of conflict (Chiu, 2004).

In this study, we describe studies of collaborative concept mapping by Haeyong et al. (2010) and Engelmann et al. (2009).

VizCept (Haeyong et al., 2010) applied concept mapping in one of three views available in the system, the concept map view. The concept map view displayed the union of all the concepts and relationships that individual users had discovered in personal workspaces. In this shared view, users could keep track of concepts added by other users and progressively make connections between them to make sense of the relationships. The nodes in the visualisation represented entities such as names, locations, objects and concepts; relationships were represented as directed edges labelled descriptively. The node colour indicated which user had originated the concept.

Multiple relationships between pairs of entities could be represented: edge thickness was increased when multiple relationships were added to the same concept pair by different analysts. The concept map view allowed analysts to share the visualisation among themselves; it helped to generate new insights and hypotheses by tracking valuable information and could also be used to help reach a conclusion. Various interaction methods, such as panning and zooming, and manual or automatic reorganisation of the layout of the map, were supported by the concept map view to help analysts explore the visualisation.

In KIA, Engelmann et al. (2009) used digital concept maps together with Cmap Tools, which were advanced digital concept mapping tools developed by the Florida Institute of Human and Machine Cognition (USA); these tools represent the underlying conceptual knowledge for each medium and allow direct interactive access to specific information. This digital concept mapping tool promotes knowledge and information awareness by allowing participants to create personal digital concept maps containing personal domain knowledge and personal information resources associated with this knowledge. This tool provides a group member with the information about the knowledge structures of other collaborators and the information resources underlying these knowledge structures.

In the KIA application, the collaborating partners' digital concept maps were arranged next to one another so that participants could compare the knowledge structures of their collaborators. Since their personal digital concept map was also included in the arrangement, it was easy to compare personal knowledge with the knowledge structures of others. Concept maps are well suited to support such comparisons because there are very strict rules governing the creation of a concept map; for example, nodes represent the concepts and links between the relationships.

4.5.6.3 Collaborative discussion board

Discussion board is a term used to describe a centre for readers to focus upon the users of information. Nowadays a discussion board is used primarily as a forum for communicating with members of a group or an online community, or to seek assistance and support from such a group or online community (Harman and Koohang, 2005). An online discussion board or online threaded discussion board is characterised by asynchronous interaction in which multiple users achieve their consensual group responses. Collaborative discussion boards can be used to support distance learning and education for people with disabilities (Myhill et al., 2007) and virtual collaborative research communities (Shih et al., 2010).

In this study, we look at collaborative discussion applications developed by Balakrishnan, et al. (2010), Engelmann et al. (2009) and Wu et al. (2013)

The Remote Collaborative System (Balakrishnan et al., 2010) used flagged discussion as a visualisation technique to help individuals to spot anomalies and perceive patterns, increase the efficiency of information retrieval tasks and data analysis, promote feelings of community and foster discussion.

KIA (Engelmann et al., 2009) used group discussion to enable the exchange of unshared information intended for collaborative problem solving among group members. In KIA, the recognition of unshared information is important because of the close arrangement of the collaborators' concept maps and the opportunity this offers for comparison. Using the group discussion technique to exchange information can help group members determine whether information has been shared among group members, which affects the coordinated sampling of information.

CIVIL (Wu et al., 2013) used a chat tool to support knowledge sharing. The chat tool was seen as useful for discussion and clarification, comparison and analysis, and getting a rapid response. Users could express personal perspectives or opinions, and these were related to objects on maps. The chat tool was also able to make individual information reviewable for future discussions; users could record information, take notes on ideas, compare the advantages and disadvantages of specific options in discussions and add comments on spatial objects.

4.5.6.4 Collaborative geographical map

A geographical map can be defined as an image of an area that represents features of the landscape such as cities and roads. A collaborative geographical map can be defined as a technique of visual representation that allows multiple users to collaborate, develop or engage in activities related to the representation of knowledge as an image that depicts the features of a landscape. Collaborative geographical map can be used to support exploration and interpretation in visual data mapping (Moere, 2007).

In this study, we look at studies of collaborative geographical map by McGrath et al. (2012), Wu et al. (2013) as well as Maceachren and Brewer (2004).

In BEM, McGrath et al. (2012) applied geographical maps in a shared visual representation called BEMViewer. BEMViewer is a tool for collaborative visual search that can be panned and zoomed on desktop displays and tablets using multi-touch gestures such as pinch and drag. Data visualised on the BEMViewer is represented as a multidimensional dataset in which two of the dimensions specify geospatial position using longitude and latitude. These dimensions are used to plot each item in the dataset on the map.

CIVIL (Wu et al., 2013) used geographical maps to explore and focus on geographic locations to develop a good emergency management plan. The data exploration activities, which could be conducted using the maps, were an effective means of organising geospatial data to support bottom-up, i.e. data-driven activities. Users could coordinate team activities using multiple, role-based views in which each group member used two maps for data exploration. One map was used for personal analysis of role-specific data and the other map was a shared map used by the team to share information and build a group plan.

GeoVE (Maceachren and Brewer, 2004) used geographical maps as part of a distributed map-based data exploration and analysis system designed to support representation and analysis of participants and their actions. The distributed map-based data exploration and analysis system was designed to track the use of a multi-window geo-visualisation display, including for example a map, scatter plot and parallel coordinate plot, used in knowledge construction activities. The distributed map-based system supported four types of collaborative knowledge construction: collaborative exploration (brainstorming), collaborative analysis (mediation), collaborative synthesis (e.g. the development of a common perspective) and collaborative representation (e.g. representation of temporal and spatial information).

Table 4.5 provides a brief summary of visualisation techniques and systems along with their technical implementation.

Table 4.5: Types of visualization techniques, systems and their technique implementation

Types of visualization techniques		
Collaborative annotation: It is a type of visualization technique that allow multiple users to collaboratively creating and managing metadata in order to annotate and categorize content		
Author(s)	System Examples	Description
Germani, et al. (2012)	CO-ENV	- Annotation is applied in the phase of collaborate conceptual design and advanced design task in order to support individual work evaluation inside the design team and decisions for future work.
Thouvenin, et al. (2005)	MATRICS	- Annotation is applied in a virtual environment that can allow the use of 3D annotation specificities in order to provide a comment contextualized in the 3D space.
Wu, et al. (2013)	CIVIL	- Annotation is applied in annotation sorting table, annotation aggregation chart and annotation timelines chart in order to cluster and aggregate information contents.
Collaborative concept mapping: It is a type of visualization technique that allow multiple users to engage in collaborating, developing or engaging activities that involved with representation of knowledge constitutes of graph, nodes and link.		
Author(s)	System Examples	Description
Haeyong, et al. (2010)	VisCept	- Concept mapping is applied in the Concept map view which displays the union of all the concepts and relationships that each user has discovered in their own workspace. Using Concept map view, the analysts can share the visualization among themselves in order to generate new insights and hypotheses by helping to track valuable information, and aid in reaching a conclusion
Engelmann, et al. (2009)	KIA	-Concept mapping is applied by means of digital concept map which is being realized with Cmap Tools ("Cmap Tools,"). Using the Cmap Tool, the group

		member is provided with the knowledge structures of the other collaborators and the information resources underlying these knowledge structures. The collaboration partners' digital concept maps that are arranged next to each other enable the participant to compare the knowledge structures of their collaborators.

Collaborative discussion board: It is a type of visualization technique that allows multiple users to communicate with members of a group or an online community, to seek assistance and support from that group or online community in an asynchronous interaction.

Author(s)	System Examples	Description
Balakrishnan, et al. (2010)	A Remote Collaborative System	- Discussion flagged is applied as the visualization technique in order to help individual's spot anomalies and perceive patterns, increase the efficiency of information retrieval tasks, data analysis, promote feelings of community and foster discussion.
Engelmann, et al. (2009)	KIA	- Group discussion is applied in order to exchange the unshared information among the group members intended for collaborative problem solving.
Wu, et al. (2013)	CIVIL	- A chat tool is applied to support the knowledge-sharing process. The chat tool was seen as useful for discussion and clarification, comparing and analyzing, and getting a response quickly.

Collaborative geographical map: It is a type of visualization technique that allows multiple users in collaborating, developing or engaging activities that involved with representation of knowledge constitutes of image that portrays the natural features of the land.

Author(s)	System Examples	Description
McGrath, et al. (2012)	BEM	- Geographical map is applied in a collaborative visual search called as the BEMViewer which can be panned and zoomed on the tabletop display and the tablets using multi-touch gestures such as pinch and drag.
Wu, et al. (2013)	CIVIL	- Geographical map is applied in exploring and focusing geographic locations to support bottom-up or data-driven activities. Users are able to coordinate

		team using multiple, role-based views where each group member used two maps for data exploration.
Maceachren and Brewer (2004)	GeoVE	- Geographical map is applied in a distributed map-based data exploration and analysis system which is designed to support representation and analysisof participants and their actions. It supports four kinds of collaboration tasks for the purpose of knowledge construction; collaborative explore (for brainstorming), collaborative analyse (for mediator), collaborative synthesize (to develop common perspective), and collaborative present (to represent temporal and spatial information).

4.5.7 Research Question 4

RQ4: Which technology is used in shared visualisation?

In this context, the technology is the system applications and technologies used to design and develop the model, framework or systems of shared visualisation. We found that most reports did not provide details of specific technological implementation, e.g. MATRICS (Thouvenin, et al., 2005), Remote Presentation System (Ogi et al., 2003), GeoVE (Maceachren and Brewer, 2004), Phone Channel (Greenspan et al., 2000). This limitation made analysis of this aspect of shared visualisation research problematic. Some reports did not provide a technological description because of their methodological approach and presentation; these include research using structured methods, e.g. CO-ENV (Germani et al., 2012), BEM (McGrath et al., 2012), Reflect (Bachour et al., 2010), and KIA (Engelmann, et al., 2009); and experimental studies, e.g. Conversation Clock (Bergstrom and Karahalios, 2012), and Remote Collaborative System (Balakrishnan et al., 2010). In the remaining papers, the technological implementation was either well described or could be determined indirectly; these studies are focused on in this section. We identified two kinds of technological implementation.

4.5.7.1 Mobile-based application system

Few researchers implemented shared visualisation in a mobile-based application environment. Studies that did use a mobile environment include Phone Channel (Greenspan et al., 2000) and Telling Calls (Grandhi et al., 2011). The technological implementation was reported only for the Telling Calls project (Grandhi et al., 2011), which used the AT&T Tilt Smartphone running Windows Mobile 6.

4.5.7.2 Web-based application systems

Most of the shared visualisations were designed and developed with web-based tools or systems. We found four papers in which a well-defined technological description is available: Haeyong et al. (2010), Wu et al. (2013), Loll and Pinkwart (2013) and Abla et al. (2010). The technological implementation of these systems is presented below.

In VizCept, an interactive concept map is implemented as a Java Applet using the Prefuse toolkit; data exchange between the client and the server is supported using files in the Java Script Object Notation (JSON) format. The concept map view supports various interaction methods, including panning, zooming, and node drag and drop from the VizCept's backend server in a real-time environment, so the underlying data for concept maps are communicated using GraphML and XML. GraphML is used to support special graph features such as coloured nodes and variable edge thicknesses. Finally, SIMILE and the timeline visualisation are implemented with JavaScript API. When the timeline view is refreshed, it contacts the server, which generates an XML file based on the current state of the system. Filtering and highlighting of events is done on the client side by reading the Document Object Model object and updating it from events in the timeline.

CIVIL was developed using Java to support a more broadly distributed collaboration. CIVIL used two tools: the CORK and Geo-tools. CORK, which stands for content object replication kit, can support the replication and manipulation of shared objects in synchronous and asynchronous collaboration. Geo-tools were used in CIVIL for the organisation and manipulation of geospatial data, which are available at (http://www.geotools.org/). The maps in CIVIL were developed with GeoTools, an open-source Java library for the organisation and manipulation of geospatial data. The storage layer at the bottom has a MySQL server to store user action and session data and a file server to store other data, such as recorded audio in collaboration sessions. The client side used a web-based, rich Internet application (RIA) developed with Adobe Flex. The synchronisation and audio and video modules in the application server were built in Adobe BlazeDS; meanwhile, other server modules were developed with Java running on a Tomcat Web server. CIVIL was also implemented on a cloud-computing service using Google Maps as the external map service.

LASAD was developed using Java, and the web-based communication interfaces were implemented using Java Remote Method Invocation to support different kinds of cooperation in the server layer. XML definition was used to specify the configuration of ontology elements in the LASAD system.

DIIII-D web portal was developed using AJAX technology to support efficient observation and server-side recording of all changes made on the client side. In addition, it also supported multiple presentation methods in synchronous operation. In the presentation layer, requests sent to the logic tier were described using HTTP/HTTPS requests. The Logic tier was implemented using Django, a python-based web framework. The web portal was developed using Memcached, a high performance, distributed memory object caching system that can speed up dynamic web applications by alleviating database load.

Table 4.6 summarises the mobile-based and web-based shared visualisation systems.

Table 4.6: Summary of technological implementation in mobile-based and web-based systems

System environment		Name of System	R&D Group	Key Features	Implementation Technologies
	Mobile-based	Telling Calls	(Grandhi, et al., 2011)	A mobile application which allows users to receive calls that display not only the standard Caller ID information, but also the caller generated information.	AT&T Tilt Smartphone running on Windows Mobile 6.
	Web-based	CIVIL	(Wu, Convertino, Ganoe, Carroll, & Zhang, 2013)	A multi-view, role-based design system that provides visualization tools to facilitate information sharing, sense-making and decision-making in small emergency management teams that consist of domain experts. It helps team members analyze geo-spatialinformation, share, integrate critical information and monitor individual activities	CORK, Geo-tools, MySQL, Adobe Flex, Adobe BlazeDS
		VisCept	(Haeyong, et al., 2010),	A web-based visual analytics system, designed to support fluid and collaborative analysis of large textual intelligence datasetsfor synchronous collaborative construction and use of visualizations in intelligence data analysis.	Java, Graph XML
		LASAD	(Loll & Pinkwart, 2013)	A flexible framework that can be configured with respect to collaboration mode and visual argument representation	Java, XML
		DIIII-D webportal	(Abla, et al., 2010).	A web portal that can provide multiple services, such as real-time experiment status monitoring, diagnostic data access and interactive data visualization.	AJAX, XML, HTML, Django, and Memcached

4.5.8 Discussion

This section describes the implications of our analysis in terms of the four specific research questions. The identification of different visualisation strategies and techniques for shared visualisation applications has implications for the design shared visualisation-based systems. We identified three kinds of support provided by shared visualisation applications and provide guidelines for future researchers seeking to design shared visualisation systems.

4.5.8.1 Social, task and cognitive supports

All the strategies and techniques identified were capable of providing three types of support: social, task and cognitive. Interestingly, projects that used multiple strategies and techniques were able to provide all the three kinds of support, e.g. KIA (Engelmann et al., 2009), CIVIL (Wu et al., 2013) and GeoVE (Maceachren and Brewer, 2004). On the other hand, projects that used a single strategy or technique offered only one kind of support, e.g. MATRICS (Thouvenin et al., 2005), Remote Presentation System (Ogi et al., 2003), Conversation Clock (Bergstrom and Karahalios, 2012) and DIIII-D web portal (Abla et al., 2010). Other projects that utilised one strategy and one technique, e.g. CO-ENV (Germani et al., 2012), and VizCept (Haeyong et al., 2010) offered two kinds of support, a somewhat surprising finding. However, these findings warrant additional research and confirmation of their possible implications for the design of shared visualisation-based systems. Table 4.7 shows the kinds of support provided by the systems.

Table 4.7: Social, task and cognitive supports in shared visualization

		RQ2	RQ3	Three kinds of support		
No	Researchers	Strategies	Techniques	Social	Task	Cognitive
1	CO-ENV - Germani, et al. (2012)	Shared multiple representations	Collaborative annotation	*NA*	Yes	Yes
2	BEM -McGrath, et al. (2012)	Shared multiple representations	Collaborative geographical map	*NA*	Yes	*NA*
3	Reflect - Bachour, et al. (2010)	Shared mirroring display	*None*	*NA*	Yes	Yes
4	VisCept - Haeyong, et al. 2010)	Shared multiple representations	Collaborative concept mapping	Yes	Yes	*NA*
5	MATRICS - Thouvenin, et al. (2005)	*None*	Collaborative annotation	*NA*	Yes	*NA*
6	A Remote Presentation System - Ogi, et al. (2003)	Shared visualization	*None*	*NA*	Yes	*NA*
7	Telling Calls - Grandhi, et al. (2011)	Shared coordination	*None*	Yes	Yes	*NA*
8	A Remote Collaborative System - Balakrishnan, et al. (2010)	Shared coordination	Collaborative discussion board	Yes	Yes	Yes
9	Phone Channel - Greenspan, et al. (2000)	Shared visualization	*None*	Yes	Yes	Yes
10	LASAD -Loll & Pinkwart (2013)	*None*	*None*	*NA*	Yes	*NA*
11	KIA - Engelmann, et al. (2009)	Shared visualization, Shared coordination, Shared multiple representations	Collaborative concept mapping, Collaborative discussion board	Yes	Yes	Yes
12	Conversation Clock - Bergstrom & Karahalios (2012)	Shared mirroring display	*None*	Yes	*NA*	*NA*
13	CIVIL - Wu, et al. (2013)	Shared visualization, Shared coordination, Shared multiple representations	Collaborative annotation, Collaborative discussion board, Collaborative geographical map	Yes	Yes	Yes
14	GeoVE - Maceachren & Brewer (2004)	Shared coordination, Shared boundary objects	Collaborative geographical map	Yes	Yes	Yes
15	DIIII-D webportal - Abla, et al. (2010)	Shared multiple representations	*None*	*NA*	Yes	*NA*

4.5.8.2 Designing shared visualization-based systems

This review is intended to provide guidelines for future researchers seeking to design shared visualization-based systems. Figure 4.8 shows the identified strategies and techniques that can be used in designing a shared visualization-based system, while Figure 4.9 and Figure 4.10 show the strategies and techniques that can be used specifically in socially shared cognitive systems and shared situation awareness systems, consecutively.

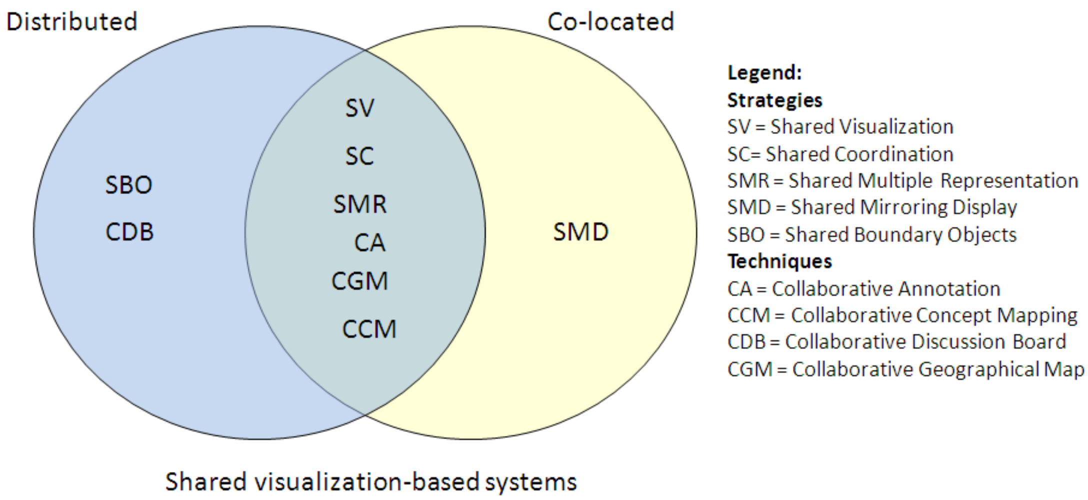


Figure 4.8: Identified strategies and techniques to design shared visualization-based systems

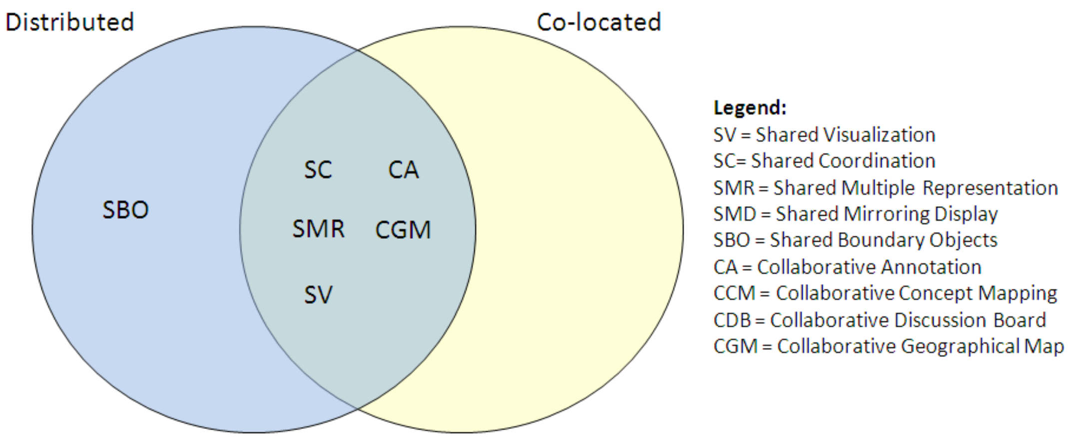


Figure 4.9: Socially shared cognitive systems: strategies and techniques

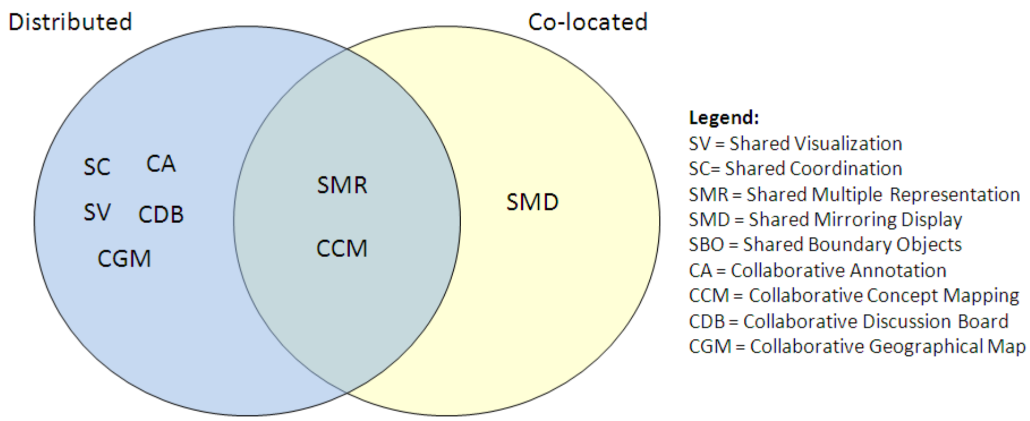


Figure 4.10: Shared situation awareness systems: strategies and techniques

Based on the projects reviewed in this study, some guidelines are proposed for the development of strategies for shared visualisation, which may be beneficial to researchers interested in shared visualisations used in system design and development. These include guidelines on multiple views (Baldonado et al., 2000), multiple representation (Ainsworth, 1999), boundary objects (Fischer, 2001) and cognitive perspectives on annotation (Boujut, 2003). Table 4.8 provides a brief summary of the strategies, techniques and technologies applied in the fifteen systems we investigated.

This study presents a systematic review of shared visualisation that investigates strategies and techniques in shared visualisation to achieve common ground or shared cognition. The aim is to identify the implications of different visualisation strategies and techniques of shared visualisation applications together with how they can be applied in designing CoVis systems.

In achieving common ground among the design team members, five visualisation strategies applied in CoVis systems have been identified: shared visualisation, shared coordination, shared multiple representations, shared mirroring displays and shared boundary objects. These strategies represent the ways that have been implemented by researchers in order to process data sharing and knowledge to arrive at the desired level of understanding. However, further studies are needed to investigate how these strategies can be effective to support CoVis with a visualisation system pertaining to the three levels of engagement teams in viewing, interacting/exploring and sharing/creating as per outlined by Isenberg, et al. (2011).

Table 4.8: Summary of strategies, techniques and technologies

No	System	Researchers	Categories of Paper	RQ1 Approaches	RQ1 Spatial	RQ2 Strategies	RQ3 Techniques	RQ4 Technologies
1	CO-ENV	Germani, et al. (2012)	Development + evaluation	SSC	Distributed	Shared multiple representations	Collaborative annotation	*Unspecified*
2	BEM	McGrath, et al. (2012)	Development + evaluation	SSC	Co-located	Shared multiple representations	Collaborative geographical map	*Unspecified*
3	Reflect	Bachour, et al. (2010)	Development + evaluation	SSA	Co-located	Shared mirroring display	*None*	*Unspecified*
4	VisCept	Haeyong, et al. (2010)	Development + evaluation	SSA	Co-located	Shared multiple representations	Collaborative concept mapping	Web-based
5	MATRICS	Thouvenin, et al. (2005)	Development + evaluation	SSC	Co-located	*None*	Collaborative annotation	*Unspecified*
6	A Remote Presentation System	Ogi, et al. 2003)	Development + evaluation	SSC	Distributed	Shared visualization	*None*	*Unspecified*
7	Telling Calls	Grandhi, et al.(2011)	Solution proposal	SSC	Co-located	Shared coordination	*None*	Mobile-based
8	A Remote Collaborative System	Balakrishnan, et al. (2010)	Solution proposal	SSA	Distributed	Shared coordination	Collaborative discussion board	*Unspecified*
9	Phone Channel	Greenspan, et al. (2000)	Solution proposal	SSC	Co-located	Shared visualization	*None*	*Unspecified*
10	LASAD	Loll and Pinkwart,(2013)	Development + evaluation	SSA	Distributed	*None*	*None*	Web-based
11	KIA	Engelmann, et al. (2009)	Solution proposal	SSA	Distributed	Shared visualization, Shared coordination, Shared multiple representations	Collaborative concept mapping, Collaborative discussion board	*Unspecified*
12	Conversation Clock	Bergstrom and Karahalios(2012)	Solution proposal	SSA	Co-located	Shared mirroring display	*None*	*Unspecified*
13	CIVIL	Wu, et al. (2013)	Development + evaluation	SSA	Distributed	Shared visualization, Shared coordination, Shared multiple representations	Collaborative annotation, Collaborative discussion board, Collaborative geographical map	Web-based
14	GeoVE	Maceachren and Brewer (2004)	Development + evaluation	SSC	Distributed	Shared coordination, Shared boundary objects	Collaborative geographical map	*Unspecified*
15	DIIII-D webportal	Abla, et al. (2010)	Solution proposal	SSC	Distributed	Shared multiple representations	*None*	Web-based

On the other hand, we have also identified four visualisation techniques, which include collaborative annotation, collaborative concept mapping, collaborative discussion board and collaborative geographical map. All of these initiatives show how shared cognition is made possible through the shared use of computer support, or systems through the contribution of joint information processing activities. However, these techniques only represent the application used in designing tools for mediating data or knowledge among the users involved. More techniques should be considered to address specific challenges in CoVis research pertaining to reaching common ground among group members, as addressed by Isenberg, et al. (2011); for instance, the aspects of task that can provide collaborative activity centric or cognitive aspects that can support collaborative foraging and collaborative sense making.

Besides, we can also see that the shared visualisation implementation on mobile-based system environments have received very little attention compared with the web-based systems. With the advent of mobile data visualisation, we suggest that some research areas can be explored in integrating rich interactive data visualisation for Android, iOS and Blackberry technologies; this function can support users in carrying out 3-D visualisation tasks or provide effective means in supporting collaborative work.

In summary, we have discovered three kinds of support through the findings of shared visualisation strategies and techniques; in specific, the social, task and cognitive elements need more investigation for further confirmation and validation. In addition, we have proposed a guide on the selection of strategies and techniques in the design and development of socially shared cognitive systems or shared situation awareness systems for both distributed and co-located CoVis environments.

4.6 Summary

This chapter reviews the theoretical concepts of SMM, evaluations in SMM and significant of shared visualization for SMM. In addition, this chapter presents a systematic review study of shared visualization which has led to some significant findings of strategies and techniques for designing shared visualization-based systems. From the discussion of the literatures, some information has been synthesized and concluded as follows:

- Theoretically, SMM is defined under SSC; however the model has also demonstrated the elements of shared awareness. Therefore, the SMM of ID and SME can be described as to support both SSC and SSA.
- In this research context, Badke-Schaub, Neumann, Lauche and Mohammed (2007)'s framework of SMM in design teams provide useful guide for determining the SMM of ID and SME. Based on this framework, ID and SME posses their own elements of knowledge and/or needs which lead to the development of individual mental model. Consequently, SMM develops when they exchange the aspects of process and task individual models with each other.
- The term "shared cognitive user task" refers to the process and tasks aspects of SMM in ID and SME. It defines shared cognition that belonged to the specific tasks in eLearning storyboard that are important to the intended users i.e. ID and SME. Consequently, it also covers the shared cognition of the process when performing those specific tasks in eLearning storyboard.
- Specific evaluation and analysis is used for investigation and evaluation studies in SMM. For investigation study, the study takes the expertise study approach in CTA. In evaluation study, SMM is measured using interactively elicited cause mapping technique which involves elicitation and representation of emergence.

- Aspects of TMM, similarity and accuracy properties are used as the elements in evaluation study. This evaluation study evaluates these elements based on the degree of agreement that they achieve based on the design contents produced by applying similar techniques in the eSCOUT.
- Role of artifact to display cognitive emergence in form visualization is important in developing SMM. As such, the cognitive data process of SMM using the role of artifact has been designed as follows:
  a) Cognitive Data Acquisition is the input process to identify internal cognitive artifact that represents the data from knowledge and needs of users.
  b) Cognitive Data Process refers to how that internal cognitive artifacts being processed.
  c) Cognitive Data Emergence is the output process which displays the emergence of that cognitive data in a form of visualization. It can be referred as the Visser (2006)'s symbolic form of external cognitive artifact.
- There are four aspects of interaction that users can perform in shared visualization systems; joining/leaving, floor control, privacy, and global view
- Five strategies and four techniques have been identified from the review study. The analysis has led to the guidelines on designing shared visualization-based systems using appropriate strategies and techniques. In this research context, shared visualization strategies and techniques which have been identified in SSC as well as in SSA can be used in formulating the eSCOUT framework.

Figure 4.11 shows achievement of research questions, summary of all the literature review chapters (i.e. chapter 2, 3, 4) and connection with chapter 5.

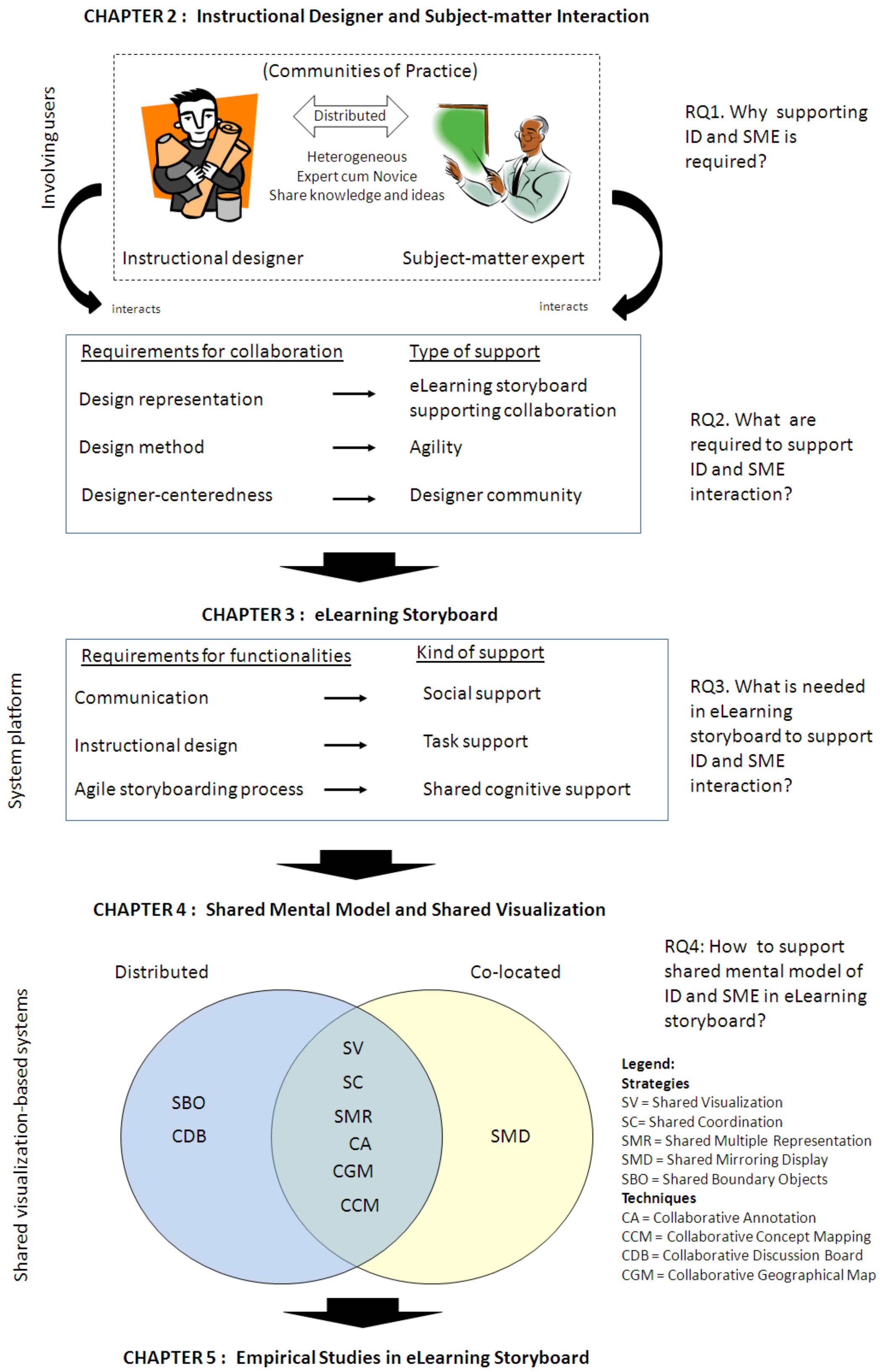


Figure 4.11: Achievement of research questions and connection from the three literature chapters to chapter 5

CHAPTER 5 EMPIRICAL STUDIES IN ELEARNING STORYBOARD

This chapter is conducted to complete research objective number one. It presents two empirical studies in eLearning storyboards. First study is conducted with a group of IDs to investigate the cognitive difficulties associate with the task in eLearning storyboard. Second study is conducted with three paired design teams consist of IDs and SMEs who are brought in from different academic background and subject-matter expertise, to investigate the form of shared visualization that are externalized from the task of designing eLearning storyboard.

The purposes of these two empirical studies are two-folds:

a) To identify the cognitive tasks difficulties and expert skills required in eLearning storyboard.

b) To identify internal cognitive artifacts acquired and how they need to be visually represented in eLearning storyboard.

These empirical studies are meant to recognize some important issues in eLearning storyboards, in relations to the support for shared cognitive user task. Summary of the empirical studies is discussed.

5.1 Empirical Study 1: Investigation on Cognitive Task Difficulties

Cognitive task analysis has notable role for examining design process (Nekvinda, 2011). As described earlier in Chapter 1, ID can be referred to an expert in eLearning storyboarding, who has richer mental model, more proficient which enable him/her to notice cues and patterns or difficulties than novice (i.e. the SME), which explains the needs to explore SME's challenges and errors in the design and process of eLearning storyboard can be investigated by probing into ID's knowledge.

Using an Applied Cognitive Task Analysis Technique (ACTA) (Militello & Hutton, 2000), this study investigates the task difficulties in eLearning storyboards through the exploration of experts' knowledge, i.e. the IDs. The objective of the study is to identify which types of cognitive tasks are required for the eLearning storyboard. The study also investigates SMEs' challenges and errors in the design and the process of eLearning.

The investigation study is organized as follows. It begins with methodology, which describes the background of participants, the design and procedures of the ACTA technique applied in this study, the instruments supplies and time line planning. The next section presents the data findings and the final section provides some discussions and recommendations.

5.1.1 Research Methodology

This section describes the participants involved in this research, cognitive task analysis and its technique, the research procedures, design, instruments and timeline planning.

5.1.1.1 Participants

In this research, expertise is identified by using the expertise framework of Farrington-Darby and Wilson (2006). As suggested by the framework, the selected experts are the main operators of the eLearning storyboard. They are identified as designers who work at the Multimedia Production Unit (MPU) in Multimedia University (MMU). MMU is chosen because it is the earliest higher educational institution in Malaysia that initiates customization of its own an internally developed eLearning content (Raja Maznah, 2004). This university has its own in-house department called as the Multimedia Production Unit (MPU) (Low, Low, & Koo, 2003). Since its establishment in 2000, one of its achievements is the development of Multimedia Learning System (MMLS) which has gained many international recognitions, such as Asia Pacific Multimedia Super Corridor Information Technology and Telecommunications Awards (APMITTA) 2000, Asia Pacific Information Technology and Communications Awards (APICTA) 2001, Merit Award for APICTA 2003 and Smart Community International Network (SCIN) Best Practice Award 2004 as well as the Winner for the Best of Smart Learning Applications and Best of Education Applications[9]. The participants in this study have designed many eLearning storyboards specifically for MMLS development as well as involvement in eLearning projects for clients such as Telekom Malaysia (TM)[10] and Majlis Amanah Rakyat (MARA)[11]. As such, they can be regarded as the experts in eLearning storyboard design. Table 5.1 shows the profile of these participants.

[9] https://www.mmu.edu.my/index.php?req=d13&id=760
[10] https://www.tm.com.my/Pages/Home.aspx
[11] http://www.mara.gov.my/

Table 5.1: Instructional designers' profile

Profile / participant #	1	2	3
Age	33	29	29
Storyboarding experience	10	5	2
No of project involvements	7	3	4
Position (s) / role (s)	Instructional designer, Multimedia designer	Instructional designer, Multimedia designer	Instructional designer, Project leader
Soft skills*	F, I, P, Cool, DW, SF, RE, M,	WebD, MMProg, Anima	MMProg, SB
Software application in storyboard*	PPT, Word	PPT, Word, AdoP, MacrF, DW, AdoI, SF, Cool	PPT, Word, Rapv, AdoP, MacrF, DW, AdoI
Formal education	Computer Science (Multimedia)	Degree in Digital Multimedia	Degree in Multimedia (pursuing MSc. in ELearning)
Certification	ID certified	Flash script 2.0	ID certified

* Note:
Soft skills:
F (Flash) – I (Illustrator) – P (Photoshop) – Cool (Cool Edit) – DW (Dreamweaver) – SF (Sound Forge) – RE (Reload Editor) – M (Moodle) – WebD (Web Design) – MMProg (Multimedia Programming – Anima (Animation) – SB (Storyboarding)
Software application in storyboard:
PPT (Microsoft PowerPoint) – Word (Microsoft Word) – AdoP (Adobe Photoshop) – MacrF (Macromedia Flash) – AdoI (Adobe Illustrator) – Rapv (Raptivity) – DW (Dreamweaver)

The ACTA toolkit recommended three to five experts in conducting this method ((Militello, Hutton, Pliske, Knight, & Klein, 1997). Interviewing a limited number of experts can lead to an increase in the knowledge of the interviewer, information can be verified among experts and a buffer can be provided for unsuccessful interviews. (Militello, et al., 1997, pp.152).

According to Ericsson and Smith (1991), the analysis of task performance approach undertaken to study expertise, tend to focus on a domain-specific training and practice that will lead to the construction of task-specific knowledge. Ericsson and Smith (1991) further proposed that in the initial step of studying expertise, it is possible to elicit superior performance in a small number of representative tasks. Furthermore, in constructing a coherent knowledge base, there is a trade-off between group size and conflicting viewpoints. An example of a study by McGraw and Seale (1988)'s work with expertise in aviation systems, has recommended using groups of only two or three experts (R. R. Hoffman, Sharbolt, Burton, & Klien, 1995).

Adopting small number of expertise has been also shown in many studies. These includes employing three interventional radiologists in identifying cognitive thought processes involved in interventional radiology procedures (Johnson et al., 2006), engaging four senior users of Fatigue Audit InterDyne (FAID™) in identifying usability areas of fatigue modeling software (Paradowski & Fletcher, 2004), selecting four military intelligence analysts in identifying leverage points for the extremely challenging tasks of intelligence analysis (R. Hoffman, Neville, & Fowlkes, 2009)and using three expert players of Quake 2 computer gaming in capturing the underlying reasoning process for agent-based models of human behavior ((Norling, 2008).

Three expert designers agreed to participate in this study. One instructional designer who has two years' experience is a project leader; the other two, who hold multimedia designer positions, have five and ten years' experience respectively in the fields of eLearning and storyboard design. All of them have a degree in digital multimedia, multimedia, and computer science (in multimedia). One of them is pursuing a master's degree in eLearning. Their selection was also recommended by the Head of Instructional Design at MPU. The request for interview was made by a formal e-mail. All of the participants agreed to attend the ACTA session. They were given a form of consent and assured the content of the session would be confidential. All participants signed the voluntary consent form and were given a token of appreciation for their involvement in the study

5.1.1.2 The Applied Cognitive Task Analysis Technique

As previously mentioned in Chapter 4, the cognitive task analysis methods are classified into four broad families, namely: 1) observation and interview 2) process tracing 3) conceptual techniques and 4) formal models (Wei & Salvendy, 2004). This cognitive task analysis family classification is meant to guide researchers, who aim for particular outputs, to select appropriate techniques.

Due to the need to specify procedures involved in the eLearning storyboard which are not well-defined as an output, this study adopts the Applied Cognitive Task Analysis (ACTA) method which developed by Militello and Hutton (1998). ACTA is derived from Wei and Salvendy (2004)'s first family classification. In this family classification, the technique, involving direct methods of watching and talking with the subjects (in this study, our subjects are IDs), is well suited to analyzing the experts' skills which need to be defined and circumscribed in the domain.

Moreover, it is useful in our study to achieve subject rapport, because it seems natural. According to Stanton, Salmon and Walker (2005), the advantages of ACTA over other cognitive task analysis methods such as Cognitive Walkthrough (Polson, Lewis, Rieman, & Wharton, 1992), Cognitive Work Analysis (Vicente, 1999), Critical Decision Method(Klein, Calderwood, & MacGregor, 1989), Critical Incident Technique (Flanagan, 1954), are its characteristics as a structured approach, the use of three different interviews to ensure the comprehensiveness of the method and probes, and the questions provided to the researchers to facilitate relevant data extraction.

The use of the ACTA technique is significant in designing interfaces that support the decision making strategies and information needs of the operator, and to uncover the skills and knowledge necessary to perform the cognitively challenging work of the system. It is also used to highlight differences between expert and novice performance, thus examining how novices can more quickly be brought to the performance level of experts (MITRE, 2010). The ACTA technique has been used in many studies which include determining whether tactical information should be displayed in 3D to improve battle space situation awareness (Eddy, M.F., Kribs, H.D., & Cowen, 1999), to analyse the decision strategies of submarine sonar and target motion analysts (Hardinge, 2000), to capture strategies and tactical concerns of air campaign planners for use in the development of a software decision support tool (Miller et al., 1999) and to guide the development of a scenario-based training program on platoon leaders of MOUT (Military Operations in Urban Terrain) operations (Phillips, McDermott, Thordsen, McCloskey, & Klein, 1998).

The usability of questionnaires in the ACTA method is also found to be clear in its output and useful in knowledge representation (Militello & Hutton, 1998). Schraagen, Chipman and Shute (2000) also denote that the knowledge elicitation approach in ACTA, such as knowledge audit interviews, schematics of equipment, scenarios that probe the key decisions and associated cues, provide the information in seeking the expert–novice differences in dealing with situations as seen by the experts. Hence, this comprehensive method which consists of probes from knowledge elicitation to data extraction which lead to clear output in knowledge representation, support the researchers in cognitive task investigation studies in the eLearning storyboard.

On the other hand, a successful cognitive study should include three primary aspects; knowledge elicitation, data analysis and knowledge representation (Crandall, et al., 2006). Compared to other cognitive task analysis methods, the ACTA toolkit provided by L. G. Militello and J. B. Hutton, (2000) covers these three aspects of cognitive study, emphasis on identifying the cognitive aspects of tasks, analysis of data in table forms and the value of structured methodology (Brandt & Uden, 2003). However, Klein and Militello (2001, pp.187) concluded that "some methods are better able to capture certain types of cognitive processes", hence, there is no method considered to be the best in cognitive task analysis.

The main objective of the ACTA technique is to elicit the critical cognitive elements of a particular task and in turn provide recommendations for a system design (Militello & Hutton, 2000). An ACTA consists of a series of four techniques; 1) task diagram, 2) knowledge audit, 3) simulation and 4) cognitive demand table. Figure 5.1 shows the ACTA session with the instructional designers conducted in a Multimedia Studio.

Figure 5.1: ACTA session with expert instructional designers in a multimedia studio

5.1.2 Research Procedures and Design

The research uses four techniques in ACTA, describes in the toolkit (refer Appendix B). Each technique is explained by Crandall, et al. (2006).

5.1.2.1 The four ACTA techniques

An ACTA, shown in Figure 5.2, is a cognitive task analysis technique that consists of three series of structured interviews, conducted in focus group discussions.

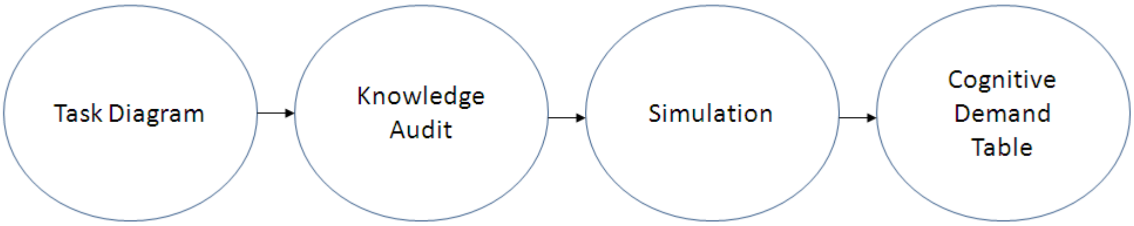


Figure 5.2: Levels of techniques in Applied Cognitive Task Analysis method

The procedure of each technique is as follows (Stanton, et al., 2005):

(a) ***Task Diagram Technique***

The purpose of the task diagram interview is to elicit a broad overview of the task under analysis. Once the task diagram interview is completed, a diagram is developed representing the component task steps involved and those task steps that require the most cognitive skill.

This technique is used to identify the cognitive skills required in the eLearning storyboard process. The steps of the technique start when the IDs are presented with the eLearning storyboard process as shown in Figure 5.3. They are asked to decompose the task into relevant task steps. The sample question as presented by Militello, et al. (1997) is used. To assist the procedure in this session, “Task of Interest” is written at the top of a whiteboard, and used to elicit the required steps in the eLearning storyboard. The tasks are recorded across the board from left to right in chronological order. Arrows are used to indicate the order in which the steps occur. The outcome of the result is projected in the form of a task diagram.

(b) Knowledge Audit Technique

This technique employs a set of probes designed to describe types of domain knowledge or skills and elicit appropriate examples. The goal is to ascertain the nature of these skills, specific events and strategies that have been used.

This technique is used to explore the cognitive task difficulties identified in the task diagram technique. IDs are asked about cues and strategies they rely on when they face eLearning design and process difficulties. In this technique, "Task of Interest" is again written at the top of the whiteboard, and the space below divided into three columns. The columns are titled "Examples", "Cues and Strategies" and "Why Difficult". Using the previous task diagram, the cognitive skills identified by the IDs are further explored using the lists of probes using the questions as shown in Table 5.2 (Militello, et al., 1997). The data findings are presented in a knowledge audit table.

Table 5.2: Questions asked in Knowledge Audit technique

Column title	Questions
Examples	This is an example of a situation where you experience cognitive task difficulties
Cues/strategies	In this situation, what cues and strategies would you rely on?
Why difficult	In what way would this be difficult for an SME? What makes it difficult to do?

(c) Simulation Technique

In simulation technique, the data finding is independent of the findings of the knowledge audit. The IDs are presented with a scenario that addresses difficult and challenging elements of the eLearning storyboard. The simulation can be either high fidelity or low fidelity. In this study, low-fidelity simulation is used by presenting the IDs with an eLearning storyboard design template (shown in Figure 3) with a simulation of the step-by-step process. In this technique, five columns are drawn on the whiteboard, titled "Events", "Actions", "Situation Assessments", "Critical Cues" and "Potential Errors". The IDs are then allowed to interact with and experience the simulation. They are asked their views about eLearning storyboard design simulation using the questions shown in Table 5.3. Each answer is recorded.

Table 5.3: Questions asked in Task Simulations technique

Column title	Questions
Event	The events that you identified as difficult and challenging
Actions	What actions would you take at this point?
Situation assessments	What is going on here? What is your assessment of the situation?
Critical cues	What pieces of information led you to this situation assessment and these actions?
Potential errors	What errors would an SME would make?

The data findings are presented in a simulation table, which provides specific detailed information on IDs' cognitive processes. It also provides a view of the IDs' problem-solving processes in design and process using the eLearning storyboard design template.

(d) Cognitive Demand Technique

The final technique is to integrate the data obtained from the data findings from the previous techniques: task diagram, knowledge audit and simulation. The data are presented in a cognitive demand table, which contains difficult cognitive elements, with "Why Difficult", "Common Errors" and "Cues and Strategies" used as the headings. It provides a format to analyse the types of information needed to design a new system.

5.1.2.2 Instruments

In this study, the following instruments were applied during the ACTA process.

(a) Storyboarding Design Process

In this study, a particular storyboard design process is used to identify the cognitive skills of the IDs during the task diagram and knowledge audit techniques. A generalized form of design cycle storyboard consists of five stages; analysis, synthesis, simulation, evaluation and decision. This design cycle involves Van der Lelie, (2006)'s design activities, purposes, and visualization styles and is produced in a particular form, which is studied earlier in Chapter 3). The storyboard design process for eLearning content development shown in Figure 5.3 is described within this form of design cycle storyboard. The design in each process in Figure 5.3 serves its own purposes and is projected in particular forms, as described in Table 5.4:

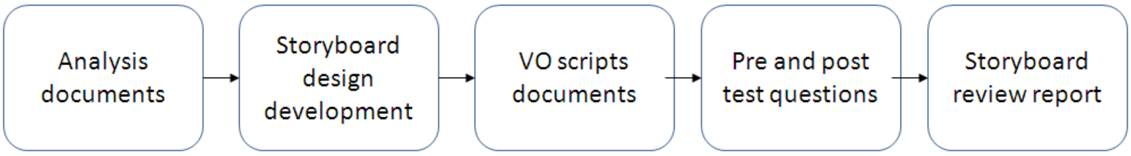


Figure 5.3: Design process in eLearning storyboard

Table 5.4: The process of storyboard, purposes and projected forms

Process of storyboard	Purpose	Forms projected
Analysis documents	To analyse the document information. The SME provides the course outline and list of reference books to the ID.	Word document
Storyboard design development	The SME develops the early sketch content of subject content. The storyboard consists of elements as shown in Fig. 2. The contents are to be developed by the ID and the development team.	PowerPoint / Word document
VO scripts	To complement the content on the storyboard. It is used to elaborate the subject matter of the storyboard content.	Word document
Pre and post test questions	To project the test prior and after the subject content. It is used to test the subject matter of the storyboard content.	Word document
Storyboard review report	To consolidate materials of the documents in storyboarding process. It is intended to ensure the SMEs submit all documents required.	Word document

(b) ***ELearning Storyboard Design Templates***

A storyboard for eLearning content requires organization. The style guide should also reflect key points for eLearning applications, such as navigation, text and layout style, narration, interaction and graphics (Brandon, 2004). Similarly, templates should provide attributes that are significant to the storyboard process (Truong, Hayes, & Abowd, 2006). In this study, the proposed storyboard design template shown in Figure 5.4 is used as an object presented to the IDs during simulation technique. It is constructed using a PowerPoint application (Brandon, 2004)

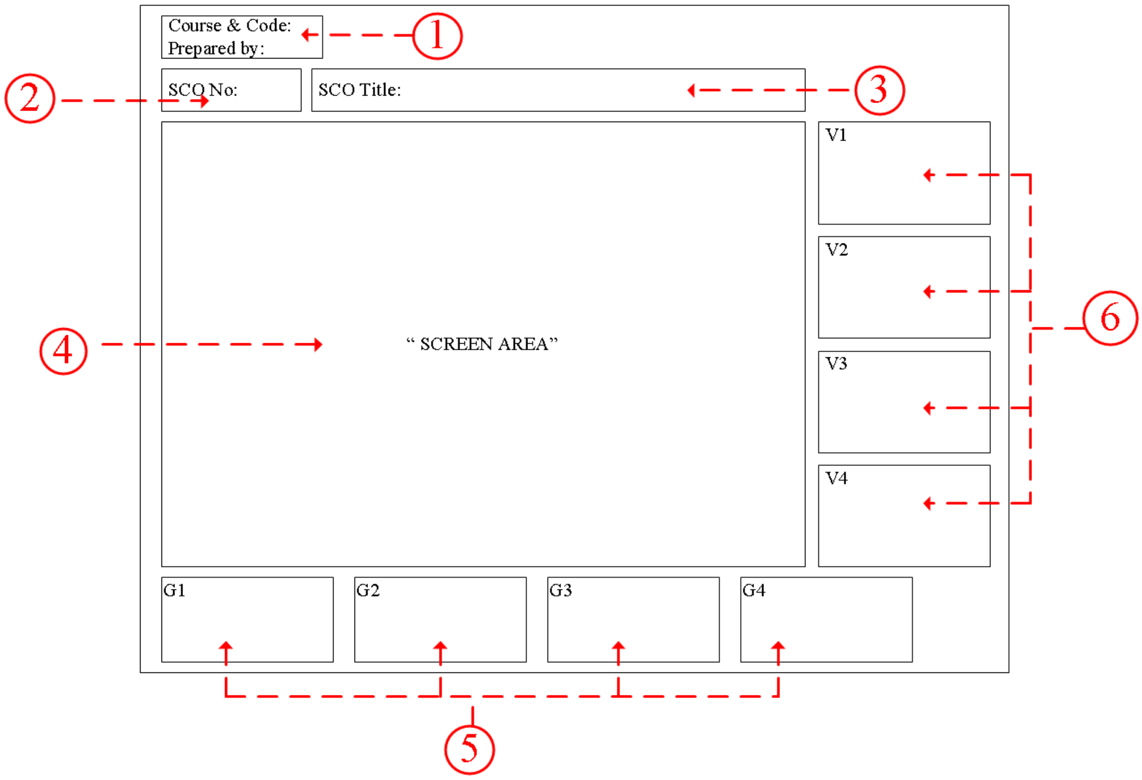


Figure 5.4: Standard template for storyboard

It projects six structures of elements as follows:

- *Course code and instructor's name*: refers to the areas in the storyboard template where SMEs need to insert their course names, course codes, and their names (Fig. 5–①).
- *SCO no.*: refers to the sharable content objects. In this study, SCO refers to the slide number and that of the total slides for the learning contents (Fig. 5–②). For example; SCO 5/25 represents the fifth out of 25 slides.
- *SCO title*: represents the learning material in the screen area (Fig. 5–③). In the context of the scenario, the SMEs need to provide a different SCO title for each slide. If the content needs to be explained in more than one screen, the same title should be stated in those new screens.
- *Screen area*: the area where learning materials are placed (Fig. 5–④). The learners may only see the content and activities after the whole storyboard is published by the multimedia designers.
- *Graphics and animation*: refers to the instructions about the content in the screen area in text and pictures (Fig. 5–⑤).
- *VO scripts area:* refers to the voice-over scripts which represent the narration (Fig. 5–⑥). It is used to illustrate scripts of the screen show animation in the area *Graphics and animation* mentioned above.

5.1.2.3 Instrument Supplies

Instruments that are used include: an electronic whiteboard for presenting the task diagram, knowledge audit, and simulation tables for the IDs; a audio-recorder using Adobe Audition application for recording the interview session; and a simulation of eLearning storyboard design templates.

5.1.2.4 Timeline Planning

The total time conducted for each set of ACTA techniques is 2 hours 50 minutes. The task diagram requires 20 minutes, knowledge audit 60 minutes and simulation technique 90 minutes.

5.1.3 Data Results and Findings

This section presents the results and findings of the ACTA study.

5.1.3.1 First Technique (Task Diagram)

Figure 5.5 shows the task diagram of the eLearning storyboard task and process. The processes that require cognitive skills are identified as VO script documents and storyboard review reports. The IDs stated that these two elements required heavy cognitive skills, particularly for problem solving. On the other hand, all the IDs agreed that the tasks in document analysis, storyboard design development and pre-test post-test questions of the eLearning storyboard do not require as many cognitive skills as the two identified processes. The problem-solving skills identified in VO scripts and storyboard review reports are presented in the knowledge audit table.

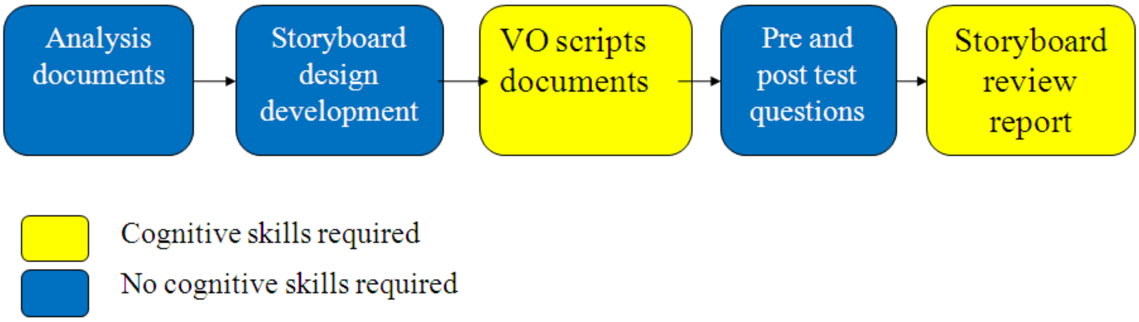


Figure 5.5: The Task Diagram: In this technique, cognitive task skills required in eLearning storyboard have been differentiated from the non-cognitive task skills.

5.1.3.2 Second Technique (Knowledge Audit)

The knowledge audit table (shown in Table 5.5) shows the detailed aspects of problem solving in VO script documents and storyboard review reports. The task difficulties in VO scripts include translating the content materials to VO scripts, handling the storyboard templates, and difficulties in differentiating and prioritizing graphic elements in relation to VO scripts. In the storyboard review templates, the review process is difficult when SMEs are located in different geographical areas. IDs also claimed that the SMEs are not familiar with the instructional design process which leads to a larger number of iterations in the eLearning storyboard process.

5.1.3.3 Third Technique (Simulation Interview)

Table 5.6 shows four identified challenging tasks in eLearning storyboard design templates. They are: VO scripts, graphics, animation and storyboard reviews. Generally, the IDs stated that the template needs integration of the opinions and actions of all team members (including the SMEs). The IDs stated that the storyboard template needed enhancement, which may reduce the challenge of communication and cooperation.

As regards VO scripts, graphics and animation, the IDs indicated that SMEs usually insert too many or too few scripts, graphics and animations, necessary for the eLearning content. On the other hand, the storyboard review process that requires feedback from reviewers and proofreaders takes a long time. This leads to a delay in submission to the development team responsible for the eLearning multimedia content.

The simulation shows that the SMEs have difficulties in developing a storyboard using the templates because they are not trained as IDs. The SMEs also lack skills in technologies, ignore the guidelines of the storyboard, and lack skills in developing VO scripts, graphics and animation. The potential error may be due to the non-attendance of SMEs at training sessions on developing eLearning courses using storyboard templates.

Table 5.5: The Knowledge Audit table

Sub-tasks	Cues and strategies	Why difficult?
Example:		
VO scripts	*Cues:* SMEs do not have knowledge in handling voice scripts. SMEs have problems with storyboard templates. The storyboard templates show the SCO no., which makes it difficult to proceed with longer VO scripts. SMEs also have difficulties in handing graphics and their relations with VO scripts.	Difficult to translate content materials to VO script. Difficult to handle the storyboard templates. Difficult to differentiate and prioritize graphic elements in relation to VO scripts.
	Strategies: Most of SMEs will convert all materials from textbooks to storyboard. SMEs tend to copy a lot of graphics to the storyboard.	
Example:		
Storyboard review	*Cues:* Many SMEs refuse to do amendments after the review process. SMEs do not understand their roles as storyboard designers, and leave all tasks to the ID. SMEs assume ID will guide and refine the storyboard. The storyboard reviews need to be reviewed by many members of the team, which includes the instructional designers, SMEs, multimedia designers, and graphics designers.	Difficult to reach SMEs. Some SMEs are resident in other institutions. IDs are not SMEs. Thus, some of them do not understand the subject content of the storyboard. It is difficult to determine the number of entries for graphics and VO scripts in the screen areas, due to the style of storyboard templates.
	Strategies: ID need to communicate very often with the SMEs to get a clear view of the contents. ID need discuss every SCO with SMEs	

Table 5.6: The Simulation Interview table

Major challenging tasks	Actions	Situation assessment	Critical cues	Potential errors
Storyboard templates	Integrate opinions and actions from all teams	It is challenging because it needs communication and cooperation from all team members.	Communication Cooperation	Ignore the guidelines in the storyboard Not well-informed about the procedure
VO scripts	There are too many or too short scripts	It is challenging because it needs skills in prioritizing VO scripts appropriate for the storyboard	Too many VO scripts Not enough / too few VO scripts	Not enough skills in VO scripts, graphics and animation SMEs are not trained as instructional designers Some SMEs do not have skills in technologies which makes it difficult for them to create the storyboard contents Some SMEs do not attend the training provided for storyboard designers which makes it difficult to comprehend the task of storyboarding development.
Graphics and animation	There are too many or few graphics and animations	It is challenging because it needs skills to prioritize VO scripts appropriate for the storyboard	Too many graphics and animations Not enough / too few graphics and animations Many SMEs rely on animations, media and graphics from textbooks, and internet	

			Some SMEs use the graphical tools available in the power point application	
Storyboard reviews process	Reviews are a long process	The standard of operation requires the storyboard to be completed within 3 months; some lag up to 6 months or a year behind	The reviews take into account feedback from the reviewers and proofreaders Some reviews take too long to complete which makes the cycle of the storyboard process longer and delays it	Unable to identify and differentiate tasks of storyboard designers and subject content providers Delay review process

5.1.3.4 Final Technique (Cognitive Demand Table)

The cognitive demand table provides a comprehensive view of the cognitive task difficulties and expertise experienced by IDs. Table 5.7 shows four difficult cognitive elements integrated from the previous two techniques.

Storyboard templates, VO scripts, graphics, animation and the storyboard review process are five difficult cognitive elements summarized in the study. These difficulties are caused mainly by lack of assessment skills and thinking skills, which require years of experience in terms of developing a good eLearning storyboard. For example, SMEs who use storyboards to develop eLearning content will need to know effective ways of translating the content of the textbook. They also need to differentiate and prioritize graphic elements in relation to the VO scripts. The findings from this table pinpoint the cause of the errors often noticed by IDs who have experience and expertise in instructional design.

Table 5.7: The Cognitive Demand table

Difficult cognitive elements	Why difficult?	Common errors	Cues and strategies used
Storyboard templates *VO scripts* *Animation and graphics* *Storyboard review process*	Difficult to translate content materials to VO scripts. Difficult to handle the storyboard templates. Difficult to differentiate and prioritize graphic elements with relation to the VO scripts. Difficult to reach SMEs. Some SMEs are resident in other institutions. IDs are not SMEs. Thus, some of them do not understand the subject content of the storyboard. It is difficult to determine the number of entries for graphics and VO scripts in the screen areas, due to the style of storyboard templates.	Ignore the guidelines in the storyboard. Not well-informed of the procedure. Not enough skills in VO scripts, graphics and animation SMEs are not trained as instructional designers Some SMEs do not have skills in technologies which makes it difficult for them to create storyboard contents Some SMEs do not attend the training provided for storyboard designers which makes it difficult for them to comprehend the task of storyboarding development. Unable to identify and differentiate tasks of storyboard designers and subject content providers. Delay review process.	*Cues:* SMEs do not have knowledge in handling voice scripts. SMEs have problems with storyboard templates. The storyboard templates show the SCORM no., which makes it difficult to proceed with longer VO scripts. SMEs also have difficulties in handing graphics and its relation to VO scripts. SMEs tend to avoid doing amendments after the review process. SMEs do not understand their roles as storyboard designers, and left all tasks to the ID. SMEs assume ID will guide and refine the storyboard. The storyboard reviews need to be reviewed by many members of the team, which includes the instructional designers, SMEs, multimedia designers, and graphics designers. *Strategies:* Most of them will convert all materials from textbooks to the storyboard. SMEs tend to copy a lot of

	graphics to the storyboard. IDs need to communicate very often with the SMEs to get a clear view of the contents. ID need to discuss every SCO with SMEs

5.1.4 Discussion

This section discusses the findings of two aspects of eLearning storyboards in this study: cognitive task difficulties and expert skills. It also provides some recommendations for a proposed eLearning storyboard system.

5.1.4.1 Cognitive Task Difficulties

In the study, four sub-elements of eLearning storyboards which demand cognitive skills were identified, namely: storyboard templates, VO scripts, graphics and animation, and review process.

(a) ***Storyboard Template***

The IDs found that most SMEs seem to ignore the guidelines provided in the storyboard, and some of them claimed that they were not well-informed of the procedure, although the guidelines handed to the SMEs consist of specific documentation regarding procedures and design. The IDs also stated that the storyboard templates seem difficult for SMEs to handle because of the features of the PowerPoint application. IDs reported that SMEs had insufficient room to add more inputs to VO scripts and graphics animation areas. IDs also said that the SMEs are not able to decide on the amounts of each element required in storyboard templates to accommodate the eLearning content. Although some works report the efficiency of a PowerPoint application for design and presentation (Holzl, 1997; Atkinson, 2007), the application of

PowerPoint alone to assist IDs and SMEs with eLearning content is inadequate and unable to provide collaboration and communication between IDs and SMEs.

(b) ***VO Scripts, Graphics and Animation***

In terms of the prescriptive interaction components in the storyboard, the IDs found that SMEs seem to include too many or not enough objects and prescriptions of VO scripts, graphics and animation. The IDs also indicated that SMEs rely more on text descriptions from reference books and internet images. Some of the SMEs use the graphical tools available in the PowerPoint application. The IDs stated that SMEs need skills in prioritizing which VO scripts, graphics and animation are appropriate for the storyboard. The findings show that there are three factors contributing to the difficulties of SMEs' tasks in terms of prescriptive interaction components: 1) SMEs are not trained as IDS, 2) SMEs do not have skills in technology which makes it difficult for them to create storyboard contents and 3) SMEs do not attend the training provided for storyboard designers, which makes it difficult for them to comprehend the task of storyboard development. According to Ertmer et al. (2009), novices and experts in instructional design differ in terms of their abilities to arrive at ill-defined problems, and their speed and efficiency in doing the task. The use of scaffolds or guidance may leverage an inexperienced eLearning storyboard designer to analyse and solve instructional design problems.

(c) ***Review Process***

Results from the study show that the reviews take into account feedback from the reviewers and proofreaders. These reviews take too long to complete, which makes the cycle of the storyboard process longer and subject to delay. The IDs stated that the standard operation of completing an eLearning storyboard should take up to three months but, owing to the long review process, the task takes six months to a year to complete. The factors that contribute to the delay in the review process were identified as follows:

- Many SMEs refuse to do the amendments after the review process.
- SMEs do not understand their roles as storyboard designers, and leave all tasks to the IDs. SMEs assume IDs will guide and refine the storyboard.
- The storyboard reviews need to be reviewed by many members of the team, which includes the IDs, SMEs, multimedia designers, and graphics designers.
- SMEs are difficult to contact. Some SMEs are members of other institutions.

This finding is supported by Kam (2008) who studied the roles expected to be assumed by SMEs versus the actual roles that should be performed by SMEs. Kam (2008) stated that SMEs expect to provide all information including the unavailable content, explain concepts related to subject-matter, provide examples and analogies, and provide answers to all content-related queries. The author also explained that the different roles are one of the reasons why the review process in eLearning storyboards is delayed. Another study by Saroyan (1992) stated that there are differences between IDs and SMEs' ways of reviewing evaluations. IDs act as generalists and use a comparative method of review which is directed by the heuristics of an instructional systems design model. On the other hand, SMEs act as specialists and use a sequential method of review which is directed by domain knowledge. The literature also explains that the different methods of review are as a result of the different backgrounds and expertise.

5.1.4.2 Expert Skills in eLearning Storyboards

In the study, the IDs justified why training in eLearning storyboards should be given before tasks are assigned to the SMEs. The skills provided may provide an insight into how to perform in the design and the process of eLearning storyboards. Difficulties occur, however, if the training is not attended by SMEs. Some related comments from IDs include:

"*Most of the SMEs are not well-informed of the procedure in eLearning storyboards*"

The IDs claim that the skills required can affect the interaction between IDs and SMEs. For example:

"We need to communicate very often with the SMEs to get a clear view of the contents". "We need to sit down and point every SCO towards the SMEs, should there be any amendments to be made to the storyboard"

According to You and Teclehaimanot (2010), developing eLearning course design is effective under the following conditions: 1) SMEs believe that working with IDs prepares them for the implementation of best practices in eLearning course design and delivery; 2) SMEs work with IDs for multiple purposes, such as technological and pedagogical support, and 3) SMEs work with IDs individually, either in a face-to-face consultation sessions or via phone and e-mail. They explain that the effective interaction of IDs and SMEs can lead to leveraging of the skills of SMEs in the design and the process of eLearning storyboards.

5.1.5 Recommendations

Based on the discussion above, three recommendations are offered to improve cognitive tasks and leverage the skills of SMEs in the design and the process of eLearning storyboards: 1) training development, 2) graphics and animation development, and 3) interaction design and document development.

5.1.5.1 Training Development

The ACTA findings in this study have uncovered the skills and knowledge necessary to perform the cognitively challenging work of the eLearning storyboard. The findings have also highlighted differences between expert and novice performance, thus examining how SMEs as novice designers can more quickly be brought to the performance level of experts.

One of the suggestions is to provide proper training for SMEs. This is supported by a study by Albi (2007) which investigates the real-life experiences of four professors in discovering how they either learned instructional design or adapted an instructional design process to design and develop their online courses. The study findings found that these participants, who were self-taught IDs and developers, would have been more effective IDs and developers if they had received instructional design and development training prior to their first online instructional design experiences (Albi, 2007). This study also concluded that administrators at institutions of higher education should encourage their institutions to offer a variety of training opportunities for their online instructors. It showed that training should not only include how to teach online courses effectively, but also how to design and develop online courses and course materials. This training can be incorporated in future eLearning storyboard systems.

5.1.5.2 Prescriptive Interactive Component Development

VO scripts, graphics and animation are difficult for SMEs because they rely on multimedia elements, such as animations, media and graphics from textbooks and the internet. In this study it was shown that an eLearning storyboard should include the prescriptive interactive component. This is supported by Liaw, Huang and Chen, (2007) who found that multimedia instruction, such as voice media instruction, image media instruction, animation media instruction and colourful text media instruction, is one of the critical factors that lead to eLearning performance. On the other hand, Gümüs and

Okur (2010) proposed that the number of multimedia objects in eLearning content should also be appropriate because it provides high interaction with the students. In this study, some SMEs also used the graphical tools available in PowerPoint applications. The search for the right multimedia elements has led to a longer storyboard review process. The standard of operation requires completion within three months but this may take from six months to one year. The reason may be the inadequate understanding of multimedia objects such as text, audio, video and graphics. One of the suggestions for solving these difficulties is to apply Mayer (2002)'s principles of multimedia learning based on cognitive theory. Recommendations for improving VO scripts in animations are stated as follows (Mayer & Moreno, 2002, pp.63):

- *Multimedia Principles:* presenting words and pictures promotes deeper learning than words alone.
- *Contiguity Principles:* presenting words and pictures simultaneously rather than successively results in deeper learning.
- *Coherence Principles:* presenting extraneous words, sounds or pictures may disrupt the process of learning.
- *Modality Principles:* presenting words as VO scripts provides deeper learning than on-screen texts.
- *Redundancy Principles:* presenting words as VO scripts alone provides deeper learning than presenting in both VO scripts and on-screen texts.
- *Personalization Principles:* presenting the VO scripts in a conventional style promotes deeper learning than a formal style.
- *Interactivity Principles:* presenting a control button for user interactivity that allows the learner to control the presentation rate provides better learning engagement.
- *Signaling Principles:* incorporating signals into VO scripts allows better learning than non-signaled presentations.

5.1.5.3 Interaction Design Document Development

In this study, the problems in eLearning storyboard design templates are mainly due to the design factors (e.g. insufficient room for VO scripts and graphics areas). Due to its characteristic of being a two-way communication medium, the challenge is to develop a design instruction document to maximize the amount of interaction in eLearning storyboard materials. This is justified by E.R Misanchuk (1992) who concludes that eLearning instructional materials should be used with language more like that used for speaking than for writing journal articles or books. The guidelines for writing eLearning instructional materials has been detailed further, and includes: using short sentences, avoiding compound sentences and excess information in sentences, using active voice point forms and writing the instruction as if they were spoken. On the other hand, E.R. Misanchuk (1994) suggests a course introduction for all eLearning materials. Suggestions include: the instructor's background information, a course overview, course objectives, the textbooks, reference books or ancillary learning materials, and information about assignments, examinations, and grading.

With regard to the design problems in a multimedia eLearning storyboard, two ways to solve these difficulties are by referring to Marie & Klein (2008) detailed design and Truong, et al. (2006) effective storyboard guidelines. Marie & Klein (2008)'s detailed design guidelines which have been described in Chapter 3 can be used for developing storyboards that lead to faster client approval and fewer edits during the design and development process. It is also be used for developing web-based training, computer-based training detailed design and storyboard documents. The detailed storyboard design which aims to maximize the efficiency of a team's development, offers three levels of activities: eLearning challenges, detailed design development steps and storyboard templates steps. Each activity is guided with a detailed design document which serves as a roadmap for developing the storyboard. Effective guidelines proposed by Truong, et al. (2006, pp.15) have also being described in Chapter 3.

5.1.5.4 eLearning Storyboard Guidelines for ID and SME Interaction

According to Klein and Militello (2001), a cognitive task analysis project needs to have three criteria for success: provide an important discovery, represent effective communication of the discovery and achieve meaningful impact resulting from the communication. Firstly, we have discovered how the IDs identify the difficulties in the design process of eLearning storyboards and determine the challenges faced by the SMEs. In the task diagram interview, a task diagram represented and identified two tasks which, among others, require higher cognitive skills; namely VO script documents and storyboard review reports. Subsequently, the knowledge audit interview elicited the expertise necessary to perform those particular tasks, involving the cues, strategies and difficulties faced by SMEs. A simulation interview further revealed additional challenging tasks of the eLearning storyboard including storyboard templates, graphics, animation, and a storyboard review process. Secondly, the findings in the cognitive demand table communicated the discoveries from the previous technique of interview and provided some common themes in the data. This table represents generic knowledge structures which entail the list of difficulties and common errors faced by SMEs in an eLearning storyboard. On the other hand, the cognitive demand table also provides an understanding about the different cues and strategies used by the SMEs during the design process of an eLearning storyboard. The results further communicate the factors that lead to interaction between IDs and SMEs during the design process of an eLearning storyboard.

According to Klein and Militello (2001), the cognitive task analysis results derived from the operators' cognitive skills are beneficial for recipients such as system developers who appreciate the representation from the users' perspective. A study by Nisbett and

Wilson (1977) showed that when people attempt to report on their own cognitive processes, they do not do so, instead their reports are based on prior judgments. It shows some experts themselves are not able to articulate their own strategies. The role of the ACTA results is essential to advocate the subtle cognitive tasks in an eLearning storyboard and support the tasks to be performed effectively. Finally, we have achieved meaningful impact from the study which resulted in three recommendations to develop a new framework for an eLearning storyboard initiated for two purposes; to train the SMEs as eLearning storyboard users, and to provide effective interaction between IDs and SMEs in communicating the design and the process in an eLearning storyboard.

Earlier in the literature reviews, it was clear that the interaction between IDs and SMEs plays a critical role in the design and the process of eLearning storyboards. In support of other research (Saroyan-Farivar, 1989; Willard, 1995; Castro-Figueroa, 2009; Ertmer, et al., 2009; Leigh & Tracey, 2010), the findings of the study identified five essential challenges in eLearning storyboard development in terms of the interaction between IDs and SMEs:

- *Communicative components:* an eLearning storyboard should have excellent communicative medium components to enable effective ID and SME communication in visual presentations. It can also increase the productivity by reducing the time needed for analysis, synthesis, simulation, evaluation and decision making in the storyboard design cycle.
- *Multimedia components:* SMEs should be well-informed in their selection of appropriate multimedia components such as VO scripts, graphics, and animations from which to choose a learning-specific process. They should be supplied with alternative sources of multimedia to apply in the eLearning storyboard.
- *ELearning storyboard components:* a good eLearning storyboard should have the comprehensive elements and guidelines of an eLearning course. The design process

of the eLearning storyboard should be well-structured, in order to optimize the design and transform it into an appropriate logical work pattern.

- *Training components:* a good eLearning storyboard should be able to train SMEs in the design and the process. An embedded training tool can overcome the costs of face-to-face training for SMEs.
- *Problem solving/decision making components:* an eLearning storyboard should assist IDs and SMEs to perform multiple roles and tasks, and overcome certain obstacles within the deadline. It should be able to automate ways of making decisions and solve the problems for IDs and SMEs in the design and the process.

This research offers five components in developing an eLearning storyboard: a communication component, a multimedia component, an eLearning storyboard component, a training component and a problem solving/decision making component. Based on the results of investigating the cognitive task and skills required of SMEs, six guidelines should be considered for eLearning storyboard components: effective medium communication, well-informed multimedia components, well-structured storyboard design patterns, embedded (built-in) training, automated problem solving and decision making. Figure 5.6 shows the guidelines for developing an eLearning storyboard for effective interaction between IDs and SMEs. The findings of the study are useful for developing a platform or system featuring the efficient design and process of eLearning storyboards, leading to improved methods of interaction between IDs and SMEs.

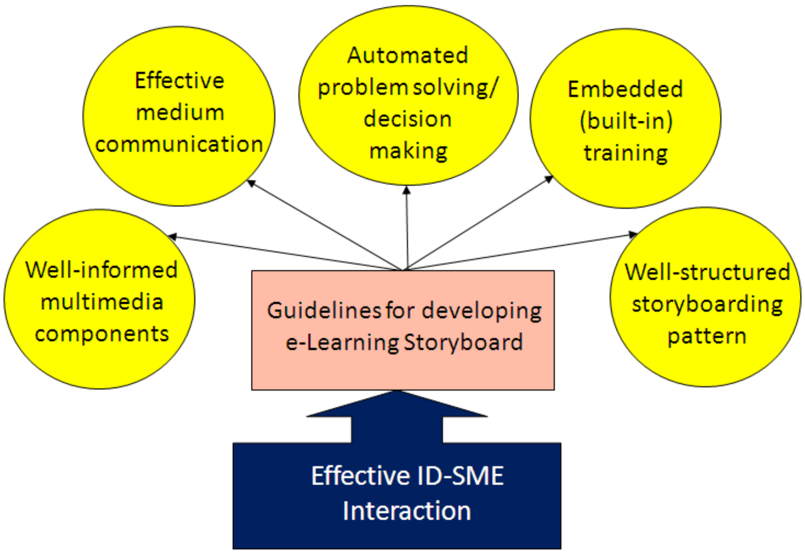


Figure 5.6: Guidelines for developing eLearning storyboard for effective ID-SME interaction

5.2 Empirical Study 2: Experimentation on Artifact and Visualization

While the previous empirical study discovered components for an eLearning storyboard system for the purpose of mitigating the difficulties in ID and SME interaction, this study aims to identify what are the internal cognitive artifacts acquired and how they need to be visually represented. In other words, it means the study investigates what are the internal cognitive artifacts acquire from them, and how these internal cognitive artifacts can be externalized from their mind or thinking i.e. from the task of designing eLearning storyboard, could be represented in a visual form. This investigation will also need to identify the agility ways in the eLearning storyboard design process that can allow adaptive design changes and modifications.

5.2.1 Related Works

In a similar work, Van der Lelie (2006) show the influence of visualization styles in each storyboarding design process in order to generate ideas and concepts as well as enhance communication within the design team of different backgrounds, Wahid, Branham, Cairco, Mccrickard and Harrison (2009) show the model of collaborative storyboarding by manipulating a representation of artifacts within three phases of activities; exploring, differentiating and constructing, and Truong, et al. (2006) identify a guidelines for designing storyboard for novice designers, which consists of five different attributes of storyboards.

While methodologies found in these literatures may contribute in supporting the task in the instructional design process, collectively they do not represent precise information about the cognitive representation that are needed by ID and SME to achieve common understanding during the design process in eLearning storyboard. This empirical investigation is designed to address this need.

The investigation study is organized as follows. It begins with research methodology, which describes the background of participants and artifact simulation technique applied in this study. The next section explains the research procedures and design, and the final section presents the data findings which lead to some discussions and recommendation.

5.2.2 Research Methodology

This section describes the participants involved in this research as well as the applied instruments.

5.2.2.1 Paired Design Team of ID-SME

In the previous investigation, instructional designers are selected as the participants where their opinions are gathered. On the other hand, this investigation invited three SMEs where they are paired with the previous participated IDs (please refer Table 5.1 of the ID's profile). The SMEs who are two academic faculty members and a primary school teacher brought in to represent three different academic faculties (two represented two different faculties from Multimedia University Malaysia and University Putra Malaysia, and another one is a smart school teacher from Putrajaya, Malaysia), different subject matters expertise and different background. All of them have experience in designing courses as well as working as part of the eLearning design team. It is important to note that previously, the paired design teams have been working collaboratively on different subject matters to design eLearning course. They have also experience in designing eLearning course following the linear ADDIE steps. Together with the experience in collaborating eLearning course design and linear design, the selected SMEs can be the suitable representatives to participate in this study. Table 5.8 shows the profile of the participating SMEs.

All of the participants agreed to attend the investigation study session. Similar with the previous study, they were also given a form of consent and assured the content of the session associate with their identity would be confidential. All participants signed the voluntary consent form and were given a token of appreciation for their involvement in this study.

Table 5.8: Subject-matter experts' profile

Profile / participant #	1	2	3
Designation	Associate Professor	School Teacher	Senior Lecturer
Background	Mathematics	Science Education	Computer Science
Subject-matter expertise	Statistics	Understanding Logo Design	IT Management
Programme	Masters of Business Administration	Art Education	Bachelor of Information Technology
Academic background	PhD	Bachelor Degree	Master's Degree
Storyboarding experience	5	9	7

5.2.2.2 Instruments

(a) ***Storyboarding artefacts***

An artefact is any item made or used by mankind whereas artefact analysis is the evaluation of objects made or modified by humans. According to Sears and Jacko (2009), artefacts are the interest of ethnographers studying the material world of people; however the term has been widely used in HCI research to study and analyse users' activities in interaction design.

In this experimental study, three sets of physical storyboarding artefacts were produced on A4 paper (8.27 x 11.69 inches), shown in Figure 5.7. The storyboarding artefacts represent three sets of three different subject-matters which contain five physical SCOs produced in chronological order, which had been previously produced by the SMEs. SCOs are a set of related technical standards, specifications, and guidelines designed to conform to the Sharable Content Object Reference Model (SCORM) standard requirement, used by IDs worldwide in order to organize, plan and design storyboards (Glithero, 2003). Similarly, the IDs own copies of unrelated subject-matter storyboard design artefacts were brought in to the study. The use of the physical storyboarding artefacts was intended to explore how the IDs and SMEs make use of the artefacts as a medium to capture, represent and present their cognitive thoughts. Using physical paper or real materials was suggested by Sellen and Harper (1997) because they can be used to assist participants in revealing how they make use of affordances to complete tasks. Participants were also provided with markers and self-adhesive double-sided sticky tape to locate the artefacts as desired.

(b) ***Agile storyboarding process***

A particular challenge in this study is to identify the application agile process to the storyboarding activities. In this research context, agile storyboarding involves the quick development of a storyboard: analysing the design and making improvements based on the analysis. Particularly when a storyboard is designed and developed in a distributed design environment, the SMEs may need to go through several iterations, with feedback from IDs, before they can all be satisfied and arrive at a common decision on the final storyboard design. Therefore, communicating design requirements here is different from methods that apply to a similar effort in a single institution. The distributed instructional design team adopts an iterative approach to storyboard design, wherein the knowledge of the storyboard design is captured, represented, presented and refined until the desired common understanding of the design can be achieved.

In the context of this investigation, the storyboarding process uses a basic design process, or (Simon, 1969)'s Rational Model, which is divided into three processing levels: pre-processing, processing and post-processing. Simon's (1969) Rational Model is based on rationalist philosophy and the Waterfall Model of system development life cycle (Gasson, 1998).

Figure 5.7: Three sets of storyboarding artefacts representing the subject-matter of (a) statistics, (b) logo design and (c) IT management

Here, we add re-design phase to provide an iterative activity that holds in an agile process. The four storyboarding activities are provided as follows:

- *Pre-processing:* refers to detailed eLearning course design document development which follows Marie and Klein (2008)'s activities: identifying learners, gathering and analyzing contents, developing instructional objectives, identifying instructional strategies and identifying the flow of the content.
- *Processing:* refers to the detailed eLearning course design interface development that follows Truong, Hayes and Abowd (2006)'s five significant attributes of storyboards for demonstrating system interfaces: how many objects and actors might be presented in a particular frame, text either through tagline narrations for each pane or story entirely using visual elements without text, inclusion of renditions of

human characters, and number of frames and indicate time passing within a storyboard

- *Post-processing:* refers to the reviews of the storyboarding artefact that follows Marie and Klein (2008)'s activity: compare the artefacts whether it aligns with the detailed eLearning course design.
- *Re-design*: refers to the iterative design decision activity which follows Jonassen (2008)'s agility practices in designing instruction.

5.2.3 Research Procedures and Design

The research uses three sessions of experiments which are described in the next section.

5.2.3.1 Pre-experimental session

Prior to the experimental study, the storyboarding artefact sets are solicited from the IDs. Since the storyboarding design artefacts belonged to the company properties of the IDs', an agreement has been signed between the researcher and the department manager to ensure the artefacts are used only for research purposes. The copy of the storyboarding design artefacts associated with the SMEs' subject-matters, contains completed multimedia elements (such as contents graphics, images, slides presentation, audios, music background, animations etc) which are intended for storyboarding design.

5.2.3.2 During experimental session

The ID and SME worked in a closed room with three tables and two chairs for each table. The SME are given the storyboarding design artefacts related to their own subject-matter which are glued to individual cardboards. The procedure contained a series of four sessions planned as follows:

- **Session 1 – No Shared View:** In this session, SMEs are asked to provide contents information of storyboard design cards based on the four storyboarding activities to the IDs without placing the storyboard design cards on the table. SMEs need to explain the contents to IDs until they reach common understanding of the design. When both ID and SME have arrive to the understanding of storyboard design contents and without shared view, the session completes and time is recorded.

- **Session 2 – Using Shared View:** In this session, the SMEs are asked to place the storyboard design cards on the table, in order to allow sharing views of the storyboard design cards. The SMEs are also asked to organize the sequence of the storyboard design cards according to the chronological SCO titles. Then, SMEs are asked to provide contents information of storyboard design cards based on the four storyboarding activities to the IDs by looking together at the storyboard design cards on the table. SMEs need to explain the contents to IDs until they reach common understanding of the design. When both ID and SME have arrived to the understanding of storyboard design contents and by sharing the same view, the session completes and time is recorded.
- **Session 3 – Using Shared Multiple Views:** In this session, it is the ID's turn to place his/her storyboard design cards on the table to be viewed by the SMEs. It is to allow sharing multiple views of the storyboard design cards. At this time, IDs need to freely share any storyboard design of his/her own to the SMEs. Again, SMEs are asked to provide contents information of storyboard design cards based on the four storyboarding activities to the IDs by looking together at the storyboard design cards belonged to them on the table. SMEs need to explain the contents to IDs until they reach common understanding of the design. When both ID and SME have arrived to the understanding of storyboard design contents and by sharing the multiple view, the session completes and time is recorded.
- **Session 3 – Using Shared Multiple View and Annotated View:** Finally, SMEs are asked again to provide contents information of storyboard design cards based on the four storyboarding activities to the IDs by looking together at the storyboard design cards belonged to them on the table. In this session, both of them are asked to annotate

their comments using a pen/pencil on the storyboard design cards. When both ID and SME have arrived to the understanding of storyboard design contents, by sharing the multiple view and by annotating comments, the session completes and time is recorded. Each group is given one hour to complete the whole sessions. Three research assistants are designated at each table to assist throughout the investigation session. Each of the research assistant takes photos of their activities and records the audio conversation between the ID and SME. The data timing is noted for each session. The research assistants only answered questions that are related to the investigation instructions. Figure 5.8 illustrates the pictorial views of the four sessions.

5.2.3.3 Post-Experimental Session

In this session, the IDs and SMEs were asked to gather and discuss their activities using a whiteboard. Acting as moderator, researchers asked questions related to the activities and approaches undertaken to achieve common understanding of the design process. The research assistants also took photos of their activities and recorded conversations between themselves and the participants.

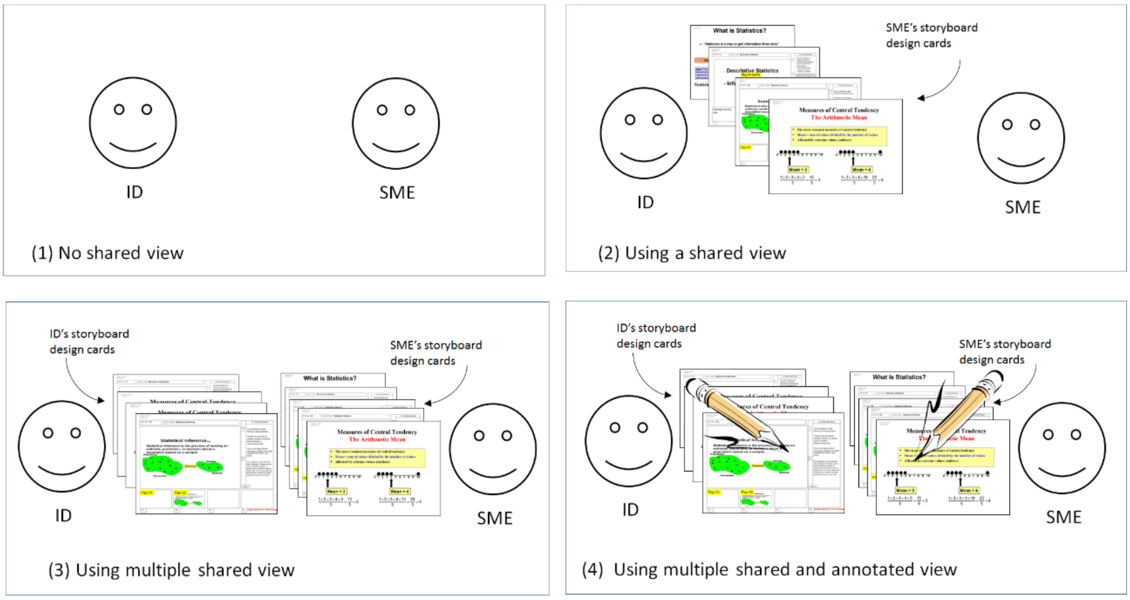


Figure 5.8: A storyboarding process which consists of ID and SME working in four different sessions

5.2.4 Coding and Analysis

The images of these activities and the audio of the conversations were transferred into digital format and collected for analysis purposes. For each group, the digital images and audio were separately analysed to find out the critical activities of interest based on the aforementioned Agile storyboarding process. Coded results were transferred into Microsoft Excel 7, containing the headings of the four processing levels and the design group. At the end of the study, the findings are analysed based on the cognitive data process of SMM using the role of artifact which have been explained in Chapter 4.

5.2.5 Experimental Results

This section presents the results based on the four sessions.

5.2.5.1 Session 1- No Shared View

The results and timing for session one for each group are depicted in Figure 5.9. The graph shows the pattern of time spent by the three design teams when they were asked to communicate without any storyboarding cards. This shows that most of the time spent during the processing activity involved managing the assets of each of the SCOs.

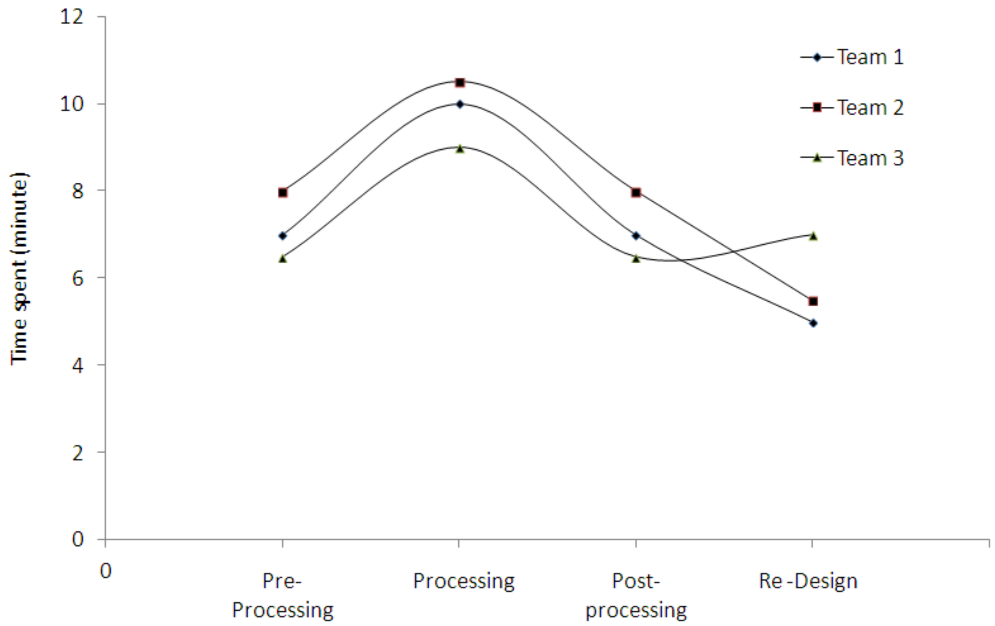


Figure 5.9: Result and timing when no shared view is presented

5.2.5.2 Session 2 – A Shared View

The results and timing for session two for each group are depicted in Figure 5.10. This graph shows significant differences in terms of time spent after participants were allowed to share and view one of the SCOs. It was found that less time was spent in the pre-processing, post-processing and re-design levels; more time was spent at the processing level.

5.2.5.3 Session 3- Shared Multiple Views

The results and timing for session three for each group are depicted in Figure 5.11. This graph shows slight decreases in time spent in pre-processing and re-design levels, when participants were asked to share and view multiple storyboarding cards. However, time spent increased in the processing and post-processing levels.

5.2.5.4 Session 4 - Shared Multiple and Annotated Views

The results and timing for the final session for each group are depicted in Figure 5.12. This graph shows no differences in time spent in pre-processing and re-design stages when participants were asked to share and view multiple storyboarding cards and at the same time communicate via writing on cards. However, there is a decrease in time spent in processing and post-processing levels.

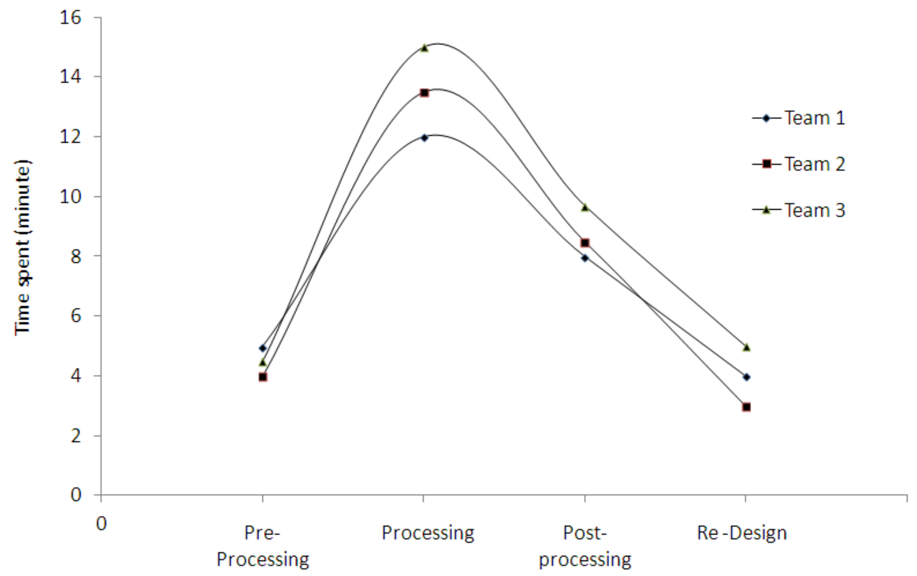


Figure 5.10: Result and timing when a shared view is presented

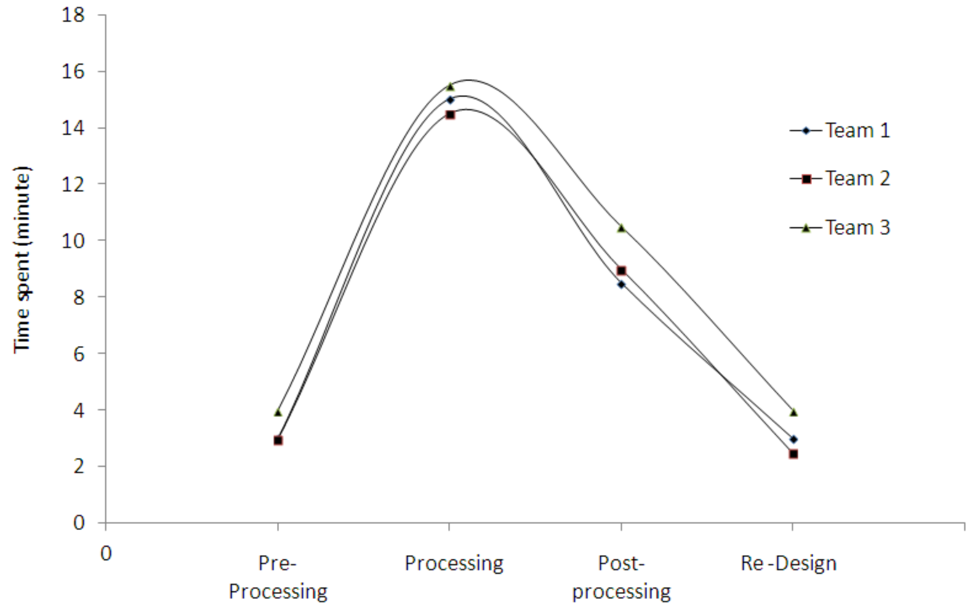


Figure 5.11: Result and timing when multiple shared views are presented

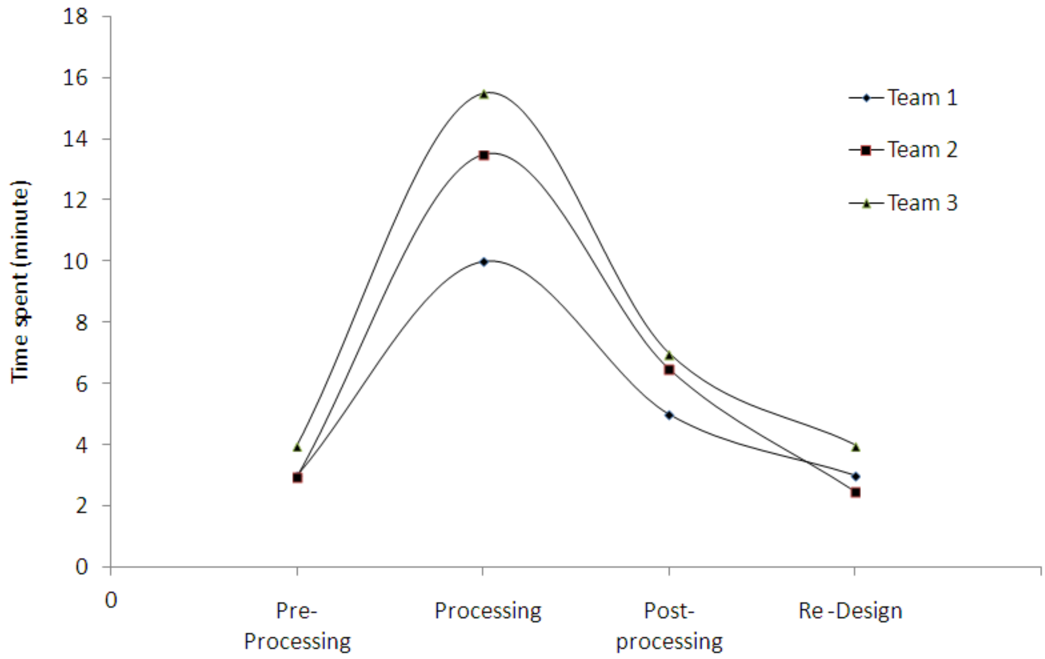


Figure 5.12: Result and timing when multiple shared and annotation views are presented

These results demonstrate that there were key factors that emerged at certain processing levels during the four investigated sessions. It was also found that the processes were not dependent on each other; in fact subsequent processes moved due to previous processes. Based on these results, the data were aggregated according to the four processing levels and all the time spent was calculated based on averages, depicted in Table 5.9. Table 5.9 shows the findings of the total time spent by the three groups in four different sessions. It shows that the total average time increased in sessions two and three, whilst later a significant drop of total average time was observed in session four.

Table 5.9 - The average time spent in the four storyboarding processes

	Pre-processing	Processing	Post-processing	Re-Design	Total Average
Session 1	7.2	9.8	7.2	5.8	30
Session 2	4.5	13.5	8.7	4	30.7
Session 3	3.3	15	9.3	3.2	30.8
Session 4	3.3	13	6.2	3.2	25.7

5.2.6 Post-Experimental Results

In order to understand the situations observed, the next step of the investigation involved delving into the thoughts of the IDs and the expert participants. This post-experimental session required all of the participants to participate in a discussion of the activities and approaches with the researcher who acted as moderator. The aim of this discussion was to understand which significant differences were experienced at certain points of the processes in regard to different views on the storyboarding cards.

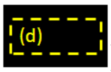
The participants explained that by having shared views (either of a single view or multiple views) they were able to externalise and share their thoughts better with each other than when no shared views were allowed. As seen in Figure 5.13 and Figure 5.14, the pre-processing and processing activities could be transitioned to back and forth while any changes were embraced by both parties quickly. In both figures, six activities are delineated. These activities are highlighted using different colours, described as follows:

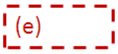
(1) The analysis of SCO information highlight in [(a)] in Figure 5.13 and Figure 5.14 can undergo any changes when desired by the IDs and SMEs.

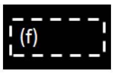
(2) The comments which can be pointed at on the storyboard card highlighted in [(b)] from Figure 5.14 can be a useful strategy in supporting annotated task activity.

(3) The displays of the assets belonged to the storyboard cards highlight in [(c)] can be a useful strategy to support collaborative narrative discussion of the storyboarding assets.

(4) The views of multiple storyboard cards belonged to the SMEs highlighted in

[] which can be seen in Figure 5.14 can be used as strategy to support common views and artifacts coordination between IDs and SMEs.

(5) The shared views of multiple storyboards cards belonged to the IDs highlighted in [] can be useful strategies to support shared design knowledge and design learning with the SMEs.

(6) The shared view of the storyboard cards associated with activities such as SCO information analysis, annotated task and narrative discussion can be useful IDs highlighted in [] to support collaborative design canvas.

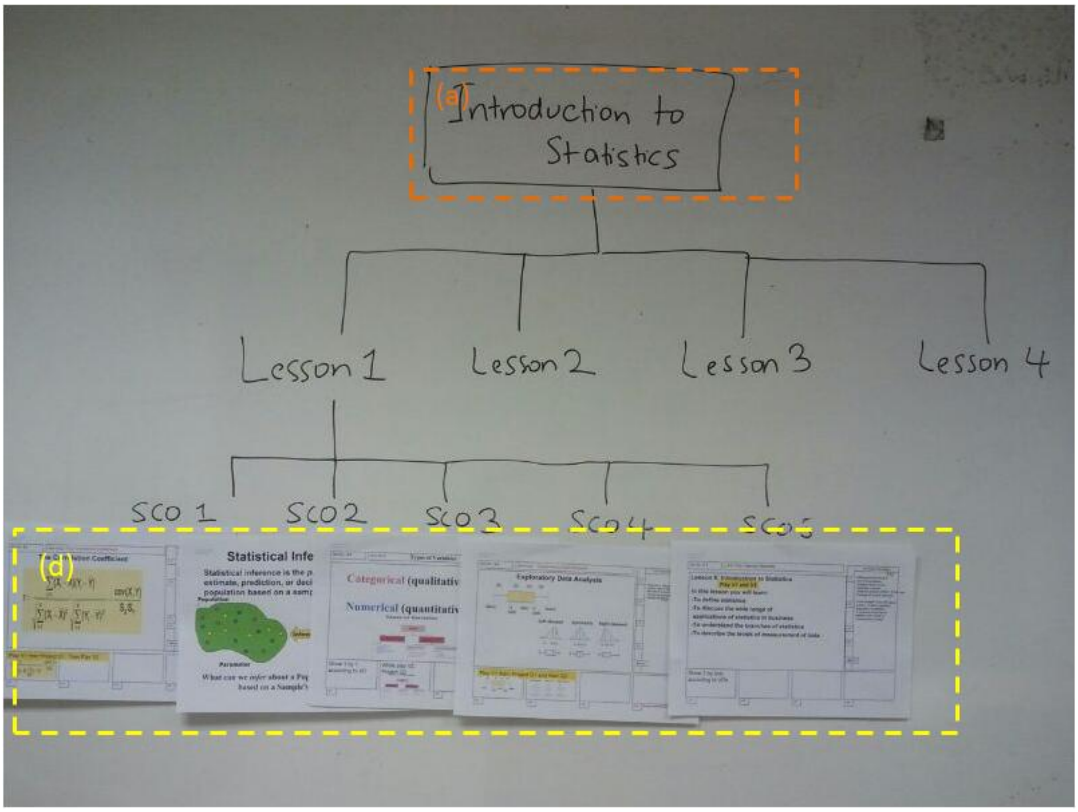


Figure 5.13: Externalizing cognitive artifact representation of SCOs' structuring

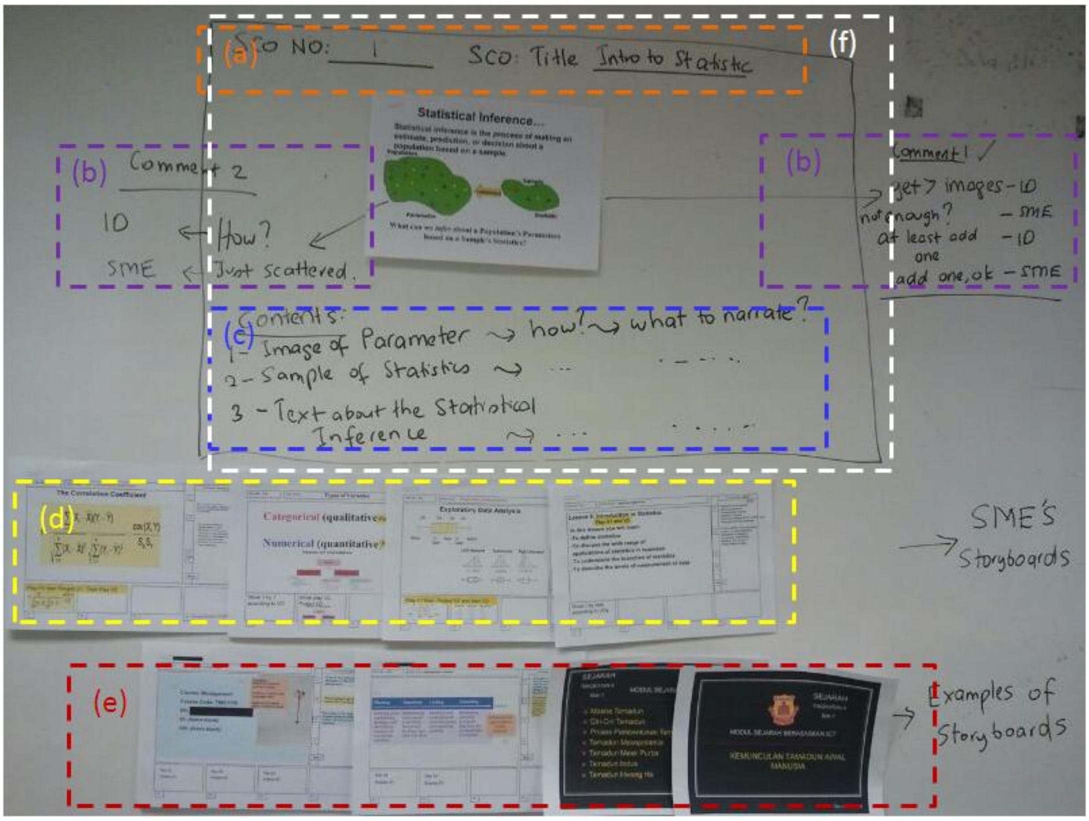


Figure 5.14: Representation and presentation of shared multiple views of SCOs

In the early discussion sessions of the pre-processing activity, the participants expressed their opinion that the storyboarding cards should be organised in some form and need to be viewed by all parties. This finding is supported by the results demonstrated by Robinson (2008) who observed analysts working in pairs to complete an information synthesis task using paper artefacts: it was noted that a significant amount of time during the beginning of each session was spent in establishing a common understanding.

In the processing activity, the IDs conveyed their views that when the storyboard cards are shared in multiple views, they were able to come up with better ideas in regard to the subject-matter. Moreover, the SMEs also expressed the advantages of being allowed to observe and view artefacts shared by the IDs. This finding correlates with the recommendations made by Truong et al. (2006), in which any design tool should take into consideration ways to allow a collection of designers to be able to show what they are creating and allow members of the same team to observe and easily borrow artefacts from other members.

5.2.7 Discussion

This section discusses two findings of experimentation on artefacts and visualization in eLearning storyboards: recognition of three shared cognitive dimensions and identification of six forms of shared visualization that was externalized from internal cognitive artefacts. It also provides some recommendations for a proposed agile storyboarding design process.

5.2.7.1 Three Shared Cognitive Dimensions

The analysis allowed recognition of three main shared cognitive dimensions in achieving a shared mental model during idea and information sharing and data exchange. They are called dimensions as they differ in terms of the process tasks, communication needs, collaborating member's knowledge and interaction styles. A brief description of the identified shared cognitive dimensions follows:

- *Shared conceptual storyboarding design:* This refers to the first communication activity involving IDs and SMEs. In this phase, the concept of the e-learning course was required, which involves the content and structure of the course and lessons. During the shared conceptual storyboarding design, the SMEs work was evaluated inside the design team where decisions on any changes and approvals were taken. It was found that shared visualisation in terms of structural views is important for reaching shared understandings and decisions. Nevertheless, it was also found the shared concept mapping strategy used as the medium of collaborative structuring led to a deeper conceptual understanding of the topic.
- *Shared detailed storyboarding design:* This refers to the process of embodiment and detailed storyboard design and mainly consists of requirements for multimedia assets. In this phase, the detailed storyboarding design requirements of the e-

learning lesson were required, which involved the multimedia content and structure of the lessons. During the shared detailed design, the SMEs work was evaluated and shared inside the design team to determine any required specific changes required. It was found that within this dimension, shared visualisation in terms of multiple views of storyboard artefacts designed by SMEs, shared views of the narrative abstraction and shared storyboarding artefact designs were crucial for sharing and exchanging the detailed design ideas.

- *Shared completed storyboarding design:* This refers to the final design produced from the detailed storyboard design. In this phase, the communication of the design production is required which involves the overall view of the completed design artefacts. This investigation identified that by having the collaborative annotation technique and shared thread discussion, the understanding of the shared design production could be achieved quickly.

5.2.7.2 Shared Visualization from Internal Cognitive Artifacts

Besides of recognizing shared cognitive dimensions, the analysis also allows the identification of internal cognitive artifacts that need to be displayed in shared visualization form in order to achieving common understanding of the storyboard design contents information:

- *Shared visualization for mapping conceptualization* - According to Stoyanova and Kommers, (2002), concept mapping is an effective tool for mediating computer-supported collaboration for cognitive construction and reconstruction. In this research context, using a concept map may support the IDs and SMEs in reaching common views using a shared view of the course structure, its lessons and associated links to particular SCOs. This is supported by Fischer, Bruhn, Gräsel and Mandl (2002) who found that by providing users with content-specific visualisation tools as a structural support, the process and the outcome of cooperative effort is improved, which can foster collaborative knowledge construction.

- *Shared visualization for mental image imagery*: Petre (2004) has shown that externalised images provide coordination mechanisms. In this research context, providing access to the multiple views of storyboard artefacts designed by SMEs may evoke comparable mental imagery in their minds which in turn supports coordination of storyboard design with the IDs.
- *Shared visualization for narrative abstraction:* In e-learning storyboards, SCOs contain narratives composed of navigation styles and interactivity of multimedia assets. In this research context, shared views of the narrative abstraction can determine the appropriate multimedia assets, branching specifications and voice-over scripts which can be applied to SCOs for each lesson. This may assist SMEs to detect vague and underspecified information which is required for multimedia development purposes. This was demonstrated by Davis, Li, O'Neill, Riedl and Nitsche (2011) who found that narrative abstraction can generate vague and underspecified mental images which can be explored and refined using Machinima digital film production techniques.
- *Shared visualization for design artefacts coordination:* Storyboarding design artefacts are at the centre of coordinating cooperation in design activities. The value of artefacts has been described by Susi and Ziemke (2001) who emphasized that artefacts play a strong role in human collective behaviour and thus can support interactions, in particular the coordination of cooperation. In this research context, a shared storyboarding artefact design which contains collections of multimedia objects with desired locations within the storyboarding canvas can be applied to support design activity coordination for the purpose of IDs' and SMEs' cooperation.

- *Shared visualization to support visual analytics:* In this investigation study, annotated commentary that is linking with the storyboarding cards conducted in the final session is able to reduce the time spent in all of the four levels of agile processing compare to the previous sessions. As being highlighted by Heer and Agrawala (2008), linking commentary with visualization states has significant role to support visual analytics. In this research context, collaborative annotation technique that is incorporated during the shared views of storyboarding artefact design may able to support end-user annotation of storyboard imagery to identify image and analyze points of interest.
- *Shared visualization to support community discussion:* Community discussion is technique that can integrate team members' decisions into patterns (Carroll, Rosson, Convertino, & Ganoe, 2006). As a part of CoP in instructional design, ID and SME's decision can be supported using shared visualization of threaded discussion.

5.2.8 Recommendation

During the experimental sessions, all of the four activity sessions presented to the participants have incorporated the agile storyboarding process. The IDs and SMEs expressed their opinions of the agile storyboarding process activities allowed the changes of their design to be more adaptive to their needs and requirements. The iterative method that was implemented during agile storyboarding is valued due to its ability to permit modifications of information or design in any of the processes. The detail design process of an agile storyboarding is summarized and depicted in Figure 5.15.

Agile Storyboarding Process	Major Activities	Cognitive Data Acquisition	Cognitive Data Representation	Cognitive Data Visualization	Shared Cognitive Dimensions
Pre-processing	The detailed eLearning course design document development	Mapping visualisation (Stoyanova & Kommers, 2002)	The course structure and assets	Collaborative concept mapping	***Shared conceptual storyboarding design***
Processing	The detailed eLearning course design interface development	Mental image imagery (Petre, 2004)	Storyboard artifacts designed by SMEs	Shared multiple representation	***Shared detailed storyboarding design***
		Narrative abstraction (Davis, Li, O'Neill, Riedl & Nitsche, 2011)	Narrative abstraction	Shared visualization	
		Design artefact coordination (Susi & Ziemke, 2001)	Storyboarding artefact design collections, User generated storyboard contents	Shared coordination	
Post-processing	The reviews of the eLearning storyboard artefacts	Visual analytics and sense-making (Heer & Agrawala, 2008)	Online commentary linking with the storyboarding cards	Collaborative annotation	***Shared completed storyboarding design***
		Communities of Practices (Carroll, Rosson, Convertino & Ganoe, 2006).	Online threaded discussion	Collaborative discussion board	
Re-design	The modification or alteration of information and design that occurs in any or all processing phases if corrections are needed				

Figure 5.15: Agile storyboarding design process and cognitive data process of SMM in eLearning storyboard

This process shows shared visualization techniques and strategies in relations with the agile storyboarding design process and major activities which is described as follows:

- In pre-processing phase, collaborative concept mapping technique can be used to represent course structure and assets.
- In processing phase, three shared visualization strategies are recommended. First is shared multiple representation of the storyboard artefacts designed by the SMEs, second is shared visualization of narrative abstraction, and third is shared coordination of storyboarding artefact design collections as well as user generated storyboard contents.

- In post-processing phase, two shared visualizations technique can be used. First is collaborative annotation to represent online commentary linking with the storyboarding cards and secondly is the collaborative discussion board to represent online threaded discussion.

There is no shared visualization technique and strategies can be recommended during re-design phase.

5.3 Summary

This chapter presents two empirical studies in eLearning storyboard. The first investigation study is aimed to identify cognitive task difficulties and expert skills required from the design process of eLearning storyboard. The second investigation study is aimed to identify the driven strategies of agile process and shared visualization required in eLearning storyboard to achieve particular common understanding.

From the two investigation studies, some information has been synthesized and concluded as follows:

- As a subject-matter and a novice storyboard designer, the SME faces two types of difficulties; cognitive task difficulties and inadequate skills in storyboarding. Within the context of cognitive task difficulties, the study has identified four sub-elements of eLearning storyboards which demand cognitive skills from the SME, namely: storyboard templates, VO scripts, graphics and animation, and review process. On the other hand, inadequate training in storyboarding has been found as the critical factor for the SME to perform storyboarding activities. As such, three recommendations are proposed which have led to the development of design guidelines of an eLearning storyboard to support ID and SME interaction.
- The roles of shared visualization and agile process are significant in eLearning storyboard to achieve particular common grounds between the ID and SME. Storyboarding activities which are performed in an iterative manner using different

ways of shared visualizations strategies, have led to different results of time spent in different processing levels. The value of integrating shared multiple views with annotation in eLearning storyboard to achieve particular common grounds between the ID and SME, have demonstrated a significant finding. As such, an agile model of storyboarding process and cognitive data process of SMM in eLearning storyboard is recommended.

Figure 5.16 shows achievement of research questions, summary of the literature reviews chapter (chapter 2, 3 and 4) and its connection with chapter 5.

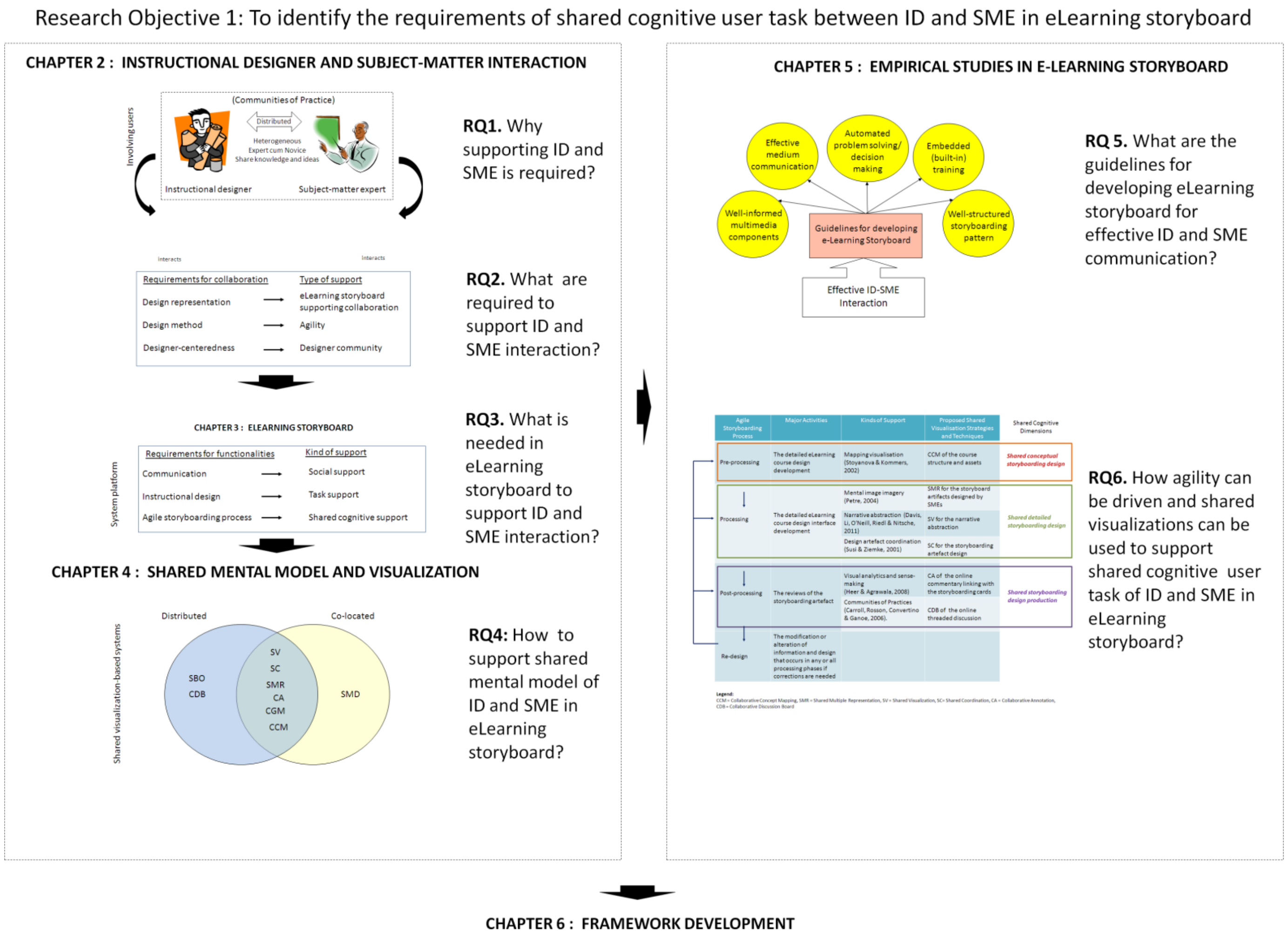


Figure 5.16: Achievement of research questions and connection from three literature review chapters, empirical study chapter to chapter 6

CHAPTER 6 FRAMEWORK DEVELOPMENT

In the previous chapters, three literature reviews and two empirical studies have been conducted, which have led to the achievement of research objective in identifying the requirements of shared cognitive user task between ID and SME in eLearning storyboard.

This chapter describes research work activities in order to complete research objective number two. It presents initial framework development of the eSCOUT, framework evaluation study and revised framework development. Summary of the framework development is discussed.

6.1 Introduction to Framework Development

The aim of the framework is to support shared cognitive user task in eLearning storyboard which is intended to ID and SME. This framework is called the eSCOUT, an acronym for "eLearning Storyboard for **S**hared **Co**gnitive **U**ser **T**ask".

In this research, the proposed framework is developed based on the information that has been synthesized from the previous three literature reviews and empirical studies conducted. Then, this initial framework is evaluated through expert evaluations. Consequently, the feedback serves as the input to improve the proposed eSCOUT framework.

6.2 Initial Framework Development

This section describes initial framework development of the eSCOUT, which begins by explaining its structure and continues by describing the focus and information of content. Finally, the working process of the eSCOUT framework is described using a scenario. Figure 6.1 shows a mapping thesis chapters information with the initial framework development.

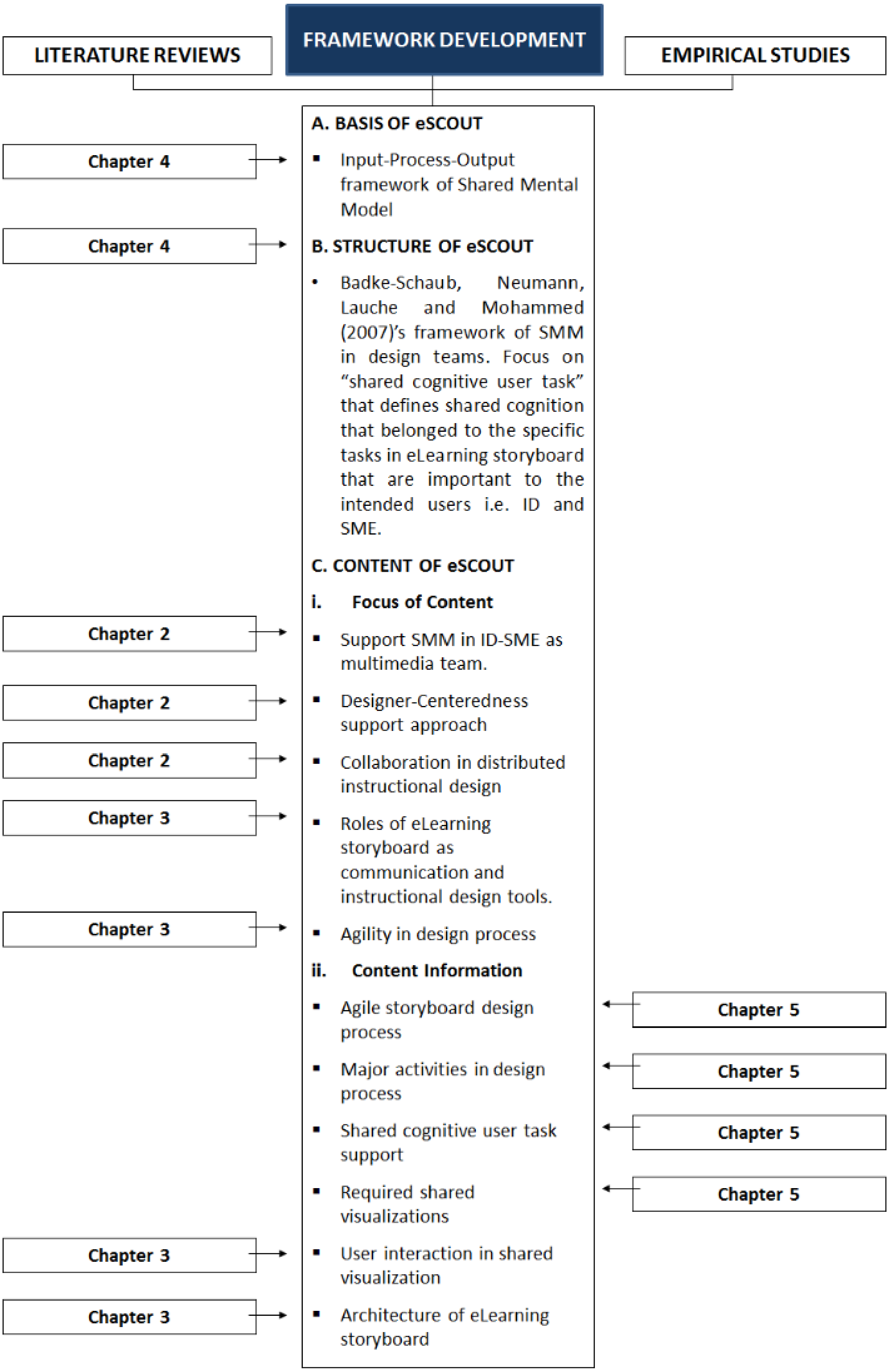


Figure 6.1: Mapping thesis chapters information with the framework development

6.2.1 Structure of eSCOUT

The basis of the eSCOUT is designed based on Badke-Schaub, Neumann, Lauche and Mohammed (2007)'s SMM framework for design team that follow the IPO structure. As being mentioned in Chapter 3, the knowledge and needs derived from ID and SME form the individual mental model. According to this model, when ID and SME interact with each other, the SMM develops. The eSCOUT focuses on the aspect of task in SMM which can lead to the development of TMM. It is referred to the "shared cognitive user task" that concerns on shared cognition that belonged to the specific tasks in eLearning storyboard. Figure 6.2 shows the structure of the eSCOUT.

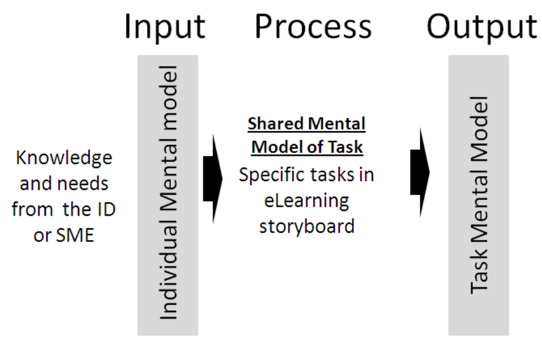


Figure 6.2: Structure of the eSCOUT

6.2.2 Contents of eSCOUT

Contents of the eSCOUT refer to the detail composition of the structure. The eSCOUT framework focuses on several aspects identified from the literature review. First, it focuses on the support of ID and SME as a multimedia design team. Second, it is an approach that support designers-centeredness rather than leaner-centeredness. As such, this framework does not aim to assist learners for learning. Conversely, it is aimed to assist design teams interaction who develops the eLearning course. Third, it also focuses on collaborative work between ID and SME in a distributed instructional design environment. Fourth, the eSCOUT needs to perform the common roles of any eLearning storyboard; the ability to allow communication between ID and SME as well as the ability to perform instructional design activities. Finally, the eSCOUT offers agility in design process which is seen only in a few storyboard tools, conceptual model and frameworks. The contents of each structure are described following the structural process, which contains three parts; input, process and output.

6.2.2.1 Input

The input refers to the data process that derived from the knowledge and needs of ID and SME. In the literature, these data sources are graphic themes, instructional methods, interactivity, constraints, ways of evaluation in the course and preliminary course plan (Donahue, 2005). These data constitutes in the individual mental model of the ID and/or SME.

6.2.2.2 Process

The process refers to the process of the data sources that lead to the development of TMM. Based on the experimental study results, this process is divided into four processing phases; pre-processing, processing, post-processing and re-design. Based on this finding, each process is supported using particular shared visualization technique and strategies, except for re-design which is shown in Figure 6.3. Next section explains the four processing phase in the eSCOUT.

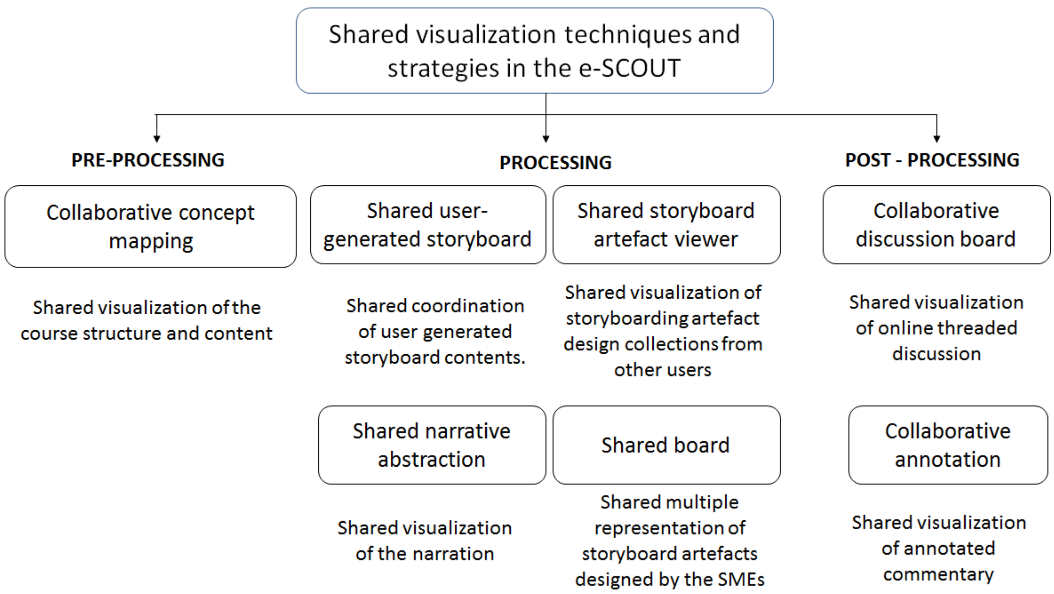


Figure 6.3: Shared visualization techniques and strategies in the eSCOUT

(a) ***Pre-processing Phase***

The pre-processing phase is intended to achieve detailed eLearning course design document development. In this phase, shared cognitive user task can be supported using collaborative mapping technique. Examples of related cognitive task activities include mapping learning objectives and instructional design methods with the SCOs. In eSCOUT, when ID and SME collaborate and share structuring content activities, they communicate the focus on pertinent information in the map which can lead to the development of TMM.

(b) ***Processing Phase***

The processing phase is intended to achieve detailed eLearning course design interface development. In this phase, shared cognitive user task can be supported using four shared visualization strategies:

- Shared board: It refers to shared multiple representation strategy of storyboard artefacts designed by the SMEs
- Shared storyboard artefact viewer: It refers to shared visualization of storyboarding artefact design collections from other users.
- Shared user-generated storyboard: It refers to shared coordination of user generated storyboard contents.
- Shared narrative abstraction: It refers to shared visualization of narration abstraction

Examples of related cognitive task activities includes identifying graphics and audio to particular SCOs as well as locating appropriate text and graphic at the display area. These activities are referred to the task in designing multimedia specifications for eLearning course. In eSCOUT, when ID and SME collaborate and share designing multimedia activities, they coordinate design activities which can lead to the development of TMM.

(c) ***Post-processing Phase***

The post-processing phase is intended to achieve completion of eLearning course design concept. In this phase, shared cognitive user task can be supported using collaborative annotation and collaborative discussion board. Examples of related cognitive task activities include online commentary linking with storyboard design content and online threaded discussion. In eSCOUT, when ID and SME collaborate and share commenting and discussing review activities, they share decision which can lead to the development of TMM.

(d) ***Re-design Phase***

The re-design phase is intended towards modification or alteration of information and design that occurs in any or all processing phases if corrections are needed. There is no proposed visualization strategy and technique for this phase.

(e) ***ID- SME Interaction in the eSCOUT***

Both ID and SME are able to interact with the system in terms of four aspects: joining/leaving, floor control, privacy, and global view (Brodlie, Duce, Gallop, Walton and Wood, 2004). Firstly, they are able to join and leave at any time during collaborative activities. Second, they are able to authorize access to other users in terms of allowing editing, or sharing or both editing and sharing authority. Third, they are able work privately and at the same time, still remain in the collaborative environment in order to protect some design information and content. Finally, they are able to view other users' activities.

6.2.2.3 Output

The output refers to the finalized storyboard design content which are generated from the pre-processing, processing and post-processing phase activities. The information and content is displayed in a form of shared visualization. The output of the storyboard design artefacts can be published in four types of graphic file format; Portable

Document Format (using .pdf extension), Scalable Vector Graphics (using .svg extension), Portable Network Graphic (using .png extension) or Joint Photographic Expert Group (using .jpeg extension). These formats are chosen because generally they are able to retain their original formatting and style across differing platforms or operating system. All storyboard design contents are saved as a package and kept in database. This is to allow IDs to give permission to their multimedia development teams to access contents of the storyboard for development purpose.

Figure 6.4 depicts the schematic diagram of the eSCOUT initial framework development. The horizontal flow in the diagram indicates basis of the eSCOUT; the IPO framework. The vertical flow refers to agile storyboarding design process that shows design cycles, intended goal for each design cycle, specific task activities and types of strategies and techniques to support shared cognitive user tasks in eLearning storyboard.

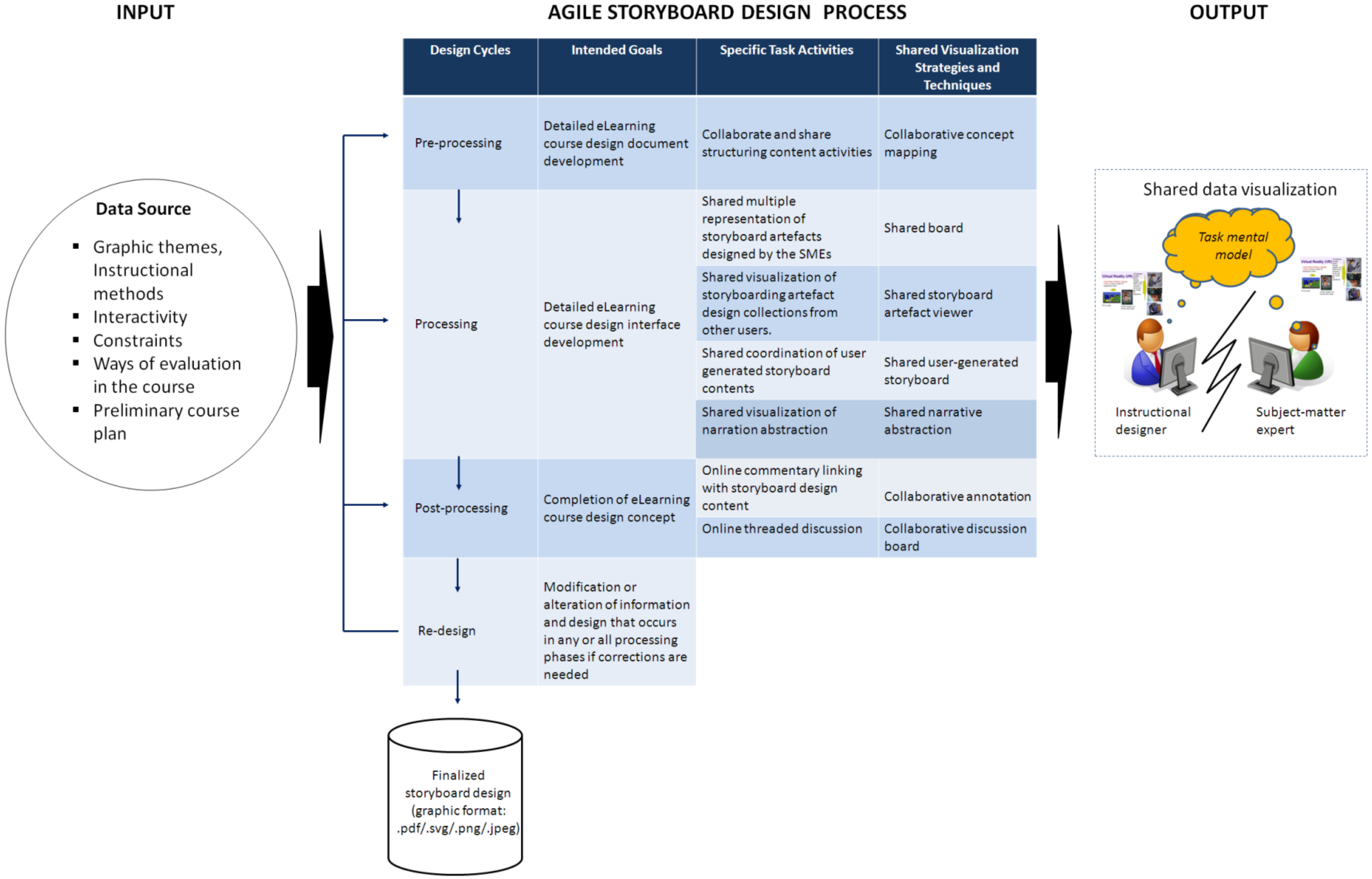


Figure 6.4: Initial framework development of the eSCOUT

6.2.3 A Scenario

In practical cases of eLearning course development, the design teams who are located in dispersed geographical areas have to communicate using the eSCOUT as part of an on-going discussion. The design process of eSCOUT starts when the SMM is built through the acquisition of team knowledge. Ellwart, Biemann and Rack (2011) advocate that successful coordination processes rely on “commonly shared knowledge that team member have about a task and each other” (2011, p. 155).

The first communication activity between ID and SME occurs in pre-processing phase. Using collaborative technique, SME starts to draw a structural view of the storyboards reflected from his/her lessons and course. SME can give authorization to the ID to access his/her structural drawing task in terms of allowing task editing, or task sharing or both task editing and task sharing. Both ID and SME can work together on the structural drawing task in real-time or different time mode.

When the structural content of storyboard is completed, the ID and SME can move to the processing phase to begin designing storyboard. SME can sketch his/her storyboard in a virtual canvas and save his/her own storyboard design contents. Using shared user-generated strategy, these storyboards design can be coordinated with ID, by giving certain access authorization. SME can also provide narrative information and share the view information with ID. Another shared visualization strategy that can be used by the SMEs in this processing phase is to share not only a single view of his/her own storyboard design, but also a view of multiple representation of his/her own storyboard artefacts with IDs. Conversely, IDs can also share his/her shared visualization of storyboarding artefact design collections from other users in the eSCOUT. In this processing phase, both ID and SME can work together on the detailed storyboard design task either in real-time or different time mode.

After the storyboard design is completed, ID and SME can move to the post-processing phase. In this phase, ID and SME use collaborative annotation and collaborative discussion board strategies to provide comments and reviews of the completed storyboard design. Collaborative annotation strategy provide shared views in terms of threaded comments given by ID and SME to any specific drawing objects or text in the virtual storyboard canvas design. On the other hand, collaborative discussion provides shared views in terms of online threaded discussion. ID and SME can use this strategy to discuss together any issues pertaining the completed storyboard design. This phase also allows ID and SME to work together on the reviewing storyboard design task either in real-time or different time mode.

If there is any modification or alteration of information and design needed, ID and SME can go back to any processing phases to do the corrections. ID and SME can published the storyboard in four types of graphic file format; Portable Document Format (using .pdf extension), Scalable Vector Graphics (using .svg extension), Portable Network Graphic (using .png extension) or Joint Photographic Expert Group (using .jpeg extension). These full packages of storyboard design content and information can be retrieved by the multimedia development team for development purpose. Next section describes framework evaluation of the eSCOUT.

6.3 Framework Evaluation

The framework is conducted using expert evaluation. The evaluation study is described as follows. It begins with providing procedure in soliciting the experts. Next, it explains research procedures and design and finally, it presents the data findings which lead to some discussions and revised framework development of the eSCOUT.

6.3.1 Purpose of Study

The main aim of the framework evaluation study is to solicit towards experts' opinions about the proposed eSCOUT framework. It includes gaining suggestions and recommendations to validate and/or improve the structural and functional process in the eSCOUT framework. We are particularly interested in the questions and recommendations and how these comments can be used to improve the initial eSCOUT framework. It is hope that the findings will provide useful and practical information to revise the proposed eSCOUT framework.

The guiding research questions are designed as follows:

- Are the four proposed storyboard processing phases appropriate and can be used to support common ground activities?
- Are the seven proposed strategies and techniques support appropriateness, importance, clarity and understandability to support common ground activities in eLearning storyboard?
- What are the advantage and disadvantages of the eSCOUT?
- What are the needs and recommendations addressed by the experts?

6.3.2 Participants

Two types of expert groups from academics and industry are pulled in and invited to participate in the study. Therefore, this process involves two sets of evaluations, the academic-based evaluation and the practitioner-based evaluation.

(a) ***Soliciting Pre-Recruited Academicians***

First evaluation of the eSCOUT framework initial design is assessed by a panel of academic experts. Tory and Moller (2005) proposed that the result of an expert review will depend on experts' qualifications, where their opinions will be subjective and vary. In this research, panels of invited academic experts are professors, associate professors, and senior lecturers in the required disciplines of computer-based instructional design, human-computer interaction and eLearning technologies. They are carefully selected from Microsoft Academic Research portal[12], Research Gate portal[13], authors whose publications appeared in high reputable journals indexed by the Institute for Scientific Information (ISI), and through recommendations of the respondent experts.

(b) ***Soliciting Pre-Recruited Practitioners***

Second evaluation is assessed by a professional group of practitioning storyboard designers and eLearning practitioners. To make an in-depth review of a framework is not adequate with the academicians who may accept the proposed framework; however they rarely fully understand it in real practice. In this research, the framework evaluation has also conducted with a group of practitioning storyboard designers and eLearning practitioners who are experts in storyboarding for eLearning design and development. They are carefully selected from the LinkedIn[14] professional social

---

[12] http://academic.research.microsoft.com/
[13] https://www.researchgate.net/home.Home.html
[14] https://www.linkedin.com/

network portal and recommendations from the respondent practitioning storyboard designers/eLearning practitioners.

After identifying the potential experts' panels, the pre-recruited academicians and practitioners are contacted through emails where pre-notification messages are sent to them for the purpose of informing the experts about the invitation of the survey. In order to achieve high response rates from the experts, email invitations are designed based on Fan and Yan (2010)'s guidelines which include as follows:

- Personalization of salutation, the researcher's affiliation, and contacts
- The access control to the URL (https://www.surveymonkey.com/s/eSCOUT) / (URL: https://www.surveymonkey.com/s/eSCOUT-for-practitioner) are provided where search identifier for the domain is not accessible for any search engines. It means the URL can only be found from the email else, it needs to be typed.

The scarcity of the evaluation is also mentioned to the experts. The experts are informed that they are a small selected group that has been chosen for this evaluation and there is a need to complete the survey within a month.

After two days of initial invitation, the expert panels are sent with email follow-up reminders.

(c) ***Participating Academicians and Practitioners***

It takes approximately two months to outreach a good numbers of participating academicians and practitioners. During the period of invitation, a total of thirteen academic experts involving four international and nine locals replied the email invitation and agreed to participate in the expert evaluation study. On the other hand, fourteen practitioners of eLearning and storyboarding the area of Kelang Valley, Kuala Lumpur, Malaysia agreed to participate in the study.

According to Rubio, Berg-Weger, Tebb, Lee and Rauch (2003), an adequate number of panel experts should range between 6 – 20 participants. In this research, having more experts (i.e. total number of twenty-seven experts) should produce more information and better evaluation towards the framework. Meanwhile, other academicians and practitioners have declined the invitation due to irrelevancy to their area of expertise, occupied with work etc., while some emails go unanswered.

After the evaluation is completed, a humble honorarium is provided to the experts. The honorarium is paid in terms of cash honorarium, or a token which is sent away through post-mail, together with a note of appreciation. The design of email invitation is provided in Appendix D and F, while the complete profiles of participating academicians and practitioners are shown in Appendix H and I for reference.

6.3.3 Research Procedures and Design

The evaluation study is conducted using questionnaires and Lauesen (2007)'s Virtual Windows Method.

6.3.3.1 The Virtual Windows Method

The framework evaluation is conducted using the Virtual Windows Method (Lauesen, 2007). A virtual windows method is an early graphical realization of data presentation that resembles finished windows with some graphical details of realistic data contents (Lauesen, 2007, pp.x). In this evaluation study, the framework diagram is showed to the academicians and practitioners, accompanied with some virtual windows designs. Virtual windows design is developed from the initial eSCOUT framework. The print out (hard copy) of the screen pictures can be used by the participants to experience the screens that look like real where they can improvise the findings and results by means of paper and pencil (Lauesen, 2007, pp.61). Figure 6.5 shows the steps towards virtual windows design for the framework evaluation.

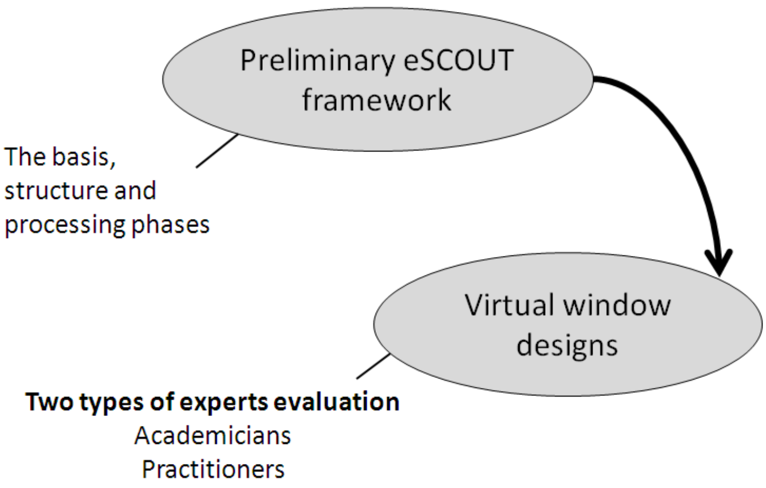


Figure 6.5: Steps towards virtual windows design for the framework evaluation

The overview of all of the virtual windows is shown in Figure 6.6. The tasks and shared visualization strategies and techniques have been indicated in each virtual window design which is sorted in ascending processing of order.

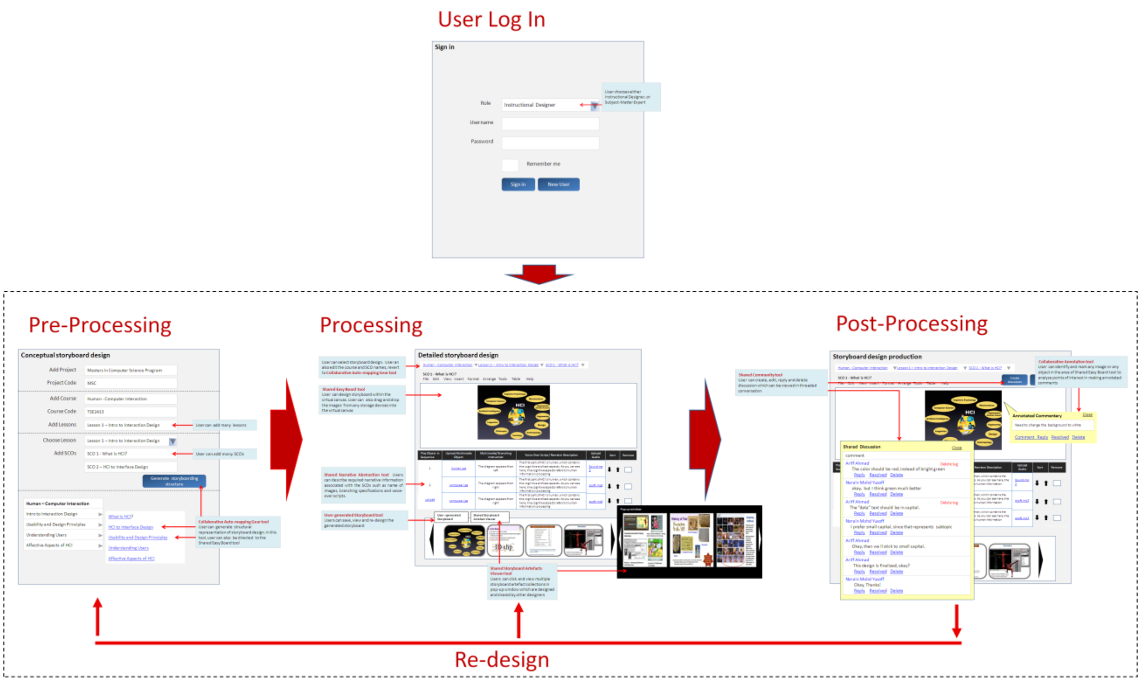


Figure 6.6: The agile storyboarding design process and virtual windows designs

6.3.3.2 Questionnaires development

This framework evaluation is designed for the participating experts to evaluate the structural and functional design process of the eSCOUT initial design model. By providing their suggestions and revisions, it is believed that the panel of experts can further enhance the quality of the eSCOUT structural and functional design process. Following Yang and Chan (2008)'s approach, the exemplification of content validity is revised and designed into framework evaluation in order to fit within the aim of this research. The following describes in detailed, the structure of questionnaires and information about the research procedures.

(a) ***Structure of questionnaires***

The framework evaluation study contains two sets questionnaires for the academicians and practitioners.

The academicians' evaluation is designed specifically to seek towards academic experts' opinions, suggestions and recommendations to validate and/or improve the structural and functional processing phases, tools and functionalities in the eSCOUT framework. On the other hand, the practitioners' evaluation is designed to check whether the structural and functional process in the eSCOUT framework is understandable and corresponds to the real tasks, or in other word, it matches the users. However, both evaluations are generally directed to solicit validation, suggestions and recommendation to improve the eSCOUT.

A similar questionnaires are supplied to both groups of experts, but the questions addressed for Part A (e.g.: demographic information) and Part B (Processing phases) are addressed in two different ways, in order to fit the career environment of both academic experts and practitioners. It is conducted such way so that an integrated evaluation result and analysis of the framework can be produced. For example, an understandability items are added to seek a better understandability of the proposed processing phases from the view of those practitioners. Moreover, using virtual windows, the understandability test can be conducted in a more meaningful way because of the detailed graphics and the realistic screen designs representing the framework.

(b) ***The four sections of questionnaire***

The set of framework evaluation questionnaires consists of four sections:

- **Part A: Introduction and Directions -** This section aims to clarify the purpose for the invited experts to validate the items in the questionnaire. It describes to the experts the purpose of study, research questions, expected information gained from the experts. It also contains needed experts information for demographic purpose. Clear and concise instructions are given to help the experts to state their opinions efficiently.
- **Part B: The Storyboard Processing Phases** – This section aims to identify whether the proposed processing phases are appropriate and can support particular storyboarding activities. It describes four storyboard processing phases and their functionalities;

  1- Pre-processing phase,

  2- Processing phase

  3- Post-processing phase, and

  4- Re-design phase

  The experts are asked to rate the appropriateness and support of the proposed processing phases by checking one of the following options: (1) Yes, it/they is/are belong to the appropriate Pre/Processing/Post processing Phase, or (2) No, it/they is/are not belong to the appropriate Pre/Processing/Post processing Phase, with comments and alternative solutions to further clarify their judgments.

- **Part C: The Shared Visualization Strategies and Techniques –** This section aims to determine whether the propose shared visualization technique and strategies are designed for the correct representatives and important for the corresponding storyboard design process as well whether the tool functionality is clear and understandable. It describes seven shared visualization technique and strategies:

  1) Collaborative concept mapping
  2) Shared board
  3) Shared storyboard artefact viewer
  4) Shared user-generated storyboard
  5) Shared narrative abstraction
  6) Collaborative annotation
  7) Collaborative discussion board

  The experts are asked to rate each of the proposed shared visualization technique and strategies based on those four indexes:

  1) Representativeness: It is used to determine whether the shared visualization technique and strategies stand for the right representation and emergence of SMM development in a five-point scale. A rating of five is the most representative for the factor. Experts can also provide a revision or comments under the rating. That is, if the expert thinks the shared visualization technique and strategies are not the appropriate representative of the corresponding processing phase, they can state reasons as to why the shared visualization technique and strategies might be more appropriate for another processing phase.

  2) Importance: It represents whether the shared visualization technique and strategies are important for the corresponding processing phase in a five-point scale. The rating of five indicates that the shared visualization technique and strategies are the most important.

3) Clarity: It represents whether the shared visualization technique and strategies are clear enough for experts to understand in a five-point scale. The rating of five represents the highest clarity. The experts can offer some recommendations about unclear description.

4) Understandability: It represents whether the shared visualization technique and strategies are understood by experts using a five-point scale. The rating of five represents the highest understandability. The experts can offer some recommendations about description which is not understood.

- **Part D: Comprehensive Evaluations of the eSCOUT –** This section aims to find out problems and recommendations that would improve the design of eSCOUT framework. It describes the schematic diagram of the eSCOUT framework and its requirements. The experts are asked to rate the overall structural and functional design of the eSCOUT, as well as providing suggestions or recommendations about the comprehensiveness of the expert validity evaluation (the entire measurement) which can improve the quality of the eSCOUT framework design and development.

The complete questionnaires addressed to both academicians and practitioners can be referred in Appendix E and G. Table 6.1 shows the structure of questionnaires mapping to the study objectives.

Table 6.1: Structure of the framework evaluation questionnaires

Evaluation Sections	Objectives	Type of Questionnaire
Part A Introduction and Direction	To clarify the purpose for the invited experts to validate the items in the questionnaire.	Open-ended questions
Part B The Storyboard Processing Phases	To identify whether the proposed processing phases are appropriate for each storyboarding activities.	Close-ended questions (yes/no) Comments/suggestions (if any)
Part C The Shared Visualization Strategies and Techniques	To determine whether the proposed shared visualization strategies and techniques are designed for the correct representatives, important and clear for the corresponding storyboard design process.	Item rated on a 5-point scale. (1='Not appropriate/ important/clear'; 5 ='Very appropriate/ important/clear') Comments/suggestions (if any)
Part D Comprehensive Evaluation of the eSCOUT	To find out problems and recommendations that would improve the design of eSCOUT framework.	Item rated on a 5-point scale. (1='Need overall revision of the shared visualization technique and strategies; 5 ='Perfect shared visualization technique and strategies') Comments/suggestions (if any)

(c) ***Methodological triangulation of data***

The research procedures conducted with academicians and practitioners are different in terms of the evaluation environment.

Due to the geographical and the time limitations of the participating academicians, the evaluation is conducted using online survey. The evaluation is conducted via emails received from the experts, which are replied where later an URL (https://www.surveymonkey.com/s/eSCOUT) is supplied to the experts to complete their survey via internet. Due to geographical constraints to outreach the academic experts, other means of communication to explain the eSCOUT framework is also conducted via Skype, telephone and emails.

On the other hand, practitioners' evaluation is conducted in face-to-face (F2F) visits. This way of evaluation is conducted with the individual practitioners (based on ad-hoc invitation) as follows:

i. A meeting with the practitioner (s) is arranged and conducted at the Microsoft.NET/ Usability lab in Multimedia University, Cyberjaya, Selangor. Some arrangements are conducted at other places, such as at their companies themselves and coffee houses.
ii. Before the meeting starts, the eSCOUT framework is explained to the practitioners.
iii. At the meeting, the copies of the virtual windows designs as shown in Appendix C are given to the designers. Each of the windows is explained about what the supporting shared visualization strategies and techniques are and the generated output that are supposed to show.
iv. The practitioners are asked to show any defects and outline alternative solutions using the online questionnaires (URL: https://www.surveymonkey.com/s/eSCOUT-for-practitioner) to complete their survey via internet.

This framework evaluation uses the mixed-mode survey suggested by Porter and Whitcomb (2007) where mix modes of email and internet are used to deliver the survey upon the response and agreement received from the pre-recruited academic expert and practitioners.

6.3.4 Framework Evaluation Results

In this section, the quantitative and qualitative results are presented. These results are separated and presented into four parts:

1- Demographic results,
2- The storyboard processing phases
3- The shared visualization strategies and techniques
4- The comprehensive feedback of the eSCOUT.

Both quantitative and qualitative data obtained from academicians and practitioners is also separated in order to see the significance opinions between the two groups. Using this mixed methods research approach that combines quantitative and qualitative research, it helps developing rich insights into various phenomena of interest that cannot be fully understood using only a quantitative or a qualitative method (Venkatesh, Brown, & Bala, 2013).

The demographic results are shown by the percentage of general demographic characteristics and expert-related knowledge and skills. The demographic information between the academicians and practitioners are separated to see the differences of the two groups.

The quantitative results are shown by the average and standard deviation from each of the feedback. Overall mean for each shared visualization strategy and technique is also calculated to find out the experts' opinions regarding the proposed processing phases, shared visualization strategies and techniques, and the overall evaluation of the eSCOUT. On the other hand, the qualitative results from the experts' feedbacks are delineated into three categories; compliments, criticisms and further improvements. Compliments in this context refer to the expert's statement that appraise or admire the particular or general features of the eSCOUT, criticisms refer to the expert's statement that disapprove, and further improvements refers to the expert's statement that contains suggestions for improvement in the future eSCOUT system.

At the end of each part, triangulation result which comes across the assessment provided by the ID and SME is compared.

Complete list of compliments, criticisms and further improvements of the experts' feedbacks are shown in Appendix J and have been paraphrased. The general demographic characteristics of the experts which include gender, education and nationality are summarized in Table 6:2.

6.3.4.1 Part 1 - Demographic Results

(a) ***Demographic Characteristics***

The general demographic characteristics of the experts which include gender, education and nationality are summarized in Table 6.2

Table 6.2: Demographic characteristics of experts (N=27)

Demographic Dimension	Demographic Items	Academicians (N=13)	Practitioners (N=14)
Gender	Male	8 (61.5%)	4 (28.6%)
	Female	5 (38.5%)	10 (71.4%)
Education	Bachelor	0 (0.0%)	6 (42.9%)
	Masters degree	0 (0.0%)	8 (57.1%)
	PhD	13 (100%)	0 (0.0%)
Nationality *	Local	9 (69.2%)	14 (100%)
	International	4 (30.8%)	0 (0.0%)

Remarks:
* Nationality includes Malaysia, Canada, the USA and Pakistan

(b) ***Expertise Related-Knowledge and Skills***

Table 6.3 shows the academicians' expertise information which includes percentage in terms of designation, areas of specialization and years of experience. Table 6.4 shows the practitioners' expertise information which includes percentage in terms of designation, storyboarding phase involvement, number of storyboard production, professional skills and years of storyboarding experience.

Table 6.3: Academicians' expertise information (N=13)

Expertise Information	Academicians(N=13)
Designation	Professor: 10 (76.9%) Associate Professor: 3 (23.1%)
*Areas of research specialization	Computer-based instructional design: 5 (35.7%) Instructional design technologies: 4 (28.6%) Human-computer Interaction: 6 (42.9%) ELearning technologies: 8 (57.1%) Others: mobile learning, simulations and gaming e-content development
Years of experience in research specialization	More than 10 years: 11 (84.6%) More than 7 years: 1 (7.7%) More than 5 years: 1 (7.7%)

Remarks:
* Research specialization may include multiple areas

Table 6.4: Practitioners' expertise information (N=14)

Expertise Information	Practitioners(N=14)
Designation	Head of department: 2 (14.3%) General Manager/Manager: 3 (21.4%) Senior / Instructional designer: 5 (35.7%) Multimedia designer: 2 (14.3%) Instructional systems designer: 2 (14.3%)
*Storyboarding phase involvement	Analysis: 12 (85.7%) Design: 14 (100%) Development: 12 (85.7%) Implementation: 10 (71.4%) Evaluation: 9 (64.3%)
Number of storyboard production	< 20 storyboard designs: 10 (71.4%) 15 > x < 20 storyboard designs: 1 (7.1%) 10 > x < 15 storyboard designs: 1 (7.1%) 5 > x < 10 storyboard designs: 2 (14.3%)
**Professional skills	Communication skills: 12 (85.7%) Instructional design models and strategies: 10 (71.4%) Problem solving and decision making skills: 12 (85.7%) Technology skills: 11 (78.6%)
Years of experience in storyboarding	3 > x < 5 years: 3 (21.4%) 5 > x < 7 years: 1 (7.1%) 7 > x < 10 years: 3 (21.4%) 10 > x < 15 years: 7 (50.0%)

Remarks:
* Storyboarding phase involvement may include multiple areas which refers to:
- Analysis – the process to define what to be learnt
- Design – the process to define how learning would occur

- Development – the process to author and produce the material
- Implementation – the process to install the instruction in the real world
- Evaluation – the process to determine the impact of instruction

**Professional skills may include multiple areas which refers to:

- Communication skills – able to communicate effectively with clients and SMEs
- Instructional design models and strategies – well-versed in different types of instructional design models and strategies for which to choose for case-specific process
- Problem solving and decision making skills – able to perform multiple roles and responsibilities, steps into new roles when necessary and overcome barriers over datelines
- Technology skills – have basic knowledge of software tools used in instructional design work and aware of newly available advanced tools

6.3.4.2 Part 2 - The Storyboard Processing Phases

This section presents the main results on the appropriateness and supports in reaching common ground activities with four storyboard processing phases; pre-processing, processing, post-processing and re-design.

(a) ***Pre-processing phase***

Table 6.5 presents the main results on the appropriateness and support of the pre-processing phase for reaching common plan. The description of result as follows:

- The views on both appropriateness and support of the pre-processing phase are higher in academicians group (M=1, SD= 0) than in the practitioners (M=0.86, SD=0.36).
- Overall mean value integrated from both groups shows that the pre-processing phase is given high rate of appropriateness and support (M=0.93).

Table 6.5: Experts' means and standard deviations of appropriateness and support of the pre-processing phase.

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
Pre-processing phase	B01. Appropriateness for reaching common plan in conceptual storyboard design activities	1	0	0.86	0.36
	B02. Conceptual storyboard design activities can be supported in this pre-processing phase	1	0	0.86	0.36
	Mean of sample means =	1	-	0.86	-
	Overall mean =	0.93			

* Items rated as yes or no (1="yes"; 0="no")

Some qualitative feedbacks of the pre-processing phase are obtained from the experts. A compliment is received by the expert who stated that this phase is critical because it reflects the beginning of interaction between IDs and SMEs. One academician questioned about the outcome of the design which does not look like a standard storyboard. Despite of these comments, seven improvements have been proposed by the experts as follows:

- To add learning outcomes
- To clarify the roles and functionalities of / for ID and SME
- To provide kinds of instructional design model to be applied in storyboard
- To provide limitation in adding lessons, SCOs and storyboard contents
- To restrict the time period or learning hours of the courseware
- To add a chat box in order to kick start the communication process.
- To provide information description of the storyboard owner such as names of ID, SME, versions for continuity and quality assurance.

(b) ***Processing phase***

Table 6.6 presents the main results on the appropriateness and support of the processing phase for reaching common decision. The description of result as follows:

- The views on both appropriateness of the processing phase are higher in academicians group (M=1, SD= 0) than in the practitioners (M=0.79, SD=0.43).
- The views on support of the processing phase are slightly higher in practitioners group (M=0.93, SD= 0.27) than in the academicians (M=0.92, SD=0.28).
- Overall mean value integrated from both groups shows that the processing phase is given high rate of appropriateness and support (M=0.91).

Table 6.6: Experts' means and standard deviations of appropriateness and support of the processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
Processing phase	B03. Appropriateness for reaching common decision in detailed storyboard design requirements	1	0	0.79	0.43
	B04. Detailed storyboard design requirements can be supported in this processing phase	0.92	0.28	0.93	0.27
	Mean of sample means =	0.96	-	0.86	-
	Overall mean =	0.91			

* Items rated as yes or no (1="yes"; 0="no")

Some qualitative feedbacks of the processing phase are obtained from the experts. A compliment is received from the academician who stated that this phase is appropriate as it allows multimedia development. However, seven questions and criticisms have been pointed out:

- Can the processing phase to allow the design team to get images that are self-created?
- Which technique and strategies allow the ID to move the content and activities that conform to the sequence of instructional event?
- Can the users set the time? Or any time locations in this processing phase?

- Confusion between two breaking modes i.e. the viewer mode and editing mode which sounds like one function (i.e. User-generated storyboard and edit storyboard design contents which previously generated by the Shared Board. Thus Shared Board is explain as "The design in this electronic virtual canvas can be saved, generated and shared with other users for viewing or editing")
- Digestion of information using the technique and strategies is too much, thus consume time to get use with the technique and strategies.
- How does the user-generated storyboard strategies appear?
- The SCOs can be as small as a text in a circle, how is the meta-data being utilized here?

Seven suggestions have been proposed by the experts for the processing phase includes:

- To reduce the interface elements.
- To provide feedback though annotations at specific points of user interface.
- To add “search function”
- To provide WYSIWYG (What-You-See-Is-What-You-Get) environment with less clicks
- To add status field on the screen so that it helps users in understand the status of the design process
- To provide functionality to seek permission from the original 'content provider' when altering or editing the content and design.
- To add in the chat and search function plus next and back button

(c) Post-processing phase

Table 6.7 presents the main results on the appropriateness and support of the post-processing phase for reaching common plan. The description of result as follows:

- The views on both appropriateness and support of the processing phase are slightly higher in practitioners group (M=0.93, SD= 0.27) than in the academicians (M=0.79, SD=0.43).
- Overall mean value integrated from both groups shows that the processing phase is given high rate of appropriateness and support (M=0.93).

Table 6.7: Experts' means and standard deviations of appropriateness and support of the post-processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
Post-processing phase	B05. Appropriateness for reaching common decision in storyboard design production	0.92	0.28	0.93	0.27
	B06. Storyboard design decision can be supported in this post-processing phase	0.92	0.28	0.93	0.27
	Mean of sample means =	0.92	-	0.93	-
	Overall mean =	0.93			

* Items rated as yes or no (1="yes"; 0="no")

Some qualitative feedbacks of the post-processing phase are obtained from the experts. A practitioner agrees that the post-processing phase is appropriate to speed-up the entire development of storyboard design process. However, there is no criticism obtained from the experts. Besides, the academicians provide three suggestions for improvements include:

- To apply standard operating procedures that focus on important issues.
- To provide a shared visualization technique and strategy which allow the ID to design the instruction i.e. arranging the content and activities that prescribed to the designated ID principle such as learning/performance objectives, recall of prior knowledge, formative assessment, etc.

- To simplify the model/framework such as taking one step on each storyboard.

(d) ***Re-design phase***

Table 6.8 presents the main results on the appropriateness and support of the re-design phase to allow modification or alteration of storyboard content and design. The description of result as follows:

- The views on both appropriateness and support of the processing phase are slightly higher in practitioners group (M=0.93, SD= 0.27) than in the academicians (M=0.92, SD=0.28).
- Overall mean value integrated from both groups shows that the processing phase is given high rate of appropriateness and support (M=0.93).

Table 6.8: Experts' means and standard deviations of appropriateness and support of the re-design phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
Re-design phase	B07. Appropriateness in allowing modification or alteration of storyboard content and design	0.92	0.28	0.93	0.27
	B08. Storyboard content and design can be modified or altered in this re-design phase	0.92	0.28	0.93	0.27
	Mean of sample means =	0.92		0.93	
	Overall mean =	0.93			

* Items rated as yes or no (1="yes"; 0="no")

Some qualitative feedbacks of the re-design phase are obtained from the experts. Four questions and criticisms have been pointed out for this phase includes:

- The division of roles between ID and SME is not clear, in terms of the tasks must be clearly shown. For example, which part that shows the ID would be able to put the content (provided by SME) into activation (prior knowledge), demonstration or delivery of content, application, assessment, etc?
- Is the system integrating the role of language editor as well? If not why? Otherwise the finished product is not 'finished' and need to send for editing".

- Is there any opportunity for SME and ID to view the SCOs in context of the course? Visualizing individual SCOs and editing/revising them is fine, but that would not give full impression unless they are visualized in the context of other SCOs as they would appear in the course itself.
- Why there is no shared visualization technique and strategies required however it allows modification?
- One suggestion has been given by practitioner is to embed this phase where no other process called as redesign is required. It is suggested that to provide the "SIGN OFF Certificate" and submit button to complete the whole process of storyboard design.

(e) ***Triangulation result***

The triangulation result (as shown in Figure 6.7), shows both experts view the four storyboard processing phases i.e. pre-processing, processing, post-processing and re-design as reasonably appropriate and do support in reaching common ground activities. While there are significant differences of views for pre-processing ($Mean^{Academician}$=1,$Mean^{Practitioners}$=0.86) and processing ($Mean^{Academician}$=0.96,$Mean^{Practitioners}$ =0.86), there is no significant differences of views for post-processing and re-design ($Mean^{Academician}$=0.92,$Mean^{Practitioners}$ =0.93) between the groups.

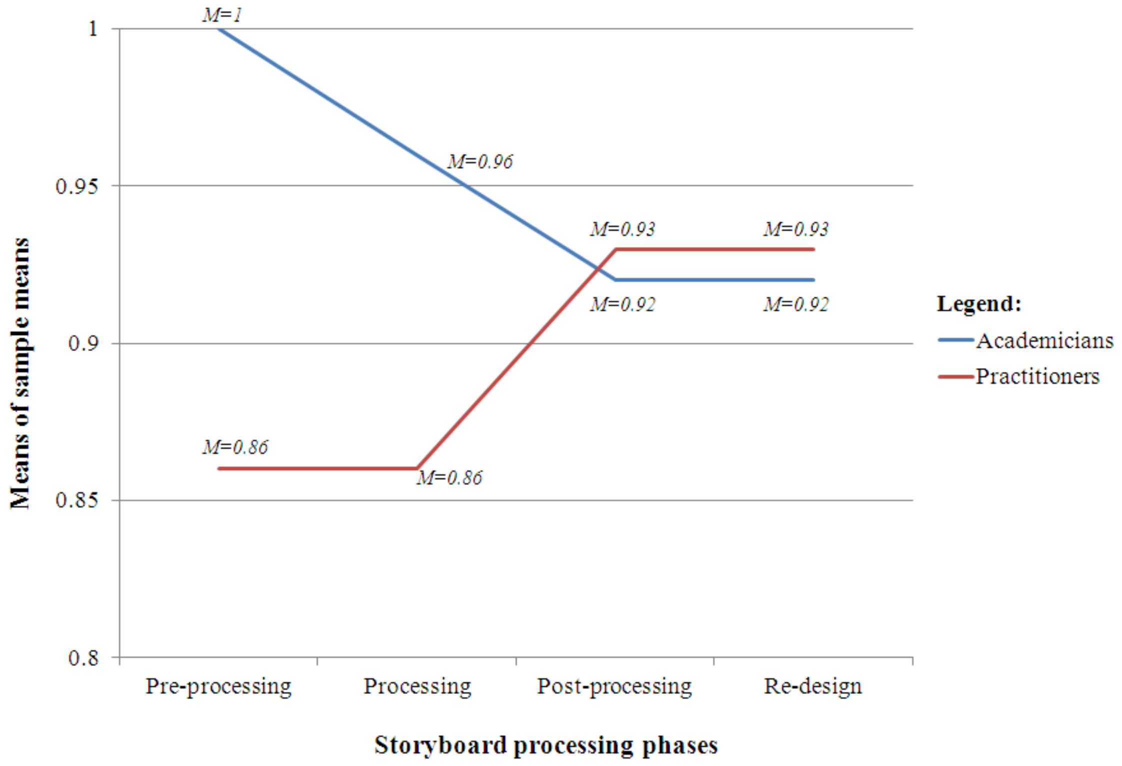


Figure 6.7: Triangulation result of the appropriateness and support of the four storyboard processing phases based on mean of sample means, which are compared between the ID and SME

Figure 6.8 shows the summary of the difference between academicians' and practitioners' evaluation of the degree in appropriateness and support of the four processing phases. There are significant differences of the groups in view of the appropriateness in pre-processing and processing. It shows that practitioners view these two processing phase lesser in the degree of appropriateness than the academicians. On the other hand, both experts have relatively similar degree of appropriateness for the post-processing and re-design phases. Regards to the degree of support, it shows that practitioners view lesser degree of support of what the pre-processing phase can offer than the academicians. However, both experts have relatively view a similar degree of support of what the processing, post-processing and re-design phases can provide.

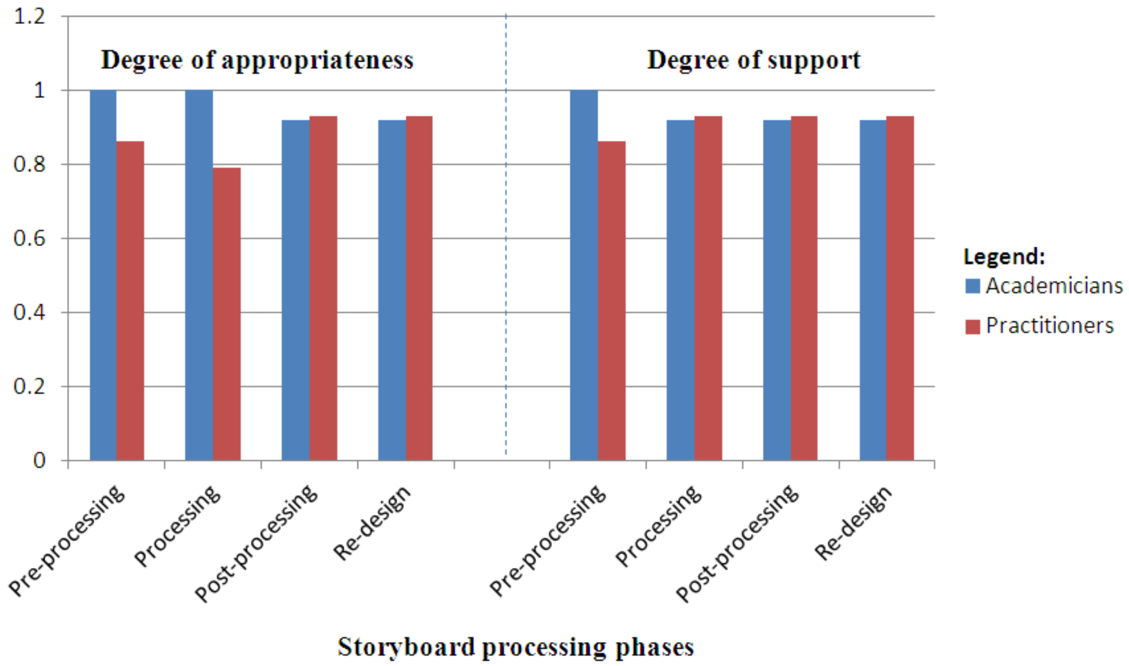


Figure 6.8: Degree of appropriateness and support of the four storyboard processing phases based on mean

6.3.4.3 Part 3 - The Shared Visualization Strategies and Techniques

This section presents the main results on the appropriateness, importance, clarity and understandability of the seven proposed shared visualization strategies and techniques in the storyboard pre-processing, processing and post-processing phases.

(a) ***Collaborative concept mapping***

Table 6.9 presents the main results on the appropriateness, importance, clarity and understandability of collaborative concept mapping in the pre-processing phase. The description of result as follows:

- The views on appropriateness of the collaborative concept mapping is higher in academicians group (M=4, SD=0.82) than in the practitioners group (M=3.93, SD=0.73; t=0.23, p<0.05).
- The views on importance of the collaborative concept mapping is higher in academicians group (M=4.46, SD=0.52) than in the practitioners group (M=4, SD=0.68; t=1.99, p<0.05).

- The views on clarity of the collaborative concept mapping is lower in academicians group (M=3.31, SD=1.25) than in the practitioners group (M=3.79, SD=0.97; t=-1.1, p<0.05).
- The views on understandability of the collaborative concept mapping is slightly higher in academicians group (M=4.15, SD=0.9) than in the practitioners group (M=4.14, SD=0.53; t=0.03, p<0.05).
- Overall mean value integrated from both groups shows that the collaborative concept mapping is rated as M=3.97 on a scale with maximum of 5.

Table 6.9: Experts' means and standard deviations of appropriateness, importance, clarity and understandability of the collaborative concept mapping in the pre-processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
The collaborative concept mapping	C01. Appropriateness of the technique for the pre-processing phase	4	0.82	3.93	0.73
	C02. Importance of technique for the pre-processing phase	4.46	0.52	4	0.68
	C03. Clearly explained technique	3.31	1.25	3.79	0.97
	C04. Understandable technique	4.15	0.9	4.14	0.53
	Mean of sample means =	3.98		3.96	
	Overall mean =	3.97			

* Items rated on a 5-point scale:
(1='not appropriate'; 5='very appropriate'), (1='not important'; 5='very important'),
(1='not clear'; 5='very clear') and (1='not understand'; 5='very understand')

Some qualitative feedbacks for the collaborative concept mapping are received from the experts. A compliment is received from the practitioner who stated that this technique helps in providing clear picture of content architecture. However, three criticisms have been pointed out:

- The storyboard is too complicated
- Personal preferences towards face-to-face communication with the SMEs

- Unclear about who is able to alter what kind of task.

Five suggestions have been proposed by the experts for the collaborative concept mapping includes:

- To suggest required pedagogical elements and this should be elicitated from educational SME.
- To add background information of the courseware.
- To empower doodling and visualization using tablets in storyboarding
- To add comment or chat button in this technique
- To present the mapping in visual manner and that can give the users the overall structure of the course.

(b) ***Shared board***

Table 6.10 presents the main results on the appropriateness, importance, clarity and understandability of the shared board in the processing phase. The description of result as follows:

- The views on appropriateness of the shared board is higher in academicians group (M=4, SD=0.91) than in the practitioners group (M=3.86, SD=0.95; t=, $p<0.05$).
- The views on importance of the shared board is lower in academicians group (M=4.15, SD=0.9) than in the practitioners group (M=4.21, SD=0.58; t=, $p<0.05$).
- The views on clarity of the shared board is higher in academicians group (M=3.62, SD=1.04) than in the practitioners group (M=3.5, SD=1.02; t=, $p<0.05$).
- The views on understandability of the shared board is lower in academicians group (M=3.62, SD=1.04) than in the practitioners group (M=3.71, SD=0.83; t=, $p<0.05$).
- Overall mean value integrated from both groups shows that the shared board is rated as M=3.83 on a scale with maximum of 5.

Table 6.10: Experts' means and standard deviations of appropriateness, importance, clarity and understandability of the shared board in the processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
The shared board	C05. Appropriateness of the strategy for the processing phase	4	0.91	3.86	0.95
	C06. Importance of strategy for the processing phase	4.15	0.9	4.21	0.58
	C07. Clearly explained strategy	3.62	1.04	3.5	1.02
	C08. Understandable strategy	3.62	1.04	3.71	0.83
	Mean of sample means =	3.84		3.82	
	Overall mean =	3.83			

* Items rated on a 5-point scale:
(1='not appropriate'; 5='very appropriate'), (1='not important'; 5='very important'), (1='not clear'; 5='very clear') and (1='not understand'; 5='very understand')

Some qualitative feedbacks for shared board are obtained from the experts. Four questions and criticisms have been pointed out:

- The experts would prefer to experiencing using this shared board rather than looking at the slides (i.e. prefer to look at the demonstration of the shared visualization technique and strategies or face-to-face explanation)
- The shared board is too restrictive.
- Whether the graphic designers are invited to the discussion?
- Whether the IDs are the liaison?

Two suggestions have been proposed by the experts for further improve the shared board includes:

- To learn from other applications such as GoAnimate[15] and PowToon[16].
- To add "search button" for metadata

[15] http://goanimate.com/
[16] http://www.powtoon.com/

(c) Shared user-generated storyboard

Table 6.11 presents the main results on the appropriateness, importance, clarity and understandability of the shared user-generated storyboard in the processing phase. The description of result as follows:

- The views on appropriateness of the shared user-generated storyboard is lower in academicians group ($M=4.0$, $SD=0.91$) than in the practitioners group ($M=4.07$, $SD=0.73$; $t=-0.22$, $p<0.05$).
- The views on importance of the shared user-generated storyboard is lower in academicians group ($M=3.85$, $SD=1.41$) than in the practitioners group ($M=4.0$, $SD=0.55$; $t=-0.36$, $p<0.05$).
- The views on clarity of the shared user-generated storyboard is lower in academicians group ($M=3.54$, $SD=1.2$) than in the practitioners group ($M=3.71$, $SD=0.99$; $t=-0.41$, $p<0.05$).
- The views on understandability of the shared user-generated storyboard is lower in academicians group ($M=3.54$, $SD=1.2$) than in the practitioners group ($M=3.93$, $SD=0.73$; $t=-1.01$, $p<0.05$).
- Overall mean value integrated from both groups shows that the shared user-generated storyboard is rated as $M=3.83$ on a scale with maximum of 5.

Some qualitative feedbacks for shared user-generated storyboard are received from the experts. Four questions and criticisms have been pointed out:

- The shared user-generated storyboard is conceptually feasible, but need the effectiveness need to be evaluated by completing an actual task.
- The division roles between ID and SME are not clear.
- The sequence in which the SCOs will appear is clear, but the relationship among them is not clear.

- How the shared user-generated storyboard works by considering thousands of SCOs uploaded worldwide
- To further improve the shared user-generated storyboard, an expert suggests making it as simple as Microsoft PowerPoint application or just using this PowerPoint, instead.

Table 6.11: Experts' means and standard deviations of appropriateness, importance, clarity and understandability of the shared user-generated storyboard in the processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
The shared user-generated storyboard	C09. Appropriateness of the strategy for the processing phase	4.0	0.91	4.07	0.73
	C10. Importance of strategy for the processing phase	3.85	1.41	4.0	0.55
	C11. Clearly explained strategy	3.54	1.2	3.71	0.99
	C12. Understandable strategy	3.54	1.2	3.93	0.73
	Mean of sample means =	3.73		3.92	
	Overall mean =	3.83			

* Items rated on a 5-point scale:
(1='not appropriate'; 5='very appropriate'), (1='not important'; 5='very important'), (1='not clear'; 5='very clear') and (1='not understand'; 5='very understand')

(d) ***Shared storyboard artefact viewer***

Table 6.12 presents the main results on the appropriateness, importance, clarity and understandability of the shared storyboard artefact viewer in the processing phase. The description of result as follows:

- The views on appropriateness of the shared storyboard artefact viewer is higher in academicians group ($M=4.23$, $SD=0.73$) than in the practitioners group ($M=3.93$, $SD=0.62$; $t=1.16$, $p<0.05$).

- The views on importance of the shared storyboard artefact viewer is higher in academicians group (M=4.46, SD=0.52) than in the practitioners group (M=4.07, SD=0.47; t=2.03, $p<0.05$).
- The views on clarity of the shared storyboard artefact viewer is higher in academicians group (M=3.92, SD=1.12) than in the practitioners group (M=3.86, SD=0.86; t=0.17, $p<0.05$).
- The views on understandability of the shared storyboard artefact viewer is slightly lower in academicians group (M=3.92, SD=1.12) than in the practitioners group (M=3.93, SD=0.63; t=-0.01, $p<0.05$).
- Overall mean value integrated from both groups shows that the shared storyboard artefact viewer is rated as M=4.03 on a scale with maximum of 5.

Table 6.12: Experts' means and standard deviations of appropriateness, importance, clarity and understandability of the shared storyboard artefact viewer in the processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
The shared storyboard artefact viewer	C13. Appropriateness of the strategy for the processing phase	4.23	0.73	3.93	0.62
	C14. Importance of strategy for the processing phase	4.46	0.52	4.07	0.47
	C15. Clearly explained strategy	3.92	1.12	3.86	0.86
	C16. Understandable strategy	3.92	1.12	3.93	0.63
	Mean of sample means =	4.13		3.94	
	Overall mean =	4.03			

* Items rated on a 5-point scale:
(1='not appropriate'; 5='very appropriate'), (1='not important'; 5='very important'), (1='not clear'; 5='very clear') and (1='not understand'; 5='very understand')

Some qualitative show qualitative feedbacks for the shared storyboard artefact viewer from the experts. Three questions and criticisms have been pointed out:

- The division roles between ID and SME are not clear.
- Whether animation files can be uploaded?
- Whether issues on copyrighted materials are included?

Two suggestions have been proposed by the experts for further improve the shared storyboard artefact viewer includes:

- To provide more permanent viewing of whole context rather than temporarily viewing multiple storyboards in pop-up windows.
- To provide publish button in order to allow users seeing the output straight away.

(e) ***Shared narrative abstraction***

Table 6.13 presents the main results on the appropriateness, importance, clarity and understandability of the shared narrative abstraction in the processing phase. The description of result as follows:

- The views on appropriateness of the shared narrative abstraction is higher in academicians group (M=4.23, SD=0.44) than in the practitioners group (M=4.14, SD=0.66; t=0.40, $p<0.05$).
- The views on importance of the shared narrative abstraction is lower in academicians group (M=4.08, SD=1.04) than in the practitioners group (M=4.21, SD=0.7; t=-0.40, $p<0.05$).
- The views on clarity of the shared narrative abstraction is slightly lower in academicians group (M=3.92, SD=1.12) than in the practitioners group (M=3.86, SD=0.86; t=-0.20, $p<0.05$).
- The views on understandability of the shared narrative abstraction is higher in academicians group (M=4.15, SD=0.9) than in the practitioners group (M=4.14, SD=0.53; t=0.03, $p<0.05$).

- Overall mean value integrated from both groups shows that the shared narrative abstraction is rated as M=4.11 on a scale with maximum of 5.

Table 6.13: Experts' means and standard deviations of appropriateness, importance, clarity and understandability of the shared narrative abstraction in the processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
The shared narrative abstraction	C17. Appropriateness of the strategy for the processing phase	4.23	0.44	4.14	0.66
	C18. Importance of strategy for the processing phase	4.08	1.04	4.21	0.7
	C19. Clearly explained strategy	3.92	1.12	4	0.78
	C20. Understandable strategy	4.15	0.9	4.14	0.53
	Mean of sample means =	4.09		4.12	
	Overall mean =	4.11			

* Items rated on a 5-point scale:
(1='not appropriate'; 5='very appropriate'), (1='not important'; 5='very important'),
(1='not clear'; 5='very clear') and (1='not understand'; 5='very understand')

Some qualitative shows qualitative feedbacks for the shared narrative abstraction are obtained from the experts. Again, an expert questions about the division of roles between ID and SME which are not clear. No further improvement has been suggested by the experts.

(f) ***Collaborative discussion board***

Table 6.14 presents the main results on the appropriateness, importance, clarity and understandability of the collaborative discussion board in the post-processing phase. The description of result as follows:

- The views on appropriateness of the collaborative discussion board is lower in academicians group (M=4.25, SD=0.6) than in the practitioners group (M=4.5, SD=0.52; t=-1.2, $p<0.05$).

- The views on importance of the collaborative discussion board is lower in academicians group (M=4.38, SD=0.65) than in the practitioners group (M=4.43, SD=0.51; t=-0.19, p<0.05).
- The views on clarity of the collaborative discussion board is lower in academicians group (M=3.85, SD=1.14) than in the practitioners group (M=4.14, SD=0.77; t=-0.78, p<0.05).
- The views on understandability of the collaborative discussion board is slightly lower in academicians group (M=4.23, SD=0.6) than in the practitioners group (M=4.29, SD=0.47; t=-0.26, p<0.05).
- Overall mean value integrated from both groups shows that the collaborative discussion board is rated as M=4.25 on a scale with maximum of 5.

Table 6.14: Experts' means and standard deviations of appropriateness, importance, clarity and understandability of the collaborative discussion board in the post-processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
The collaborative discussion board	C21. Appropriateness of the technique for the post-processing phase	4.23	0.6	4.5	0.52
	C22. Importance of technique for the post-processing phase	4.38	0.65	4.43	0.51
	C23. Clearly explained technique	3.85	1.14	4.14	0.77
	C24. Understandable technique	4.23	0.6	4.29	0.47
	Mean of sample means =	4.17		4.33	
	Overall mean =	4.25			

* Items rated on a 5-point scale:
(1='not appropriate'; 5='very appropriate'), (1='not important'; 5='very important'),
(1='not clear'; 5='very clear') and (1='not understand'; 5='very understand')

Some qualitative shows qualitative feedbacks for the collaborative discussion board are obtained from the experts. The experts stated that they like the live feedback feature on content and design and consider it as the most innovative feature in storyboarding design technique and strategies. Despite of providing compliments, an expert criticize that the unthreaded discussions can work for simple communication but would not work well when it involves communication of multiple topics.

Two suggestions have been proposed by the experts for further improve the collaborative discussion board includes:

- To provide more prominent functionalities in the discussion strategy.
- To enable capturing and documenting “date of thread”.

(g) ***Collaborative annotation***

Table 6.15 presents the main results on the appropriateness, importance, clarity and understandability of the collaborative annotation in the post-processing phase. The description of result as follows:

- The views on appropriateness of the collaborative annotation is higher in academicians group (M=4.31, SD=0.63) than in the practitioners group (M=4.21, SD=0.7; t=0.36 $p<0.05$).
- The views on importance of the collaborative annotation is lower in academicians group (M=4.38, SD=0.51) than in the practitioners group (M=4.43, SD=0.65; t=-0.19, $p<0.05$).
- The views on clarity of the collaborative annotation is higher in academicians group (M=3.92, SD=1.19) than in the practitioners group (M=3.86, SD=0.86; t=0.16, $p<0.05$).
- The views on understandability of the collaborative annotation is higher in academicians group (M=4.08, SD=1.04) than in the practitioners group (M=4.07, SD=0.62; t=0.01, $p<0.05$).

- Overall mean value integrated from both groups shows that the collaborative annotation is rated as M=4.15 on a scale with maximum of 5.

Table 6.15: Experts' means and standard deviations of appropriateness, importance, clarity and understandability of the collaborative annotation in the post-processing phase

		Academician's group (n=13)		Practitioner's group (n=14)	
		Means	*SD*	*Mean*	*SD*
The Collaborative Annotation	C25. Appropriateness of the technique for the post-processing phase	4.31	0.63	4.21	0.7
	C26. Importance of technique for the post- processing phase	4.38	0.51	4.43	0.65
	C27. Clearly explained technique	3.92	1.19	3.86	0.86
	C28. Understandable technique	4.08	1.04	4.07	0.62
	Mean of sample means =	4.17		4.14	
	Overall mean =	4.15			

* Items rated on a 5-point scale:
(1='not appropriate'; 5='very appropriate'), (1='not important'; 5='very important'), (1='not clear'; 5='very clear') and (1='not understand'; 5='very understand')

Some qualitative feedbacks for the collaborative annotation are obtained from the experts. The experts stated that they like the feedback functionality due to its importance to improve communication and collaboration. Despite of these compliments, they have pointed three questions and criticisms:

- To define who the user is.
- Whether programmers are included?
- If there are many annotated comments, would the space on the board suffice to users especially the ID who has to view the storyboard for an extensive period of time?

Eight suggestions have been proposed by the experts for further improve the collaborative annotation includes:

- To translate the shared discussion into "participatory design", where the participatory group can know the detail of age/gender/background/expertise of the discussants.
- To enable the classification of the comments into "resolved" or "commented/replied" where it allows feedback in terms of priority of the changes to be made.
- To link the annotated commentary to share discussion in order to provide a central commentary reference point and comprehensive discussion documentation.
- To add new comment indicator so that user knows. An example is given by the expert using the following URL: https://dl.dropboxusercontent.com/u/12394144/eSCOUT/commentary.png.
- To add in the dates of the thread to mark the sign off automatically because this task usually drags from time to time.
- To enable three review phases only.
- To add elements such as Objects, Roles, and LO in order to resolve the conflicts among the team members using discussion strategy.
- To add in software that can record narration automatically.

(h) ***Triangulation result***

The triangulation result (as shown in Figure 6.9) shows on the experts' view of appropriateness, importance, clarity and understandability of the seven shared visualization strategies and techniques. Both experts view the collaborative concept mapping as between somewhat and appropriate/important/clear/understandable ($Mean^{Academician}$=3.98,$Mean^{Practitioners}$=3.96). Both experts also view the shared user-generated storyboard as between somewhat and appropriate/important/clear/understandable ($Mean^{Academician}$=3.73,$Mean^{Practitioners}$=3.92). Similarly, both experts view the shared board as somewhat and appropriate/important/clear/understandable ($Mean^{Academician}$=3.84,$Mean^{Practitioners}$=3.82). There are no significant differences of views for the collaborative concept mapping, shared board and shared user-generated storyboard between the groups.

On the view of shared narrative abstraction, both experts evaluate the shared narrative abstraction as between appropriate/important/clear/understandable and very appropriate/important/clear/understandable ($Mean^{Academician}$=4.09, $Mean^{Practitioners}$=4.12). Both experts also evaluate the collaborative discussion as between appropriate/important/clear/understandable and very appropriate/ important/ clear/ understandable ($Mean^{Academician}$=4.17,$Mean^{Practitioners}$=4.33). Similarly, both experts evaluate the collaborative discussion board as between appropriate/important/clear/understandable and very appropriate/important/clear/understandable ($Mean^{Academician}$=4.17,$Mean^{Practitioners}$=4.14). There are no significant differences of views for the shared narrative abstraction, collaborative annotation and collaborative discussion board between the groups.

There is statistically significant difference of views of the shared storyboard artefact viewer given by the academicians and practitioners. For the academicians, they evaluate the shared storyboard artefact viewer as between appropriate/important/clear/understandable and very appropriate/ important/ clear/ understandable ($Mean^{Academician}$=4.13) compared to the practitioners who evaluate the technique as between somewhat and appropriate/important/clear/understandable ($Mean^{Practitioners}$=4.14). The shared storyboard artefact viewer is perceived well by the academicians than the practitioners.

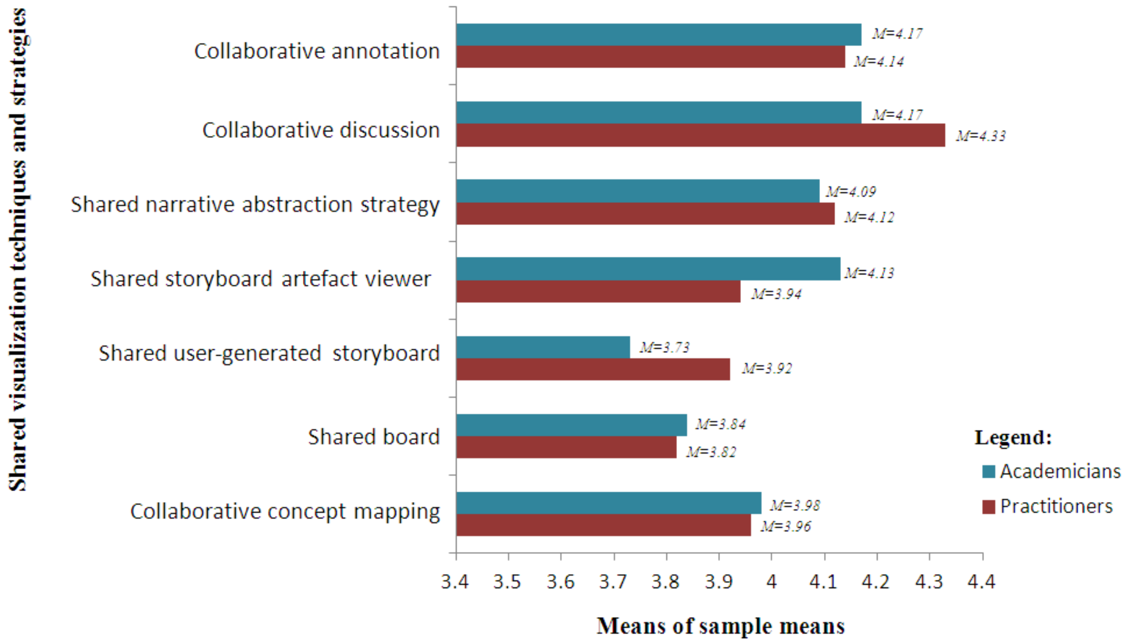


Figure 6.9: Triangulation result of appropriateness, importance, clarity and understandability of the seven eSCOUT shared visualization strategies and techniques based on mean of sample means, which are compared between the ID and SME.

6.3.4.4 Part 4 - Comprehensive Evaluation of the eSCOUT

This section presents the main results of comprehensive evaluation of the eSCOUT.

(a) ***Overall structural and functionality of the eSCOUT***

Table 6.16 presents the overall structural and functional design of the eSCOUT and overall proposed shared visualization strategies and techniques. The description of result as follows:

- The views on overall structural and functional design of the eSCOUT is higher in academicians group (M=4.38, SD=0.65) than in the practitioners group (M=4.21, SD=0.43; t=0.79, p<0.05).
- The views on overall proposed shared visualization strategies and techniques of the eSCOUT is also higher in academicians group (M=4.23, SD=0.6) than in the practitioners group (M=3.93, SD=0.62; t=1.29, p<0.05).
- Overall mean value integrated from both groups shows that the eSCOUT comprehensive evaluation is rated as M=4.18 on a scale with maximum of 5.

Table 6.16: Experts' means and standard deviations of overall structural and functionality design of the eSCOUT as well as the overall shared visualization strategies and techniques

	Academician's group (n=13)		Practitioner's group (n=14)	
	Means	*SD*	*Mean*	*SD*
D01. Please rate the overall structural and functional design for the eSCOUT	4.38	0.65	4.21	0.43
D02. Overall, are the shared visualization strategies and techniques representing the needs for each of the processing phase?	4.23	0.6	3.93	0.62
Mean of sample means =	4.3		4.07	
Overall mean =	4.18			

* Items rated on a 5-point scale:
(1='need overall revision'; 5='perfect/no need any revision') and
(1='need overall revision for the shared visualization technique and strategies'; 5='perfect shared visualization technique and strategies')

*(b) **Advantages of the eSCOUT***

The experts' statements on advantages of the eSCOUT are delineated into two types of feedback; general compliments and specific compliments.

Eight general compliments received from the experts as follows:

- "Perfect"
- "Nice diagram and ideas"
- "A nice framework to organize content"
- "Simple and easy to understand the process"
- "Guided and clear interesting work. The component in eSCOUT seems covers the whole process. All shared visualization strategies and techniques seems useful"
- "A comprehensive shared visualization strategies and techniques for storyboarding. Just make sure that all the needed storyboard designs/templates are incorporated into the shared visualization technique and strategies and interchangeable, should there's a change of mind where the design in concerned"
- "Sufficient detail that allows user to select necessary activities given the specific situation"
- "It will be able to guide the users/people to generate a system for creating storyboard"

Specific compliments are divided into two categories: specific compliments on the efficiency and effectiveness, and specific compliments on the ID and SME communication and collaboration.

Ten specific compliments on the efficiency and effectiveness received from the experts as follows:

- "It allows for collaboration which could improve the efficiency of the design process"
- "Certainly. It would provide a very effective process"

- "Enable effective ID and SME collaboration in producing storyboard"
- "Yes, saving time in designing the storyboard"
- "The collaborative annotation and collaborative discussion board and other shared visualization strategies and techniques integrated within one environment would definitely smooth out /quicken the entire process"
- "Easier for users who have no ID background"
- "The system will enable new ID/non ID person to create content using guided id framework and principle.
- "Simplified the ID task to develop the storyboard and save much more time"
- "Reduce misunderstanding with the usage of visual"
- "Centralize repository of all assets and designs"

Seven specific compliments on the ID and SME communication and collaboration received from the experts as follows:

- "The collaboration is the key advantage. The sharing is embedded within the whole system. Very good!"
- "It is good for story boarding that contains 2 way communication within ID and SME"
- "Yes. Good shared visualization strategies and techniques to collaborate when the SME and ID are at two different locations"
- "Communication could be a lot easier between SME and ID as both need time to find and have a discussion"
- "Good collaborative working environment"
- "it allows all team members to actively participate and collaborate in the development of the content by referring to a standard template"

- "If all goes as planned it will be a great support shared visualization strategies and techniques for content development with right instructional elements sourced from expert IDs and SME"

(c) ***Disadvantages of the eSCOUT***

The experts' feedbacks on the disadvantages of the eSCOUT are delineated into two types of feedbacks; general statements on disadvantages of the eSCOUT and specific statements on disadvantages addressed for specific user(s).

Eight general statements on disadvantages of the eSCOUT received from the experts as follows:

- "Thus far no until I try it out"
- "Not yet, need to see the full program running"
- "If the system could fully support its intended function and use, then there should be no disadvantage"
- "Have to get involved in using the shared visualization technique and strategies, then can find out disadvantages. So far the idea is very good"
- "Steps and work flow is not clear. It would be nice if we could get the actually system or prototype access and explore more"
- "It is too complicated in the representation - perhaps it needs clear explanation/presentation"
- "Restrictive, suitable for certain subjects that are linear based"
- "Slow and installation of required software"

Six specific statements on disadvantages addressed for specific user(s) received from the experts as follows:

- "Not to an expert, but may be to a novice"
- "Not all SME may use eSCOUT"
- "Given the scope of activities a user might be intimidated before even starting"

- "Too technical. Some SME may be high tech. Work could also be more tedious as they need to be done in an application, plus everything need to be type down"
- "Should have limitation in reviewing and do amendment base on the comment"
- "May stifle flexibility"

(d) ***Areas for improvement***

The experts' feedback for the eSCOUT improvements are delineated into two categories; general improvements and specific improvements.

Eight general improvements received from the experts as follows:

- "Overall presentation of the framework and how it links to the systems/applications"
- "Some interaction design needs to be improve"
- "The eSCOUT model is good, but the visualization of technology behind it seems 10 years old. If you are not required to program, then use your imagination to build some prototype that is click and box free"
- "Need to get some 'WOW' design, hopefully have to design the interface more interface to attract the user"
- "It looks pretty comprehensive"
- "Perhaps a range of examples based on time and funding"
- "Re-design component should be properly investigated. I am not clear how re-design will work"
- "A process to close and ends the storyboard design process. This may be the formal sign off or informal"

Fifteen specific improvements received from experts as follows:

- "Will need to use the run-time system to provide feedback"
- "The framework is shown in the system framework. But readers need to understand from which ID principle is being used in formulating this frame work. Otherwise,

the system framework looks like a sharable workspace with content mapping and collaborative technique only and devoid of crucial ID tools"

- "In terms of the theory, everything seems to be quite in order"
- "Instructional design & pedagogy"
- "Copyright issue in sharing"
- "Permission to alter design or content"
- "Annotated comments might be filling the board space."
- "Define LO, Objects and Role"
- "Asset management, user management - need to be defined and set-up properly so that the whole content development team can seamlessly work together using the shared visualization technique and strategies"
- "More graphics/file formats allowed"
- "Should use an icon to represent the technique and strategies for the Shared Board. Example, hands free drawing can use pencil icon"
- "More options of templates"
- "Review session must have to do by three times only and the amendment will do according to the comment in review session. It can cut off the time duration on development"
- “Adding the LO might help to ensure the effort is based on the correct objective"
- "Version control management for easy traceability."

(e) ***Areas to be removed***

The experts’ feedback in removing certain areas in the eSCOUT is delineated into two categories: general areas to be removed and specific areas to be removed.

Six general statements on areas to be removed received from the experts:

- "I would not remove any activities"
- "All areas should be there"

- "Not yet, need to see the full program running"
- "Nothing. All covered areas are essentially important in storyboarding"
- "So far all features seems very applicable, usable and important in the design process, so nothing to remove"
- "Perhaps try link the loose end - I think generally is acceptable however, from this survey the purpose and explanation is not clear"
- Two specific statements on areas to be removed received from the experts:
- "Less emphasis on collaboration but more on how the ID principle are being integrated into the system"
- "A-Z in terms of system design. The collaborative learning space should empower communication through existing tools such as Skype or WizIQ".

(f) ***Specific addressed problems***

The experts' feedbacks on specific addressed problems are delineated into two categories; suggestions for the system functionalities and suggestions for other issues.

Six suggestions for the system functionalities are received from the experts:

- "Will need to use the run-time system to provide feedback"
- "Just need to have more detailed features and functionality of eSCOUT"
- "Add user management and asset management module"
- "Limit authority or prompt to seek permission for big alteration"
- "ID and SME need to collaborate, discuss, and communicate each other to solve the problem. Have to limit the 'self-needs', focus on the main objective of storyboard development"
- "The storyboard can be made into sections where each section represents the instructional events. So the SME can just put in the subject content into the sections and the ID ensure the contents being put in are appropriate to the instructional events"

Six suggestions for other issues are received from the experts:

- "Is Copyright issue addressed in the sharing process among the 3 groups?"
- "Test with instructional designers who are practitioners in the field"
- "The platform (system) must be able to support this to make it fully operable"
- "Focus on the framework and let your imagination go wild. The moment you think programming, everything falls apart, unless you are an exceptional programmer with vision"
- "Make it simple and easy add more colors and pictures as guide"
- "An appendix with a variety of examples"

(g) ***Other suggestions, opinions and recommendations***

The experts' feedback for other kinds of suggestions and improvements for the eSCOUT are delineated into three categories; compliments suggestions and improvements.

Eight compliments are gained from obtained from the experts as follows:

- "Good work!"
- "Good job"
- "All the best! Anything is possible, Insya-Allah!"
- "Overall, I think this a good shared visualization strategies and techniques for storyboarding"
- "No. Seems like it is a good framework with several innovative shared visualization strategies and techniques which can eliminate some of the hassles in storyboard design process. Look forward to test it in the real platform!"
- "Great stuff. Make it as basic and simple possible. Can't wait for the output"
- "I think it is a good application overall. It would be most beneficial to IDs for recording purposes and manual recording could be quite a hassle"

- "Need to get some 'WOW' design, hopefully have to design the interface more interface to attract the user"

Nine suggestions are received from the experts as follows:

- "The run-time system should be evaluated by experts"
- "Maybe to get maximum benefit of feedback, you can have a round of focus group interaction"
- "Budget is a major factor in decision making. Examples might help illustrate the concept"
- "I am wondering if evaluation could be done on the generated storyboard."
- "Develop a working prototype and test it with added features/modules suggested"
- "I would like to give a suggestion which is to improve the interface of eSCOUT layout to be more attractive to the user. Put more icons and interesting choices of color"
- "Seems workable; suggest you use face to face validation with the experts to get their feedback"
- "Online evaluation a bit difficult, especially there may be items that needs clarifications..."
- "I would prefer to have use these shared visualization strategies and techniques and will experiencing it more easily to provide feedback. Some of the interface quite confusing in design and it influence me ... to understand the process flow better. If the researcher could visit the expert and explain the overall work with why the work is carried out then it would be much better to have overall feedback. Good luck"

Six improvements are provided by the experts as follows:

- "As it is, the system is good but need to clearly define which shared visualization strategies and techniques can be performed by SME (content input) and which shared visualization strategies and techniques can be performed by ID (structural input of the content conform to designated ID principle) and which shared visualization strategies and techniques can be performed by are sharable (collaborative strategies and technique)"

- "The interface design and background can still be improved so the end product will look more concrete"
- "Improve the user interface"
- "Improve the explanation part"
- "Work flow and steps of story boarding need to improve"
- "I could have been easier to understand if a scenario was provided"

6.3.5 Discussion

This section discusses three lines for framework improvement, special issues addressed and limitation of study.

6.3.5.1 Framework improvement

The findings of this study suggest three lines for the framework improvement. The first line pertains to the identification of seven types of knowledge or needs requirements of an eLearning storyboarding a designer’s mental model. These knowledge and needs are required before they can be shared, designed and processed alongside with other design teams:

1. *Pedagogical components:* A storyboard designer such as the instructional designer need to have knowledge of a kind of learning theory or instructional design theories which is suitable for the design of eLearning courseware.
2. *Interaction design component:* A storyboard designer should have a basic knowledge about the types of interaction design in storyboard designs which needs to be developed by the multimedia development team later on.

3. *Multimedia component:* A storyboard designer should know the basic kinds of multimedia components such as type of images, graphics and videos that are needed for the design of eLearning courseware.
4. *Copyright component:* A storyboard designer should know his/her rights to legally own and control of his/her intellectual properties of storyboard creations.
5. *Compliance-based eLearning component:* A storyboard designer should be able to design a storyboard that adheres to the compliance of eLearning standards and specifications.
6. *Storyboard component:* A storyboard designer should have be able to provide some major contents required for an eLearning storyboard such as voice-over scripts/narrations, sharable content objects, and screen mockups/sketch drawings.
7. *Communication component:* A storyboard designer should be able to choose an available communication or collaborative tools to empower communication among the design team.

The second line pertains to the generalizability of the framework. For instance, IPO basis of the eSCOUT should be operated in shared input (shared acquisition from the users), shared processing (shared representation) and shared output (shared emergence of visualization). With regards to the shared board and shared user-generated storyboard, an expert expressed confusion between the two breaking modes. Therefore, it is suggested to combine the modes of functionalities into one strategy. Despite of having the re-design phase, a practitioner suggests to embed this phase with the re-design phase and end the activity using “Sign-off Certificate”. This function is required to complete the whole process of storyboard design. From this discussion, it is also concluded that only the first three processing phases in the eSCOUT are appropriate and important, while re-design phase should be replaced with up to three iterative design reviews.

The third and final line for improvement pertains to the flexibility to choose among the shared visualisation methods in achieving common ground. The users should be given more flexibility to choose any strategies and techniques of shared visualisation in order to communicate and collaborate effectively with other design teams. For example, in order to communicate about the conceptual design of the storyboard with other design teams, the designer can use shared coordination strategies in collaborative concept mapping where they can coordinate the structural mapping of the course and its lessons. Similarly, they can also choose to use shared visualisation strategy in a shared desktop interfaces as a mechanism of discussion in this pre-processing phase.

6.3.5.2 Addressing on special issues

In addition to the above needs of improvement for the eSCOUT, the framework evaluations lead to two special issues addressed by the experts. The first issue is the pertaining to the need to support platform/system operability. This type of issue refers to the focus on building an eLearning content that complies with SCORM (Sharable Content Object Reference Model). SCORM is a set of technical specifications that enables interoperability, accessibility, and reusability of web-based learning content (Bohl, et al., 2002). It is also defined as the run-time environment that shows the communications between client side content and a host system which is commonly supported by a learning management system. An example of developing a storyboard that support SCORM is done by (Glithero, 2003) which includes several automated features such as Manifest Generator, Asset Repository, SCORM Assurance, SCO Preview, and SCORM Packager.

The second issue is the pertaining to the need of copyright of the shared storyboarding designs in the eSCOUT. According to the experts, the original work in storyboarding activities is a form of intellectual property rights that should be legally and contractually protected to the rights holders, in this case is the storyboard writers. The experts claim that copyright is an issue where not only the storyboard writers should be given credited to their work, however it is also a form to allow the storyboard writers control of and profit from those who may adapt the work to other forms.

Meta-inferences are theoretical statements, narratives, or a story inferred from an integration of findings from quantitative and qualitative strands of mixed methods research (Venkatesh, Brown, & Bala, 2013, pp.38). The meta-inferences are also important to be explained in order to prove that conducting this mixed methods research study has been achieved. In this framework evaluation study, we can conclude that the theoretical support of SMM has shown a solid design process underlying the eSCOUT framework. It is shown in the evaluation result of the storyboard processing phase.

6.3.5.3 Limitation of study

This study investigates the experts' opinions about the proposed eSCOUT framework. The findings from expert evaluation have also provided meaningful insights into eLearning design practices. During open discussion with the experts, they stated that the design process can also lead to the increase of productivity among IDs and SMEs, which reduces the time required to synthesize, analyze and document the design. This productivity improvement not only leads to lower design cost but also to shorter design project completion. Furthermore, experts have found that eSCOUT framework could reduce design errors through the use of the collaborative discussion and the collaborative annotation techniques. These factors can lead to improvement in the quality and accuracy of the storyboard design.

Considering this study, there is limitation in terms of indirect interaction approach conducted with the academic experts during the evaluation exercise. As mentioned in the earlier in this chapter, due to the geographical limitations to outreach the academic experts and the time limitations of the participating academicians, the explanation of the eSCOUT framework evaluation is mostly presented in the online survey, even though other means of communication technologies via Skype[17], telephone and emails are used. Some of the comments from the experts as follow:

> *Maybe to get maximum benefit of feedback, you can have a round of focus group interaction*
> *Seems workable; suggest you use face to face validation with the experts to get their feedback*
> *Online evaluation a bit difficult, especially there may be items that needs clarifications*

The eSCOUT framework has offered a new concept of interaction between IDs and SMEs in the design process of eLearning storyboard. It is a framework to describe the design communication that could achieve common ground of an eLearning course in the design team. It is clear that the eSCOUT framework is comprehensive and helps to support collaboration and communication to the ID and SME which are at two different locations. By improving several needs and recommendations to the current framework as well as focusing on special addressed issues, the eSCOUT can be revised to a better, more useful and practical requirements supported to the users. Next section presents the revised eSCOUT framework based on the result and findings of this framework evaluation study.

6.4 Revised Framework Development

Figure 6.10 shows revised framework development of the eSCOUT. A few improvements have been considered. They include having shared input, refining the agile storyboarding process with shared storyboarding activities and the eSCOUT techniques. In this revised version, collaborative whiteboard technique is introduced to support participatory design suggested by the expert. Iterative designs are also incorporated in the revised eSCOUT framework.

---

[17] http://www.skype.com/en/

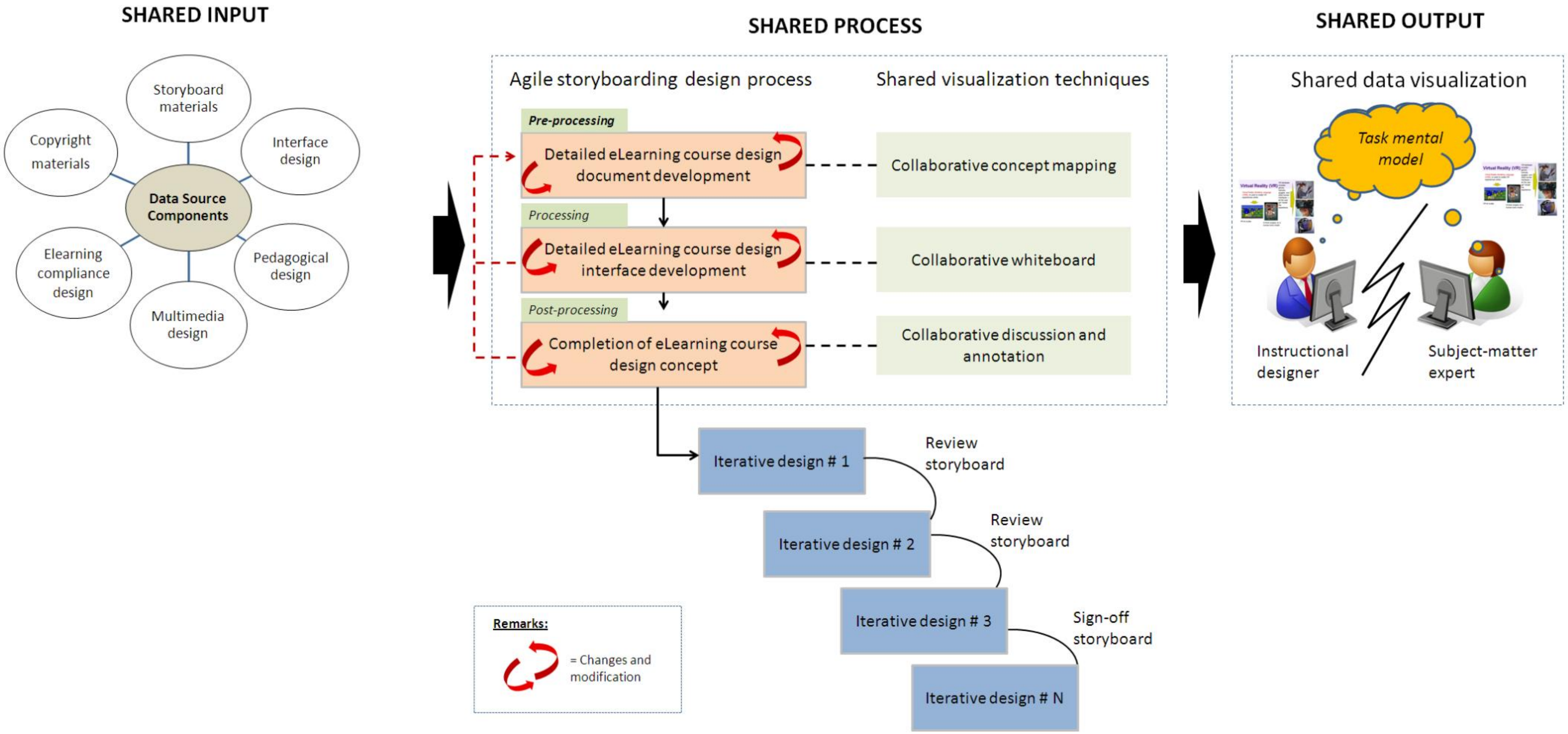


Figure 6.10: Revised framework development of the eSCOUT

6.5 Summary

This chapter presents initial framework development of the eSCOUT, framework evaluation which lead to the revised eSCOUT development. In order to assess its structural and functional design process, two sets of evaluation have been performed. First framework evaluation is conducted with experts, seeking to towards their opinions; suggestions and recommendations for framework validation and/or improvement. The second framework evaluation is conducted with industrial practitioners, which is aimed to see whether the framework correspondence with the storyboarding design process that is usually performed by storyboard designers.

From the study, some information has been synthesized and concluded as follows:

- The academic experts view the framework and testify in a form of opinion and suggestions from their research and expert knowledge which however it is not known if they have the hands on experience. On the other hand, practitioners view the framework and testify in a form of opinion and suggestions based on their hands-on experience in storyboarding tasks. It means they have direct physical experience in performing storyboarding activities in instructional design industry. Therefore, integrated input from these two types of experts should have provided meaningful information to improve the initial eSCOUT framework.
- The revised framework has been amended based on findings from the compilation of two evaluations, which may have achieved better standard development of an eLearning storyboard. However, the revised framework is still limited due to its ability which is yet to be proven in a real setting environment. Hence, further improvement of the eSCOUT is needed to test the functionality of the shared visualization technique and strategies with users in real instructional design practices. In the next chapter, a prototype is developed from the revised framework,

and the platform is used to demonstrate the proof-of-concept described in the eSCOUT.

Figure 6.11 shows achievement of research questions and connection from chapter 6 to chapter 7

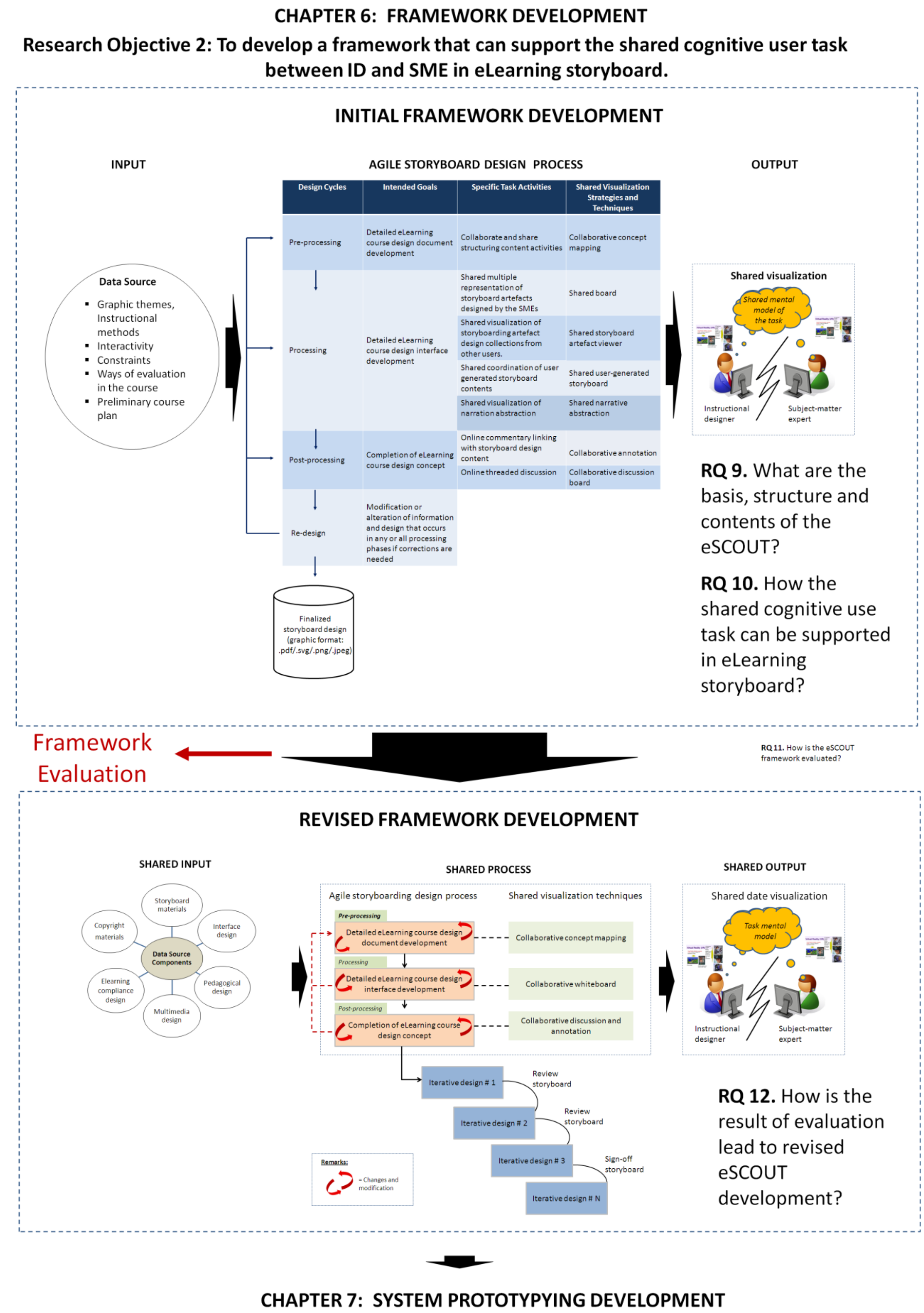


Figure 6.11: Achievement of research questions and connection from chapter 6 to chapter 7

CHAPTER 7 SYSTEM PROTOTYPE DEVELOPMENT AND EVALUATION

This chapter is conducted to complete the third and final research objective, i.e. research objective number three and four. It presents system prototyping development of the eSCOUT and system prototyping evaluation study which lead to the final revision of the eSCOUT development. Summary of the system prototyping development and evaluation is discussed.

7.1 System Prototyping Development

This section describes system prototyping development of the eSCOUT which includes software development requirements and software development architecture.

7.1.1 Software Development Requirements

The eSCOUT system is developed using three platforms; PHP, JAVA and .NET / C#. List of applications or tools required to support data storage, system builder and MVC development of the eSCOUT system for each platform as follows:

A) Platform 1 (PHP):

- Apache Web Server: To support development using PHP language
- MySQL Database: Data Storage
- Adobe Dreamweaver / Notepad++ : System builder
- Laravel Framework / Yii Framework (Optional): MVC Development Framework

B) Platform 2 (JAVA):

- Apache Tomcat Web Server: To support web development using java
- MySQL Database: Data Storage
- Eclipse or Netbeans IDE: System builder
- Grails Framework, Spring(Optional): MVC Development Framework

C) Platform 2 (.NET / C#):

- Microsoft Visual Studio: To support web development using .NET / C#

Next section describes software development architecture of the eSCOUT system.

7.1.2 Software Development Architecture

This section presents system architecture, use case, activity diagram as well as ID, SME and reviewer sequence diagrams.

7.1.2.1 System Architecture, Use Case and Activity Diagrams

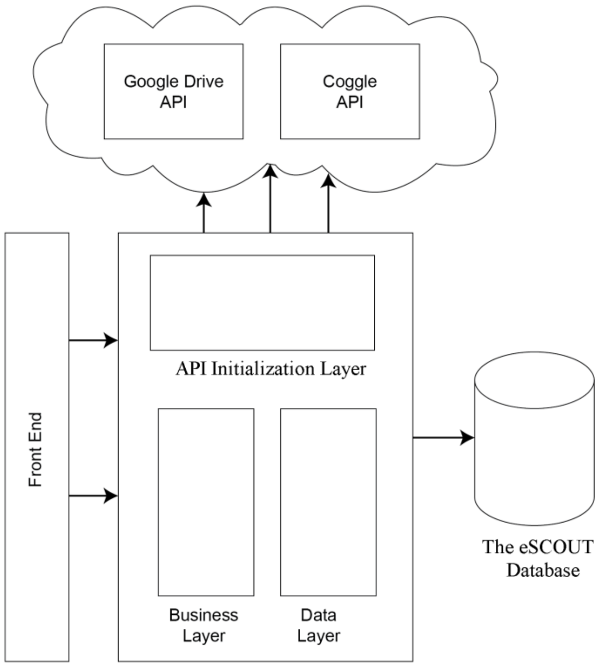


Figure 7.1: Architecture of the eSCOUT

As seen in Figure 7.1, the eSCOUT system is developed using PHP, JAVA and .NET by integrating the application programming interface (API) of Coggle and Google Drive. Coggle and Google Drive are cloud applications which enable user to create, store, access and edit files/documents online such as structural maps, documents, spreadsheets, slides and drawings. By integrating the eSCOUT with Google Drive, users are able to access, edit, and save their application files to Google Drive. This system is developed using Google Software Development Kit (SDK) or so called as the

Google Library[18]. It is also a cross-platform application where it can be used in mobile platform like android and iOS. In the eSCOUT prototype, users remotes the Google Drawing Canvas using iframe in order to demonstrate how the canvas would work. Figure 7.2 shows use cases for three actors; ID, SME and reviewer, which is self-explanatory.

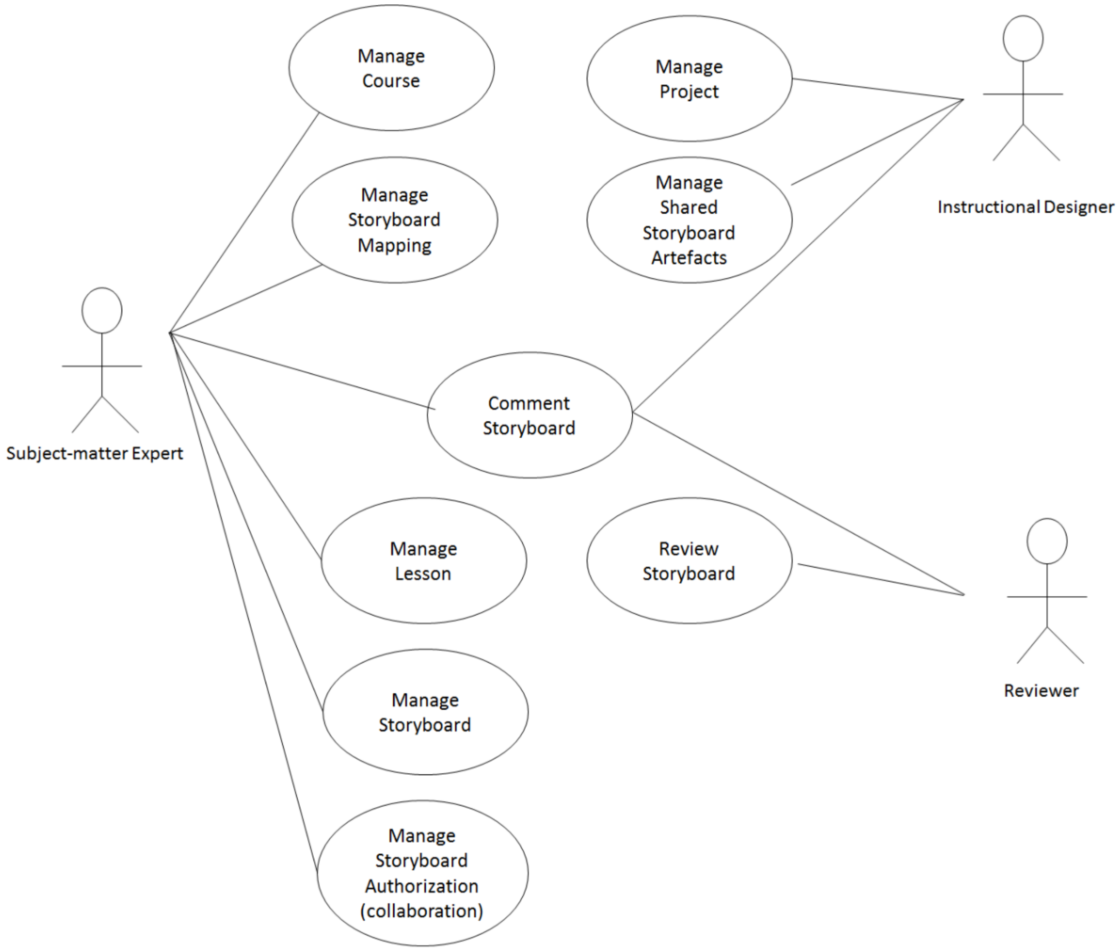


Figure 7.2: Use case diagram

Figure 7.3 shows an activity diagram between the three actors; SME, ID and Reviewer which is self-explanatory.

[18] URL: https://developers.google.com/drive/

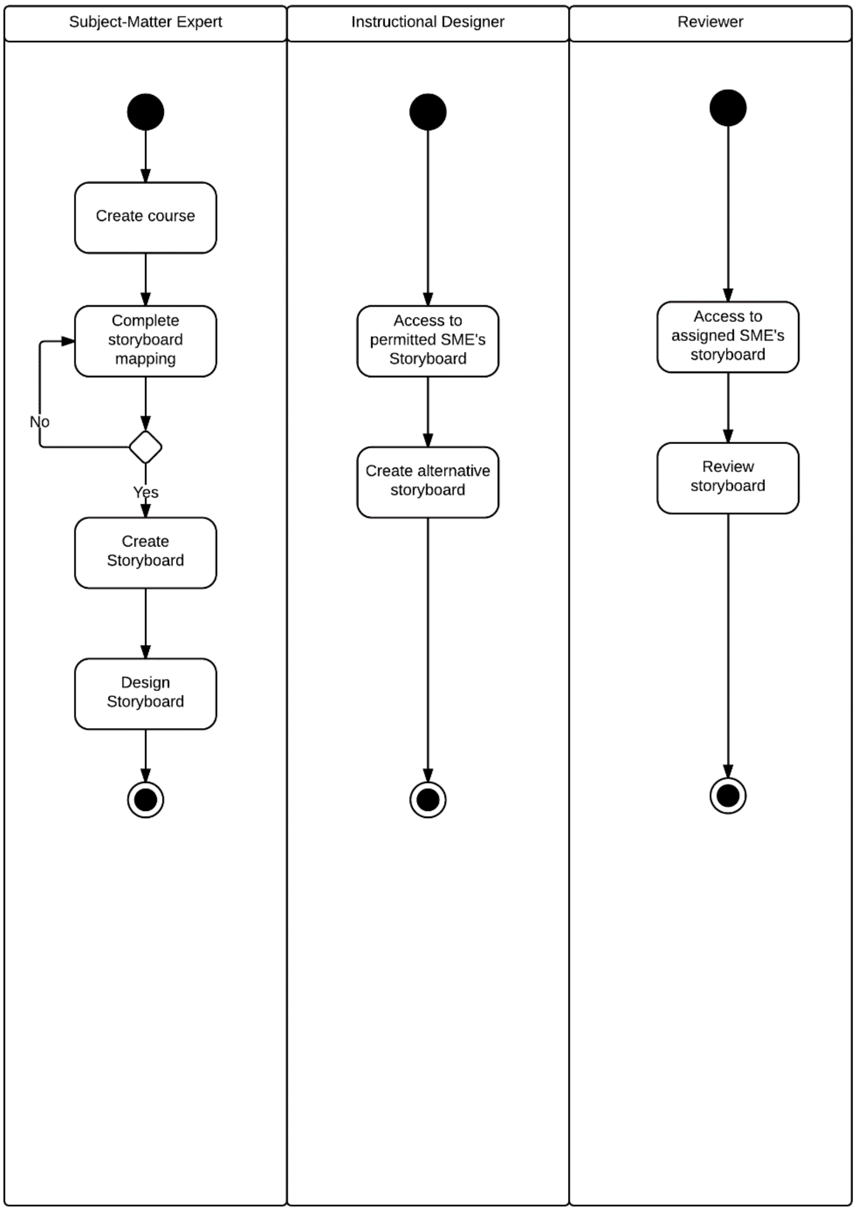


Figure 7.3: Activity diagram

7.1.2.2 Instructional Designer Sequence Diagrams

Both figure 7.4 shows a sequence diagram of ID manages a project and figure 7.5 show a sequence diagram of ID shares a storyboard, , which are self-explanatory.

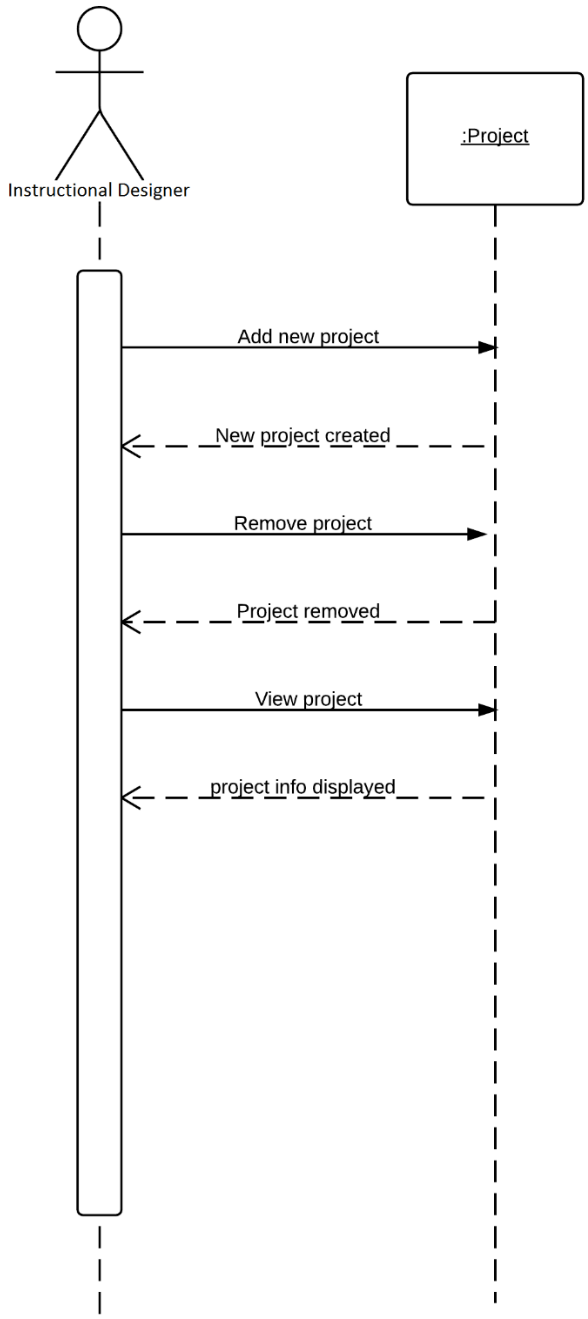


Figure 7.4: Sequence diagram – ID manages a project

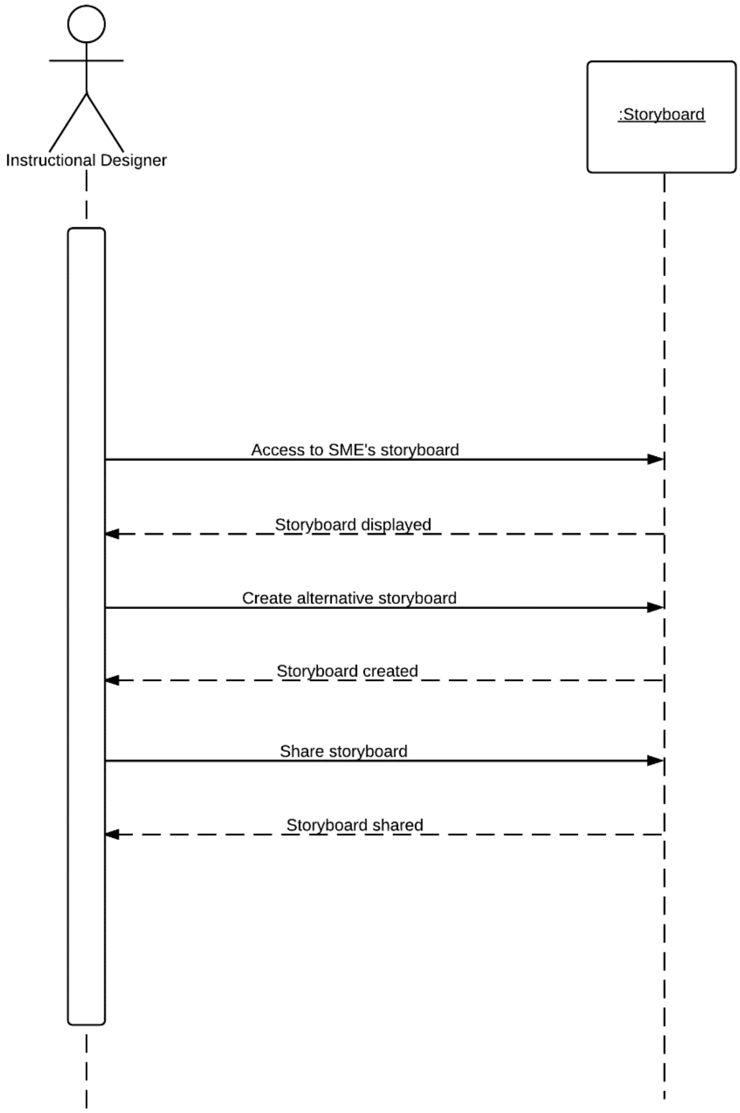


Figure 7.5: Sequence diagram – ID shares a storyboard

7.1.2.3 Subject-matter Expert Sequence Diagrams

Figure 7.6 shows a sequence diagram of SME manages a course, figure 7.7 shows a sequence diagram of SME manages a lesson, and figure 7.8 shows a sequence diagram of SME manages storyboard mapping and storyboard design. All are self-explanatory.

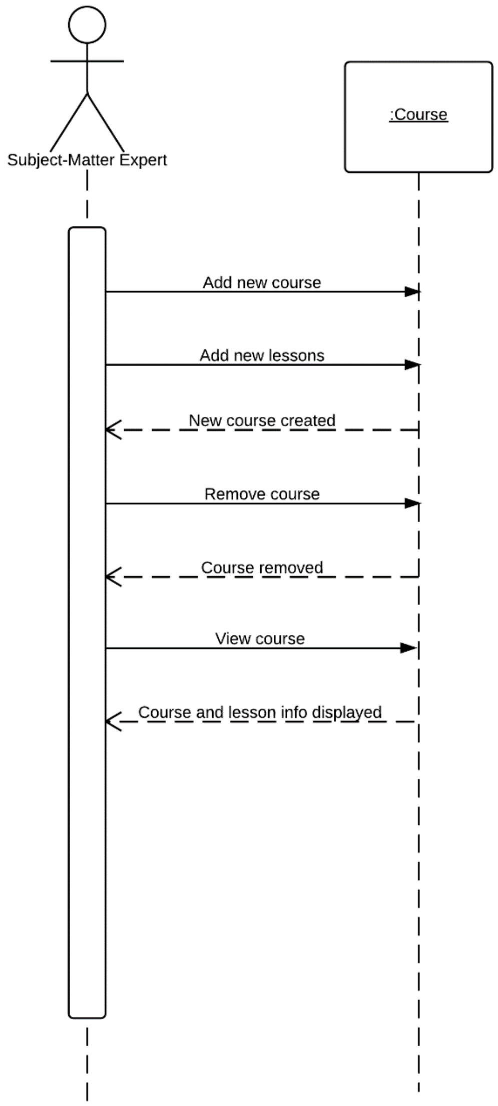


Figure 7.6: Sequence diagram - SME manages a course

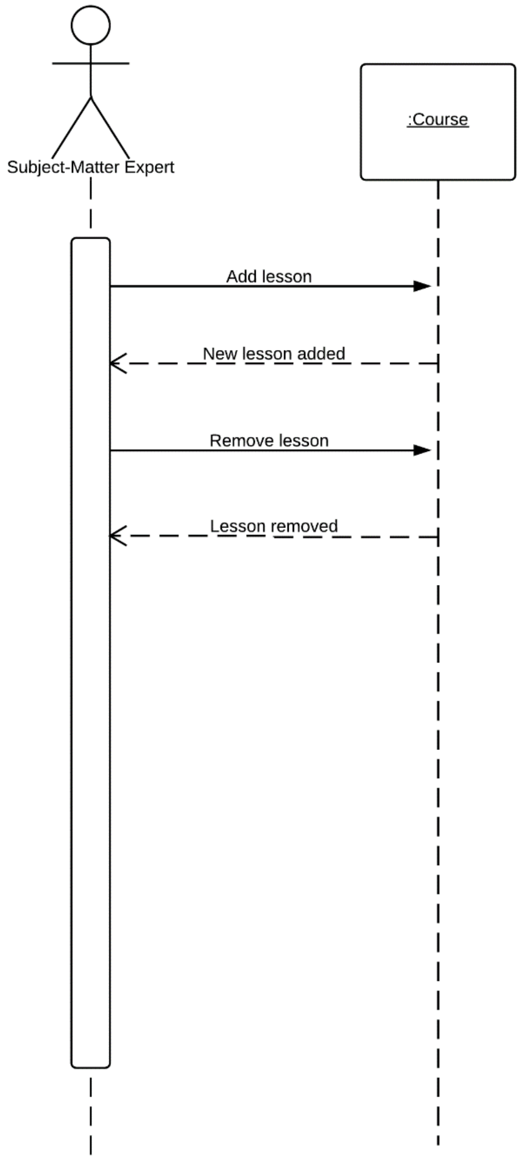


Figure 7.7: Sequence diagram: SME manages a lesson

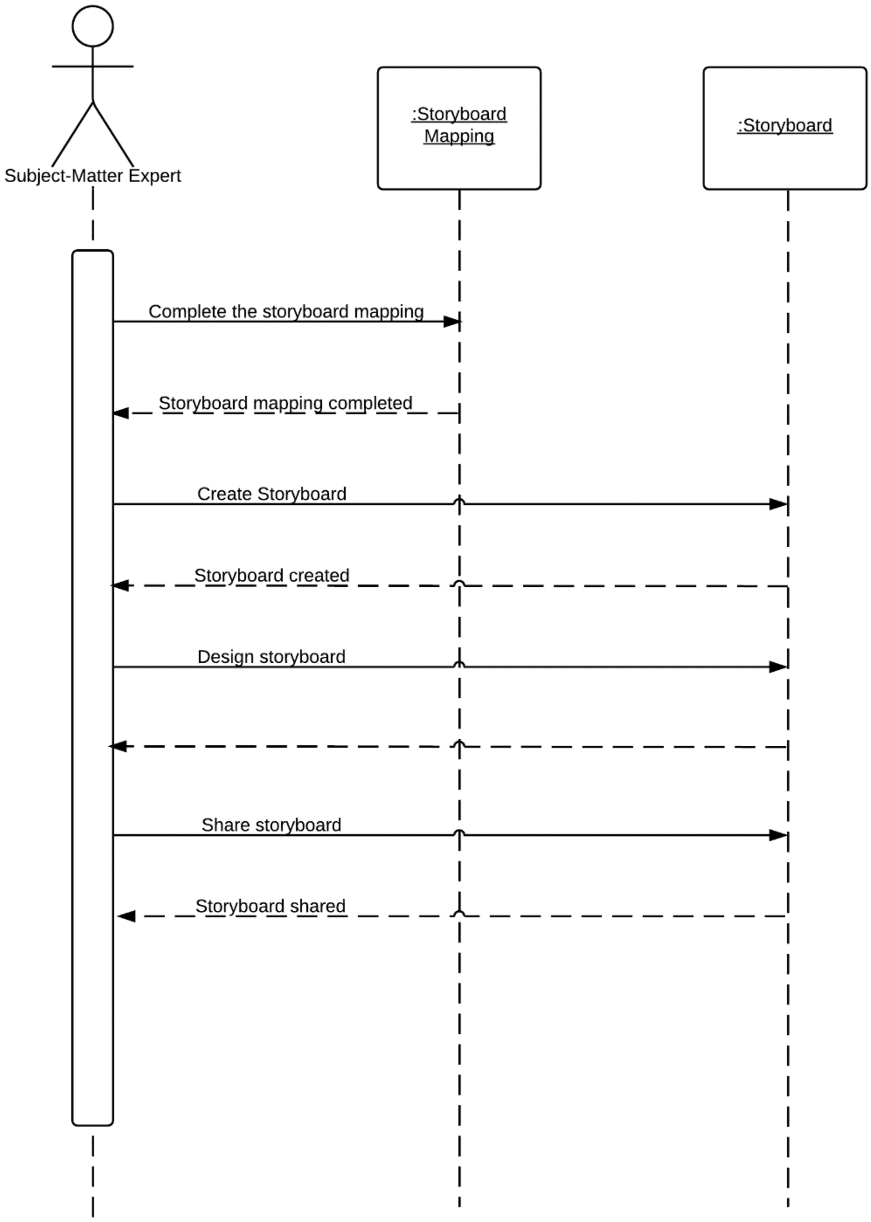


Figure 7.8: Sequence diagram – SME manages storyboard mapping and storyboard design

7.1.2.4 Reviewer Sequence Diagram

Finally, figure 7.9 shows a sequence diagram of reviewer reviews storyboard, which is self-explanatory.

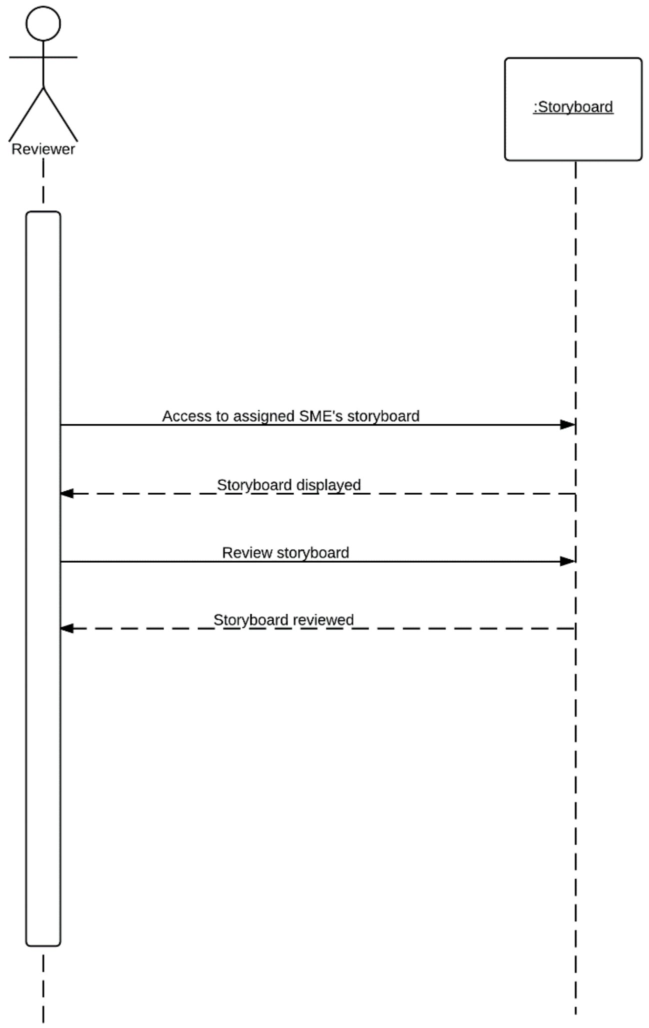


Figure 7.9: Sequence diagram: reviewer reviews storyboard

7.1.3 The eSCOUT Tools

As shown in Figure 7.10, the eSCOUT tools are grouped into general tools and specific tools.

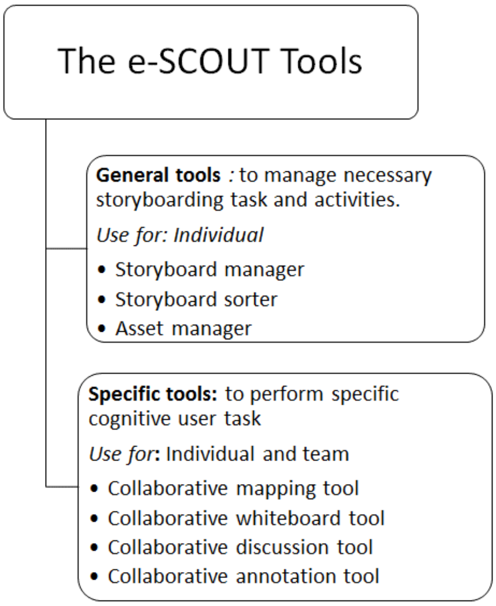


Figure 7.10: The eSCOUT general and specific tools

A) General tools

General tools are designed to manage necessary storyboarding task activities. There are three general tools in the eSCOUT; storyboard manager, storyboard sorter and asset manager

- The storyboard manager: Using the create-read-edit-delete-overview (CREDO) matrix, this tool can be used by the ID and SME to create, read, edit, delete and overview new storyboard screen with information and administration details, as per advised by Brandon (2004) such as date of storyboard creation, storyboard number, version number, revision number, writer name, reviewer name, review date, course title and number, module title and number, lesson title and number, as well as screen title and number.

- The storyboard sorter: This tool enables the ID and SME to view storyboard screens which have been created. The user can also view and sort the storyboard screens.
- The asset manager: This tool assists the users to manage the assets in the storyboard.

B) Specific tools

Specific tools are designed to perform specific task in order to support shared cognitive user task. They are collaborative mapping, collaborative whiteboard, collaborative discussion and collaborative annotation tools.

7.1.4 User Interface of the eSCOUT System

In this section, screen shots of the eSCOUT user interfaces using examples of designing eLearning storyboard for two subject courses entitles “Data Structures and Algorithms” and “Human-computer Interaction” are presented.

7.1.4.1 Log-in Interface

As shown in Figure 7.11a, the user will log-in as “Instructional Designer” or “Subject Matter Expert” or “Reviewer”, where the username and password are required. User can also sign in as an existing user or register as a new user. Both ID and SME can see their own profile (see Figure 7.11b and Figure 7.11c). Both of them can see Project List (see Figure 7.11d). ID can create new project (see Figure 7.11e) while SME can add, edit and delete course and lessons (see Figure 7.11f).

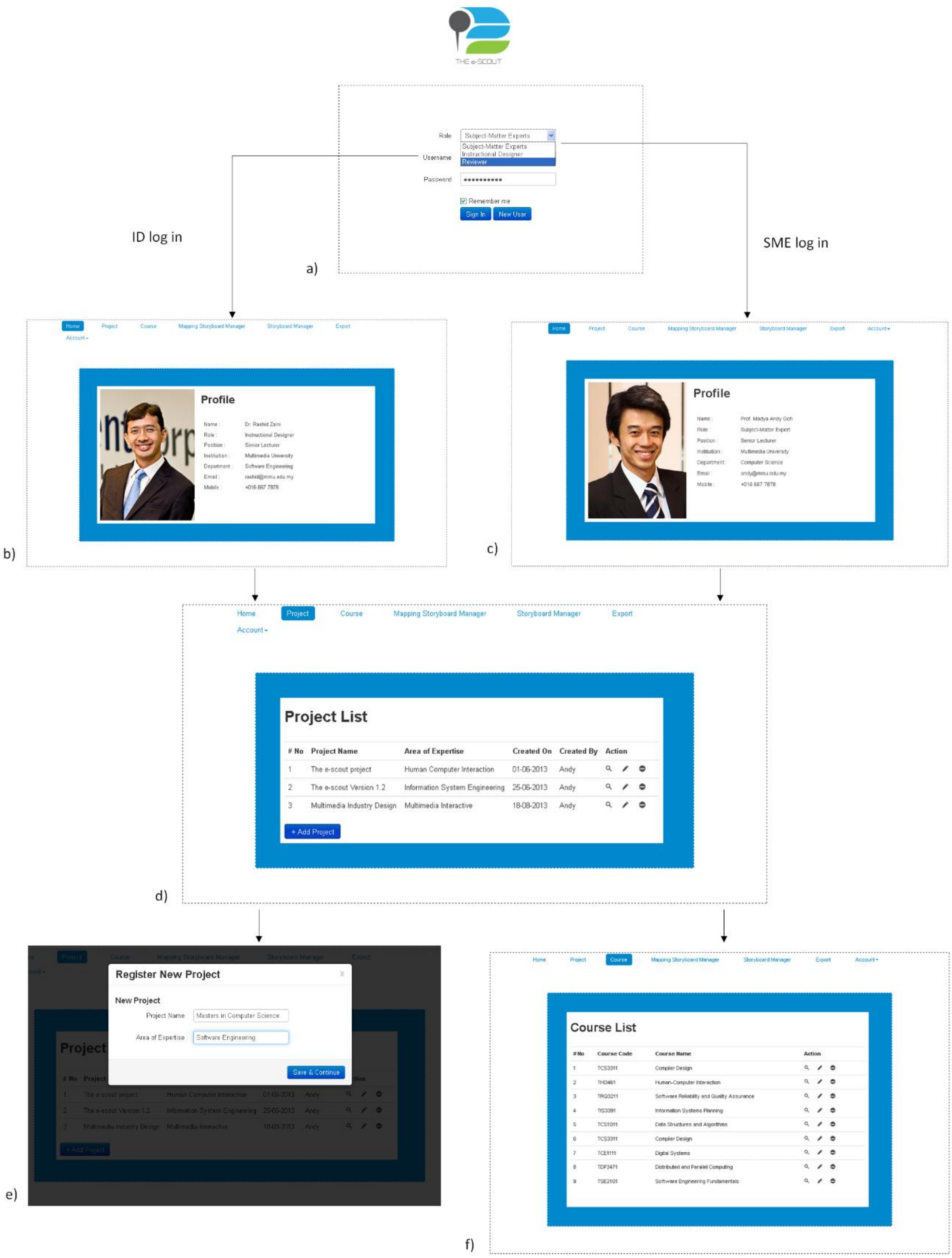


Figure 7.11: User interface begins from a) Log-in b) ID profile c) SME profiles d) Project list e) Register new project and f) Course list

7.1.4.2 Collaborative Concept Mapping Tool Interfaces

Figure 7.12 shows interface of Collaborative mapping tool and its functionalities, which is self-explanatory.

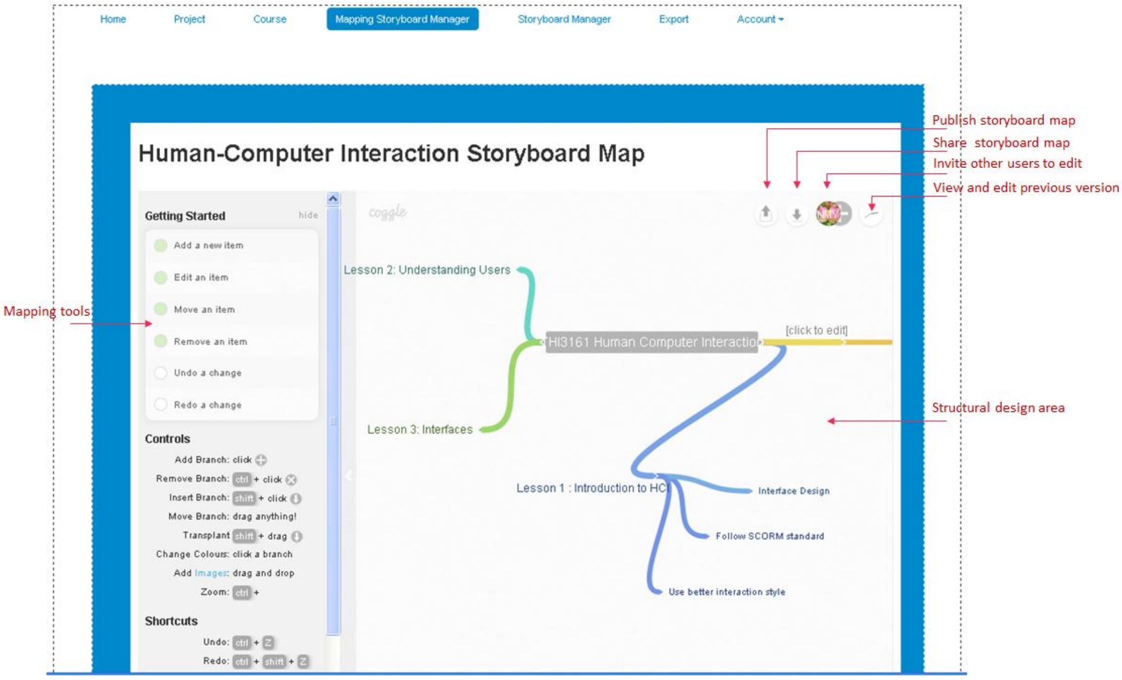


Figure 7.12: Collaborative Mapping Tool Interface

Using Collaborative mapping tool, SME can manage storyboard mapping manager of all his/her courses. The action button leads to storyboard mapping activities; while storyboard button leads to storyboard design activities (see Figure 7.13a). For example, action button for “Data Structure and Algorithm”, can generate to the list of lessons which lead to storyboard mapping activities or storyboard design activities.

Figure 7.14 shows the Collaborative concept mapping tool interfaces for a storyboard map of “Human-computer Interaction” subject (see Figure 7.14a). After the storyboard map has been created, SME can invite other users i.e. ID and SME to edit structural design (see Figure 7.14b), share structural design task (see Figure 7.14c) and/or view task history and edit the previous version of structural design (see Figure 7.14d). Finally, SME can publish the structural design in different files format such as PDF, JPEG and PNG (see Figure 7.14e).

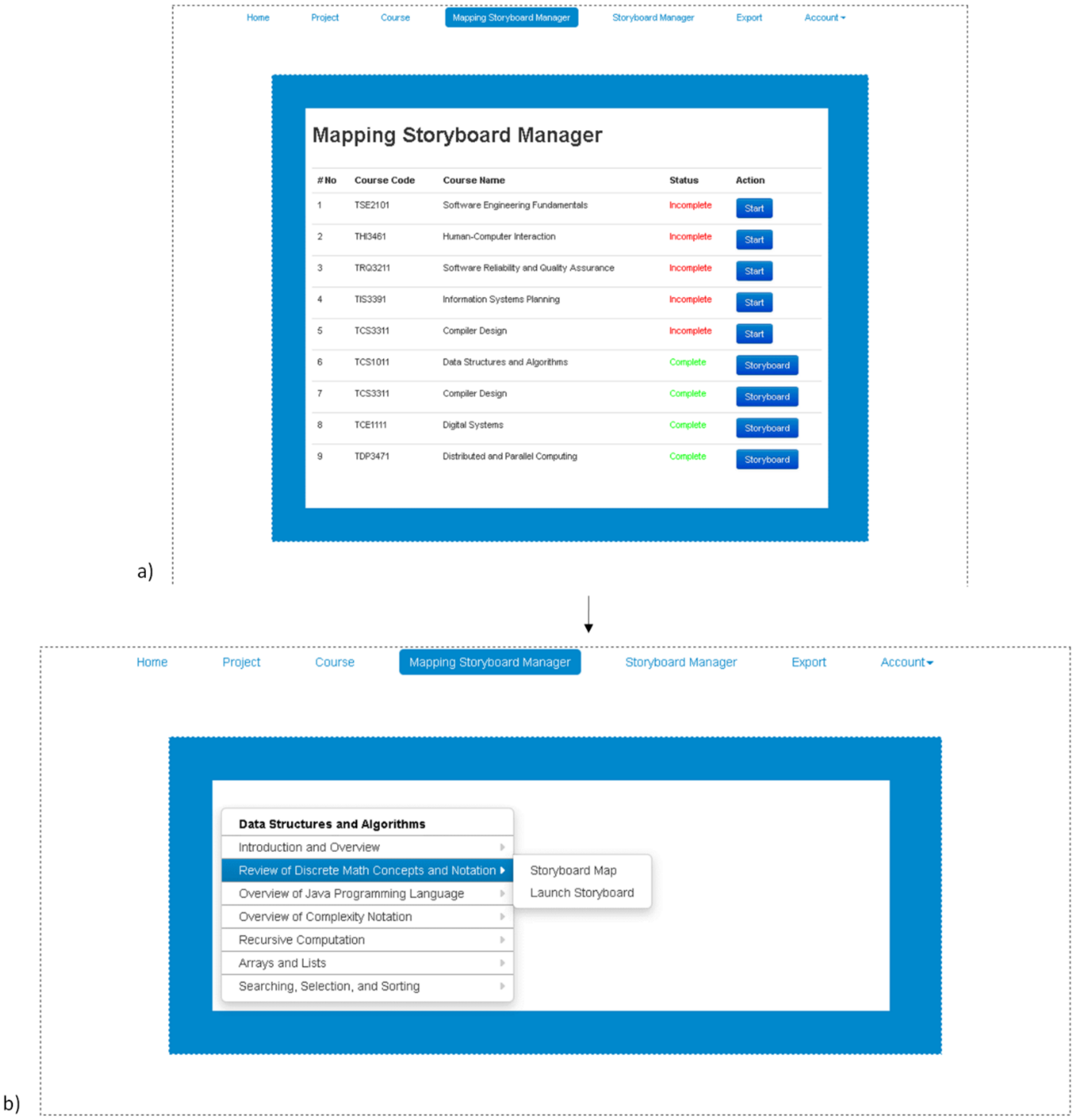


Figure 7.13: Collaborative concept mapping tool interfaces – a) Mapping storyboard manager b) "Data Structure and Algorithm" course and lessons

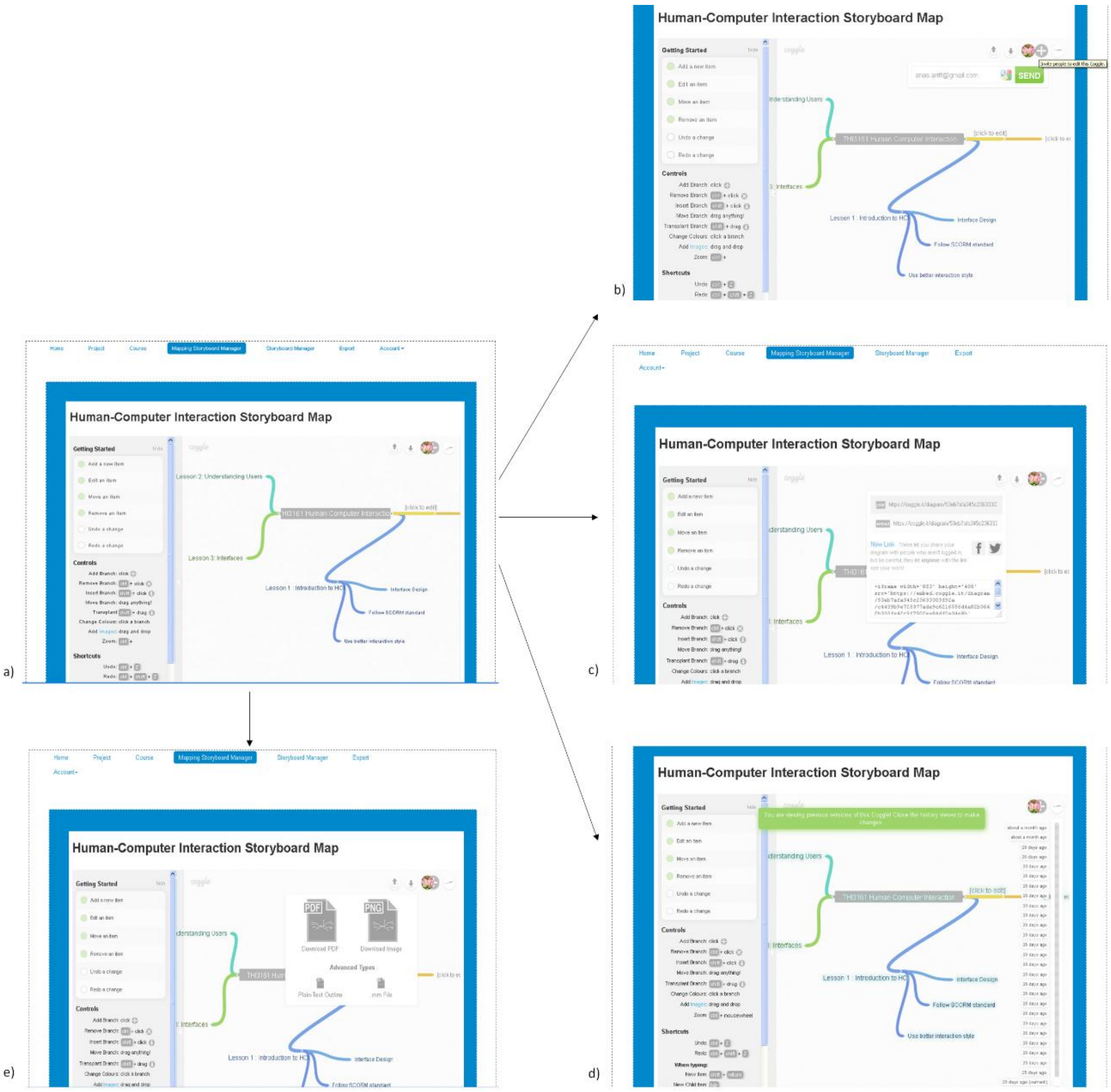


Figure 7.14: Collaborative concept mapping tool interfaces – a) Storyboard map created for "Human-computer Interaction" subject b) Inviting other users to edit structural design c) Sharing structural design task d) History view and edit previous versions of structural design e) Publishing structural design

7.1.4.3 Collaborative Whiteboard Tool Interfaces

Figure 7.15 shows interface of Collaborative whiteboard tool and its functionalities, which is self-explanatory.

In order to find particular SCO or create new SCO, SME can select course (see Figure 7.16a), select lesson (see Figure 7.16b) and select SCO or create new SCO (see Figure 7.16c). SME can select SCO title (see Figure 7.17a) and rename the SCO title (see Figure 7.17b). Besides, SME can view storyboard information/feature (see Figure 7.18a) and do some editing (see Figure 7.18b). SME can view his/her generated storyboard (see Figure 7.19a) as well as view other users' storyboard artefacts that are shared in the eSCOUT (see Figure 7.19b). Finally, SME can share his/her own storyboard with ID and other users (see Figure 7.20).

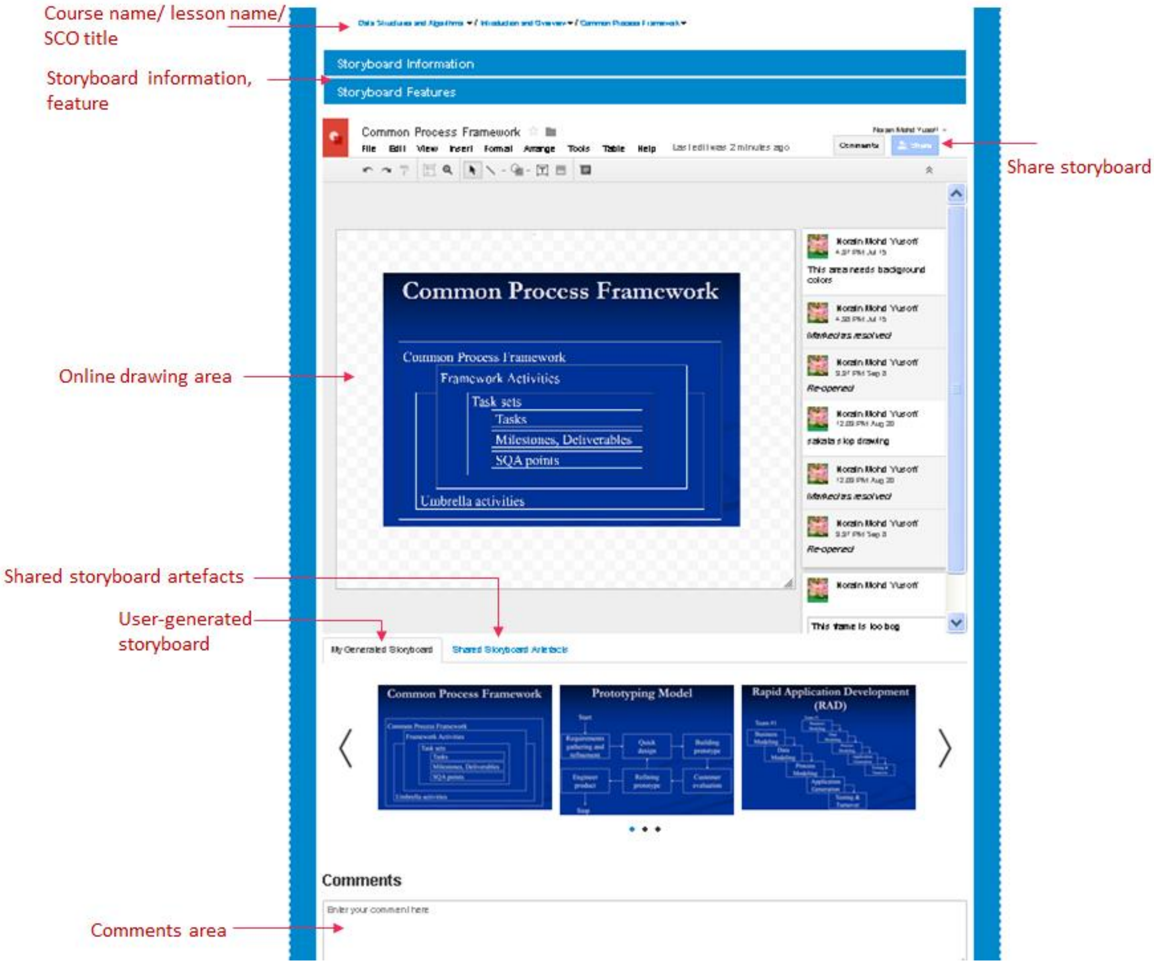


Figure 7.15: Collaborative Whiteboard Tool Interface

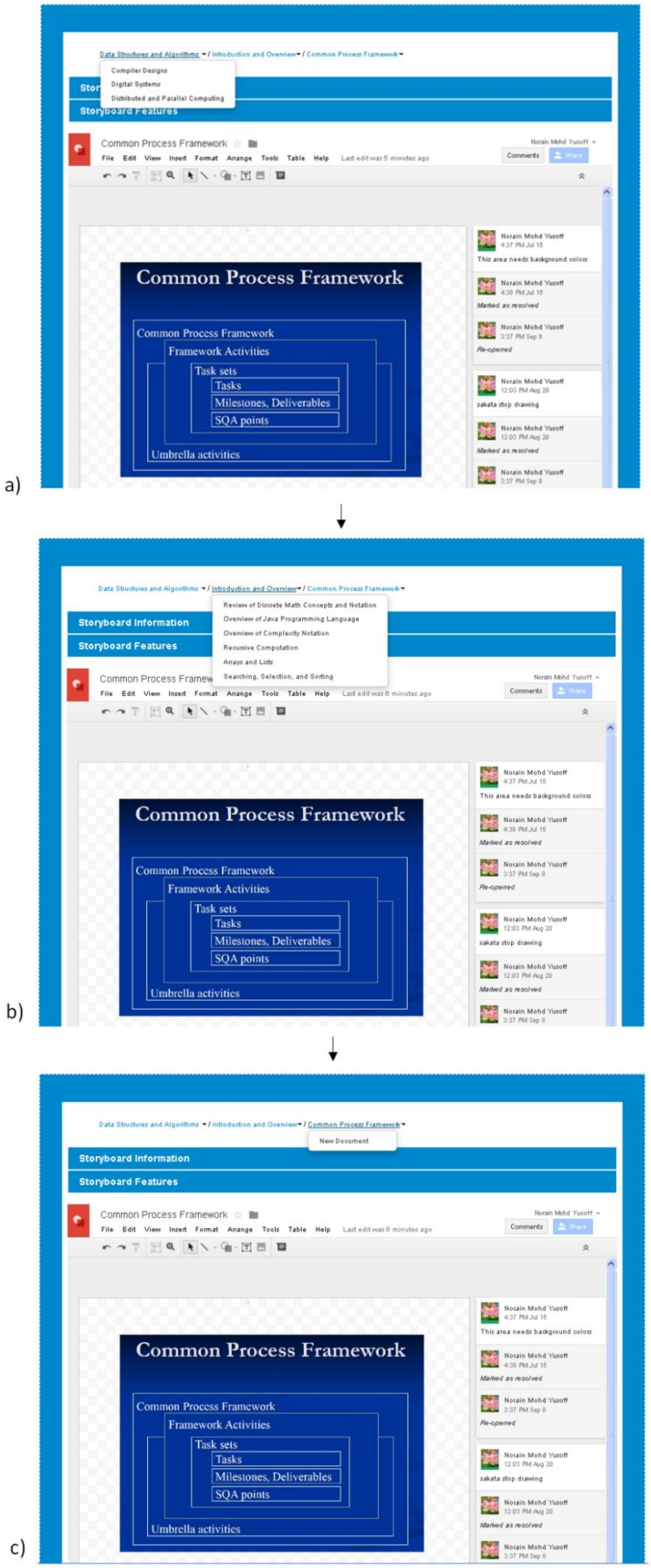


Figure 7.16: Collaborative whiteboard interfaces - a) Select course b) Select lesson c) Select SCO or create new SCO

a)

b)

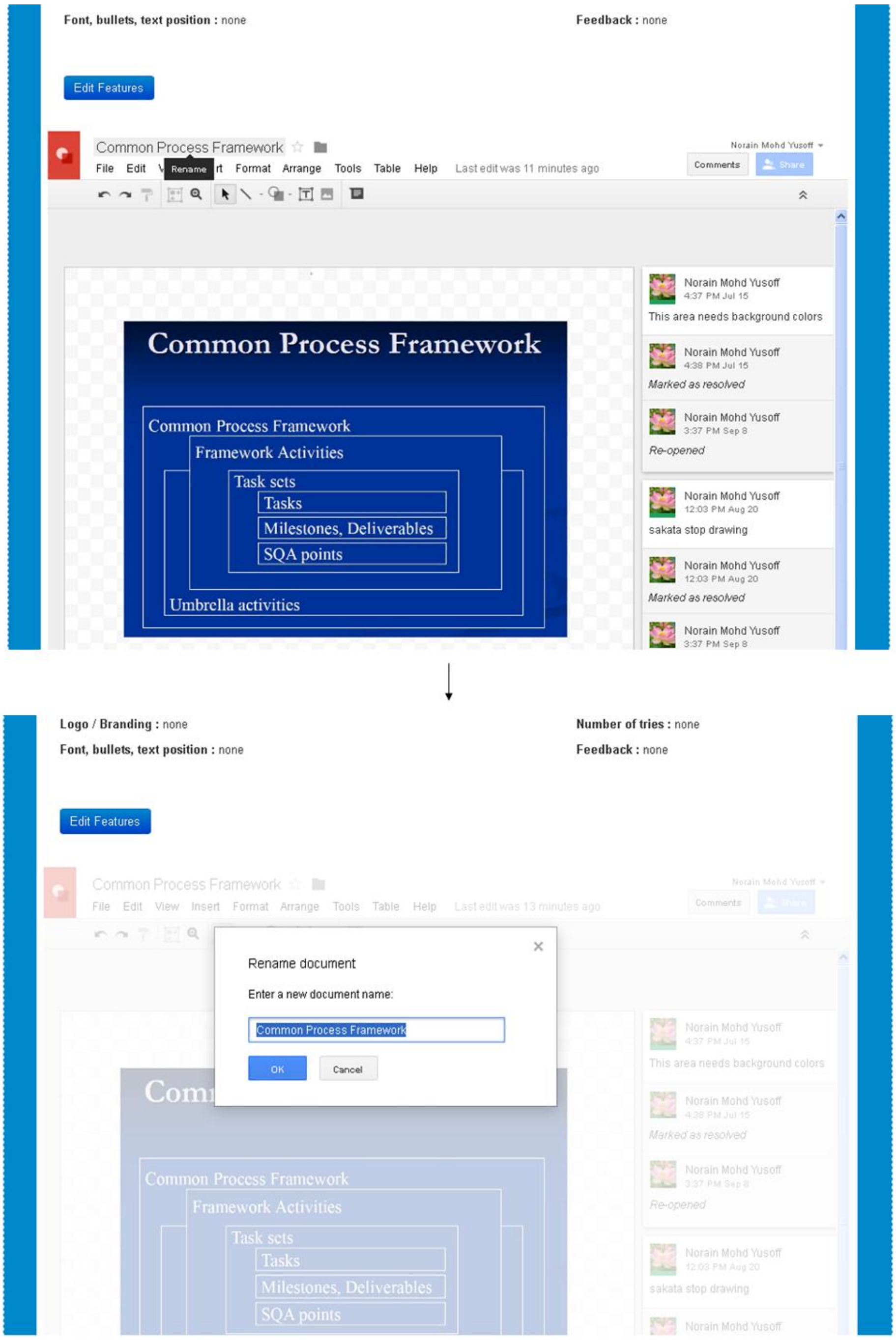


Figure 7.17: Collaborative whiteboard interfaces – a) Select SCO title b) Rename SCO title

a)

b)

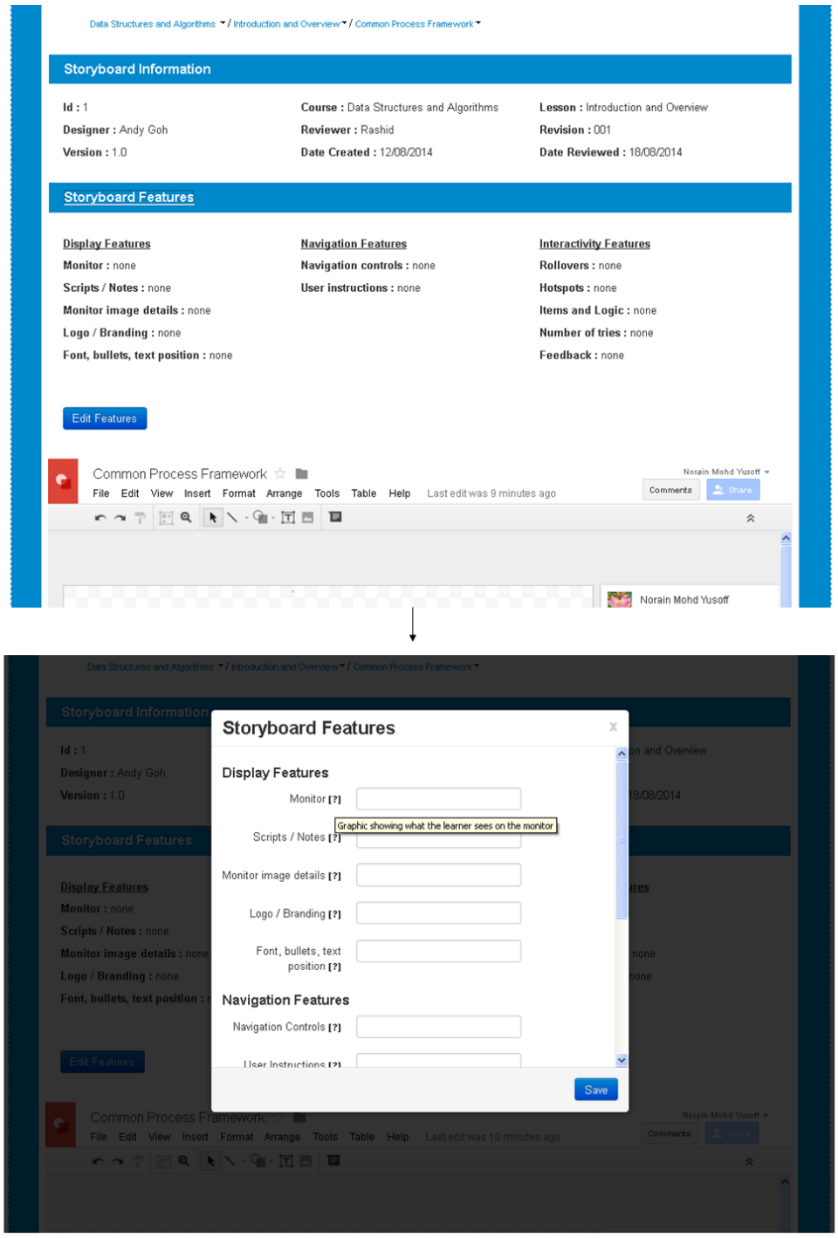


Figure 7.18: Collaborative whiteboard interfaces – a) Display storyboard information/feature b) Edit storyboard feature

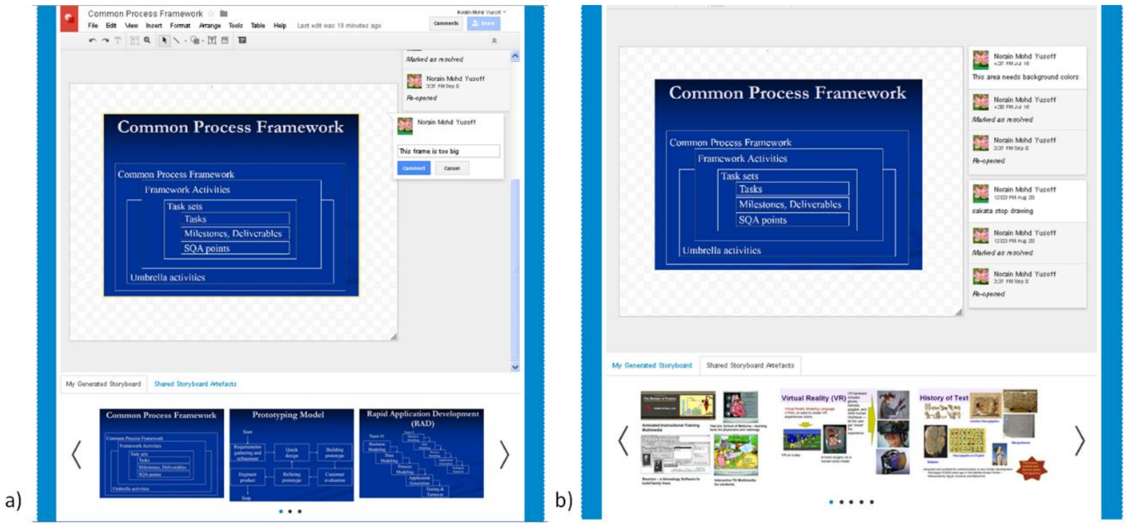


Figure 7.19: Collaborative whiteboard interfaces – a) My generated storyboard b) Shared storyboard artefacts

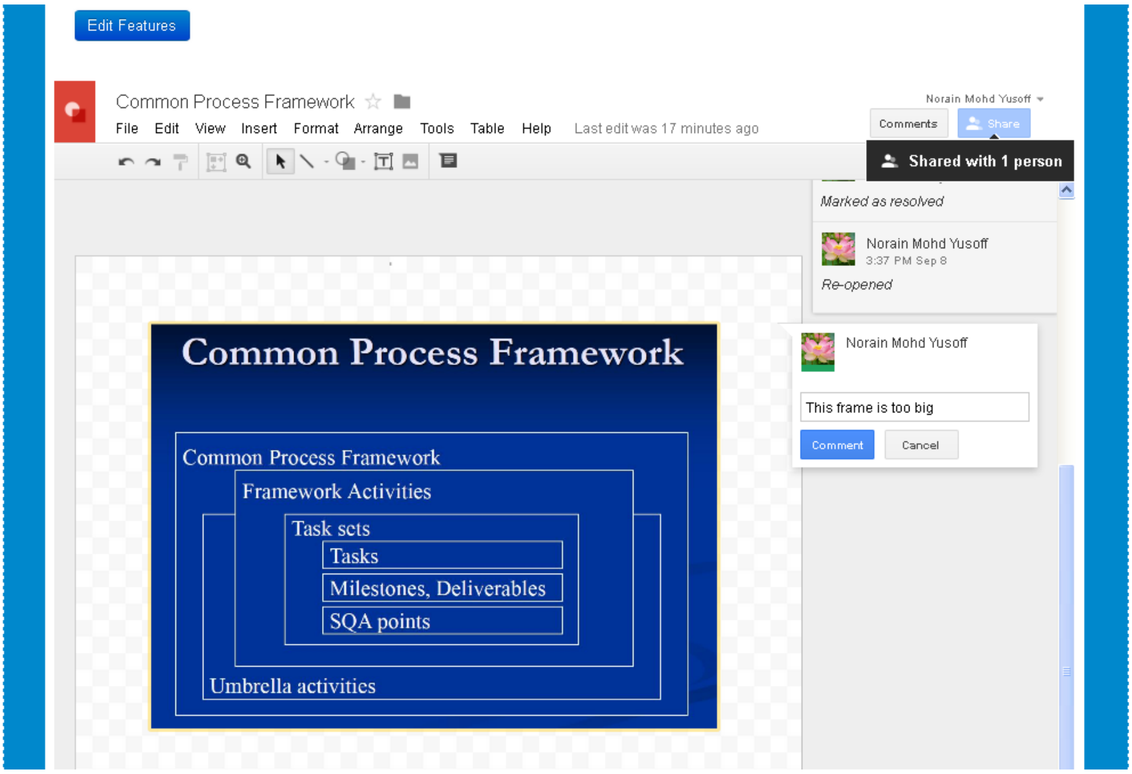


Figure 7.20: Collaborative whiteboard interface - Share storyboard with other users

7.1.4.4 Collaborative Annotation Tool Interface

Figure 7.21 shows interface of Collaborative annotation tool and its functionalities, which is self-explanatory.

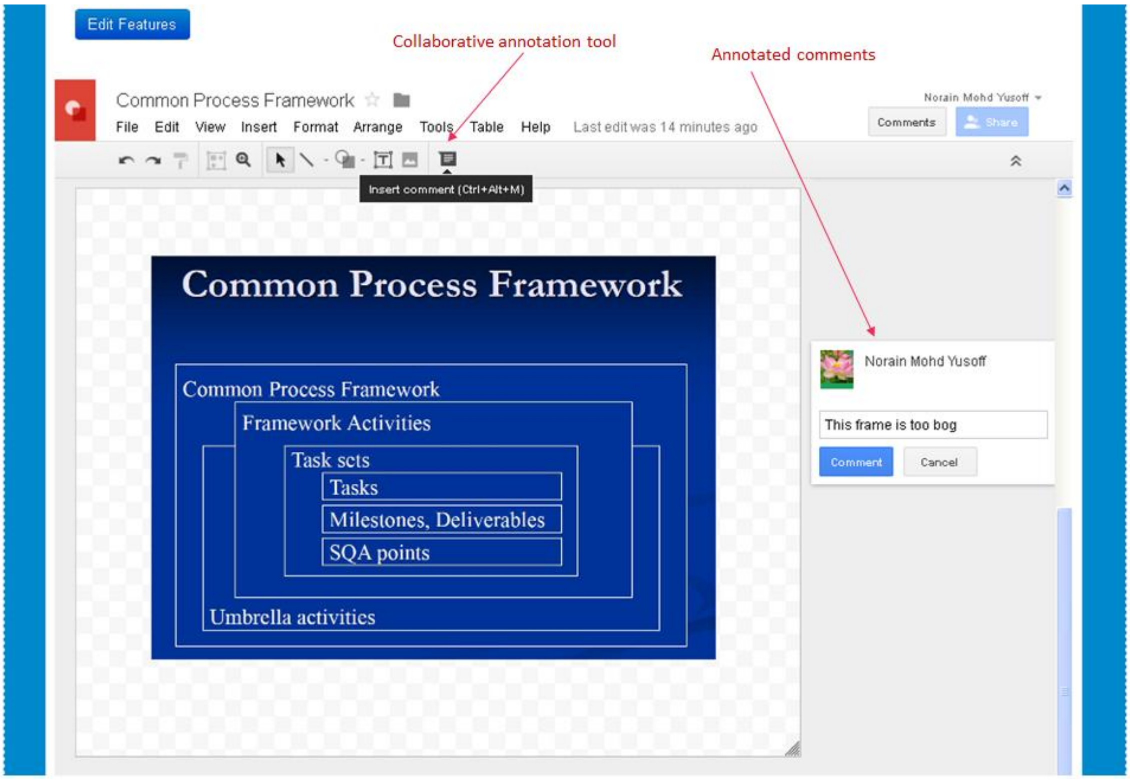


Figure 7.21: Collaborative annotation tool interface

7.1.4.5 Collaborative Discussion Tool Interface

Figure 7.22 shows collaborative discussion tool and its functionalities, which is self-explanatory.

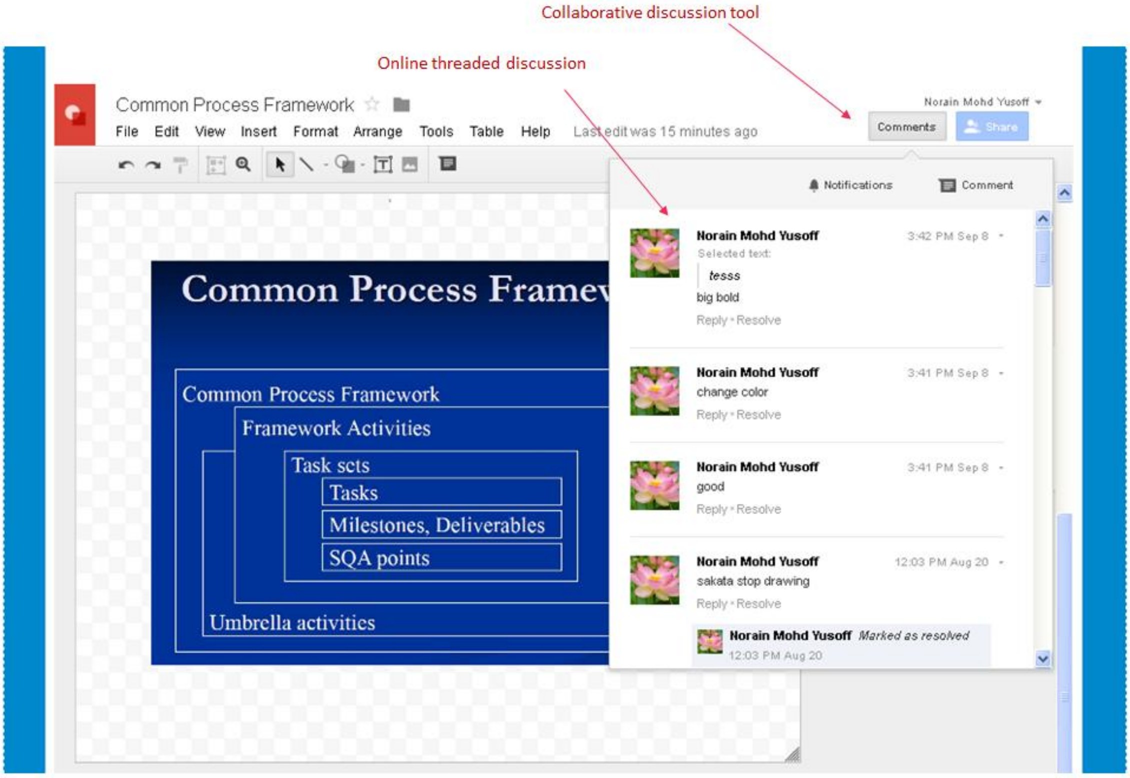
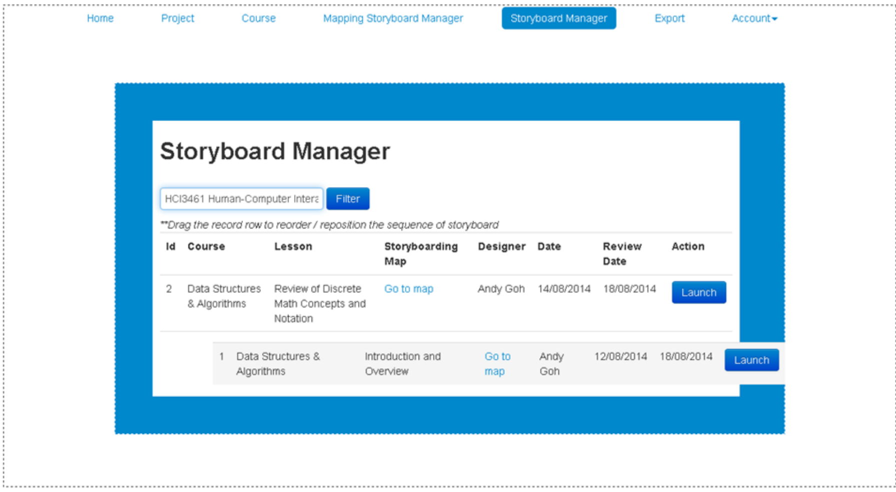


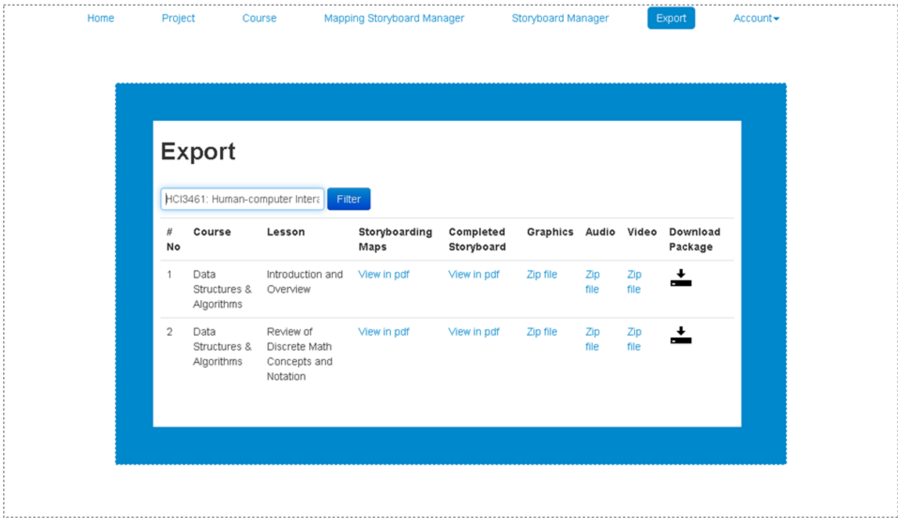
Figure 7.22: Collaborative discussion tool interface

7.1.4.6 Log-out interface

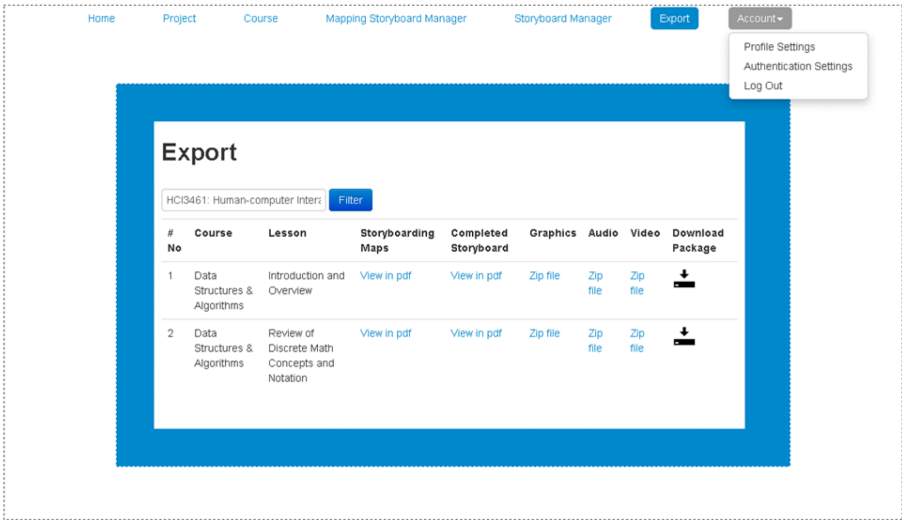
SME can manage storyboard by dragging the record row to re-order or reposition to the sequence of the storyboard (see Figure 7.23a). At the end of the process, SME can download each of SCO of the course storyboard map, completed storyboard, graphics, audio and/or video as individual zip file or altogether as one package (see Figure 7.23b). Figure 7.23c shows the log-out session.



a)



b)



c)

Figure 7.23: a) Storyboard manager b) Export storyboard packages c) Log-out interfaces

7.2 System Prototyping Evaluation

The section describes three phases in system prototyping evaluation; cognitive walkthrough, usability evaluation and SMM measurement. It begins with describing the participants, purpose of each phases of evaluation and the flow of evaluation study.

7.2.1 Participants

Two identified groups of participants are invited; instructional designers and academicians. All of the invited participants are from Multimedia University (MMU). As mentioned in Chapter 4, MMU is again chosen in this evaluation study due to its establishment in developing their internally customized eLearning contents. First group consists of seven instructional designers who work at the MPU in this university. The second group also consists of seven faculty members who work at the Faculty of Computing and Informatics and the Faculty of Creative Multimedia. Table 7:1 shows the profile of the participants.

Table 7.1: Profile of participants in evaluation study

Demographic Dimension	Demographic Items	Faculty members (N=7)	Instructional designers (N=7)
Gender	Male	3 (42.9%)	2 (28.6%)
	Female	4 (57.1%)	5 (71.4%)
Education	Bachelor	0 (0.0%)	5 (71.4%)
	Master’s degree	4 (57.1%)	2 (28.6%)
	PhD	3 (42.9%)	0 (0.0%)
Years of working experience	> 10 years	1 (14.3%)	6 (86.7%)
	> 7 years	2 (28.6%)	1 (14.3%)
	> 5 years	4 (57.1%)	0 (00.0%)
	< 5 years	0 (00.0%)	0 (00.0%)

7.2.2 Purpose of Study

First evaluation study is aimed to evaluate whether the agile storyboarding process model of the eSCOUT framework is effective and efficient. The agile storyboarding process model is a part of the eSCOUT framework that needs to be evaluated in this study. Since the steps are quite complex and requires different ways of operations, this study aims to determine whether the process model is effective and efficient for use in storyboarding activities. The first element to be evaluated is effectiveness. The context of effectiveness in this study refers to the capability to support the participants in carrying out storyboarding activities in an agile way. The second element is efficiency. The context of efficiency in this study refers to the capability to allow participants in carrying out storyboarding activities through a minimal number of steps. Second evaluation study is aimed to evaluate the usability of the general and specific tools in the eSCOUT using Purdue Usability Testing Questionnaire (PUTQ) (Lin, Choong & Salvendy, 1997). Third study is conducted to see whether the shared visualization strategies and technique which are designed in the eSCOUT tools can facilitate TMM development in eLearning storyboard. In order to achieve TMM, this study evaluate degree of agreement in terms of shared understanding of the task as well as shared understanding of similarity and accuracy of the shared data visualization.

7.2.3 Three Phases of Evaluation

Figure 7.24 shows the flow of the evaluation study. It begins with cognitive walkthrough, then continues with usability evaluation and finally it ends with SMM measurement. Both groups of participants had participated throughout the three evaluation studies.

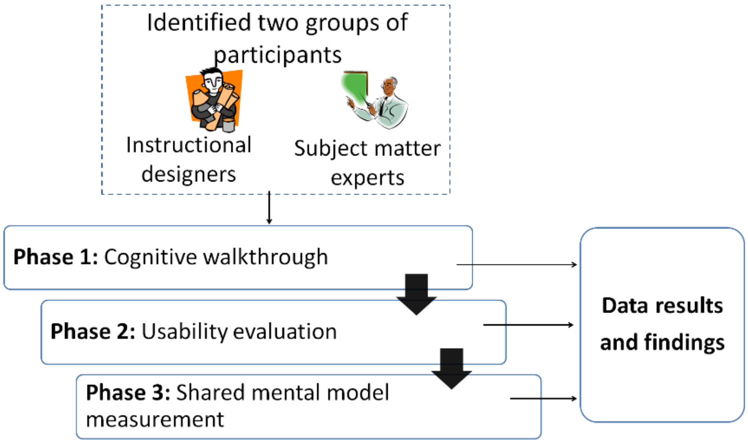


Figure 7.24: Flow of evaluation study

Table 7:2 shows the summary of each of the evaluation study methodologies in terms of the types, objectives, ways of evaluation, data gathering techniques, data analysis, supplementary guidelines, and expected evaluation outcomes.

Table 7.2: Three types of evaluation in the eSCOUT system prototype

Phases Evaluation / Description of Evaluation	**Evaluation Study 1**	**Evaluation Study 2**	**Evaluation Study 3**
Types of Evaluation	Cognitive Walkthrough	Usability Evaluation	Shared Mental Model Measurement
The objectives	To evaluate the effectiveness and efficiency of the tools and the agile storyboarding process	To evaluate the effectiveness, utility, learnability and satisfaction of the tools	To evaluate degree of agreement in terms of shared understanding of the task as well as shared understanding of similarity and accuracy of the shared data visualization
Participants	ID and SME		
Ways of evaluation	The series of task sequences using the tools and agile storyboarding design process	Self exploration using the tools	Paired Groups of ID-SME
Data gathering technique	Think-aloud technique	Questionnaires	Questionnaires
Data analysis	Qualitative and quantitative data	Quantitative data	Qualitative data
Supplementary guidelines	Task Scenario	Purdue Usability Testing Questionnaire (PUTQ)	Interactively Elicited Cause Mapping
Expected evaluation outcome	Degree of effectiveness and efficiency when the tools and agile storyboarding process are applied	Degree of agreement in terms of effectiveness, utility, learnability and satisfaction of the tools	Degree of agreement in terms of shared understanding of the task (task mental model), Degree of agreement in terms of shared understanding of similarity and accuracy of shared data visualization

These three phases of system prototyping evaluation are presented in different section. Every section describes evaluation procedures and design as well as data results and finding. Consequently, data results and findings are discussed.

7.3 Evaluation Study 1: Cognitive Walkthrough

Cognitive walkthrough is a type of cognitive task analysis methods that "focuses upon the usability of an interface, in particular the ease of learning associated with the interface" (Stanton, et al., 2005, pp.93). The procedure comprises a set of criteria which is direction to cognitive processes involves the users "walk" through each user action involved in a task step. The procedure comprises two phases, the preparation and evaluation phase. The preparation phase involves selecting the set of tasks to analyze and determining the task sequence, while the evaluation phase involves the analysis of the interaction between the user and the interface.

This method is suitable to use during evaluation study because as a non-cognitive psychology professional, it is easy to apply and the output appears to be very useful especially in evaluating the agile storyboarding process in the eSCOUT system. According to Sharp, Rogers and Preece (2007), this technique focus closely on identifying specific user problems at a high level where it is useful for application involving complex operations as it is described in the proposed agile storyboarding process.

However, this evaluation method suffers some drawback such as time consuming and require access to the personnel involved in the tasks under analysis. Even though it consumes time to complete a series of tasks, this method is useful because the participants will be exposed to the appropriate steps under the key tasks in the agile storyboarding process model. It is assumed that if they have understood and familiar about how the agile storyboarding process works, it will be easier for the researcher to move forward with the second phase of the eSCOUT evaluation.

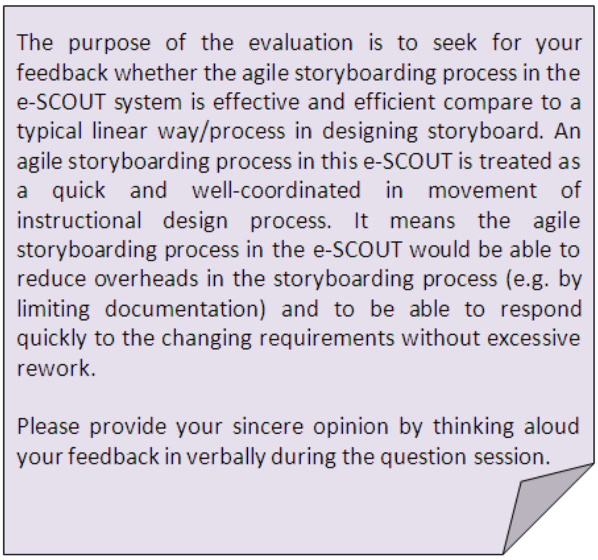
7.3.1 Evaluation Procedure and Design

This section describes briefing procedure, task description and list of actions undertaken by the participants as well as think-aloud technique.

7.3.1.1 Briefing on Agile Storyboarding Process

Firstly, the participants were introduced to the system by using a prepared online tutorial. Participants were asked to fill in demographic information in the distributed form. The overall duration of the cognitive walkthrough session took about 2.5 hours. The first 15 min were spent to give a brief explanation of the system and an introduction to the purposes of the experiment. The participants spent the rest of their time in performing series of task and actions, as well as answering to the questionnaires.

Before the walkthrough can be conducted, a briefing session with the participants is conducted. The briefing information contains welcoming notes, introductory to eSCOUT system, and procedures of evaluation studies. Full text of the briefing session and information is presented in Appendix K. The excerpt of briefing information on agile storyboarding process is shown in Figure 7.25. Next section describes the task description and a complete and written list of the actions needed to complete the task.


The purpose of the evaluation is to seek for your feedback whether the agile storyboarding process in the e-SCOUT system is effective and efficient compare to a typical linear way/process in designing storyboard. An agile storyboarding process in this e-SCOUT is treated as a quick and well-coordinated in movement of instructional design process. It means the agile storyboarding process in the e-SCOUT would be able to reduce overheads in the storyboarding process (e.g. by limiting documentation) and to be able to respond quickly to the changing requirements without excessive rework.

Please provide your sincere opinion by thinking aloud your feedback in verbally during the question session.

Figure 7.25: Briefing the Agile Storyboarding Process

7.3.1.2 Task Description and List of Actions

The tasks are developed based on the needed activities to carry out storyboarding underlying the agile storyboarding process in the eSCOUT. Figure 7.26 shows nine main tasks which are developed for this evaluation session and these tasks are grouped according to the three storyboarding phase. Each task requires a series of steps and activities.

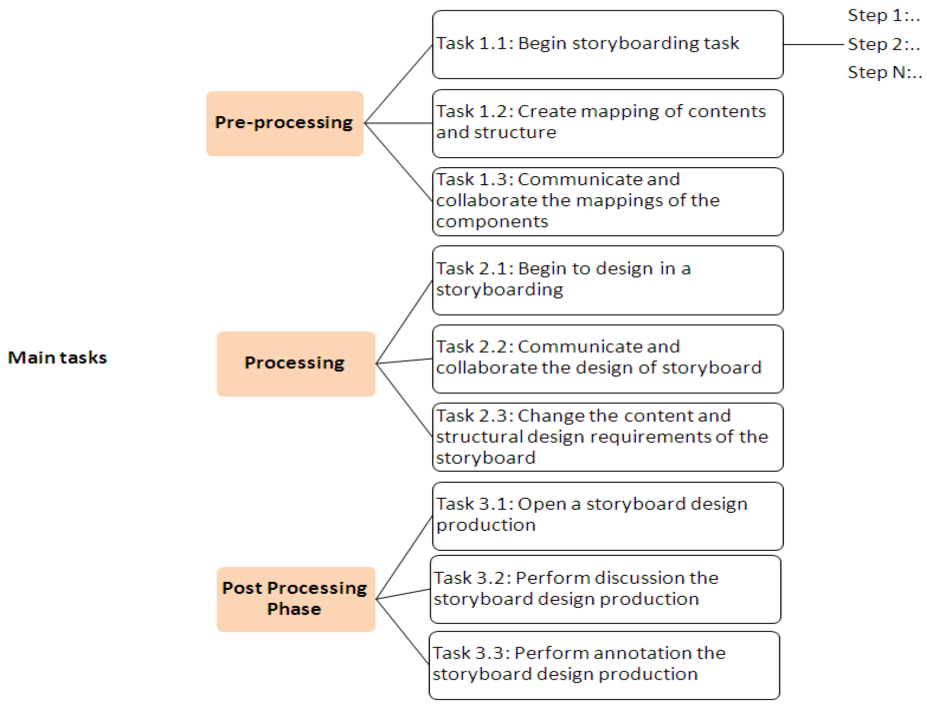


Figure 7.26: Main tasks evaluation in Cognitive Walkthrough

After each task is done, the evaluators will answer the following questions as follows:

1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

After the questions have been answered, they are asked about their thinking of this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

3. Do you face any problems?
4. Do you have any recommendations?
5. Do you have other comments?

7.3.1.3 Think-aloud Technique

Since, this evaluation emphasizes on the details of what the participants do and how they interact with the agile storyboarding process, this study requires evaluation conducted in a controlled environment. In this study, a think-aloud technique is selected to gather the data. Think-aloud is a data gathering technique to access the cognitive processes of the users through an open dialogue between the researcher and users on use, context and technology. A part from the term “think-aloud”, it has been described under different names such as verbal reports, concurrent verbal protocols, retrospective verbal protocols, after think aloud and verbal protocols (Nielsen, Clemmensen, & Yssing, 2002).

Think-aloud technique is chosen because every step can be instructed and evaluated in a controlled procedure. Therefore, in this controlled environment, we can afford to be more intrusive in gaining insight which steps works and which steps doesn’t. Moreover, it provides more relaxing view of the evaluation process when the participants can verbally thinking aloud their reasons, decision or opinions while doing the task. The data which is obtained from the participants are both qualitative type and quantitative. The feedback from the task and actions are recorded using an audio recorder in a form of verbal feedback. This transcription will be categorizing according to the three categorization themes; the pre-processing phase, processing phase and post-processing phase in the eSCOUT. On the other hand, the quantitative data in a form of questionnaires containing yes and no are obtained from each of the steps in these three processing phases. This data will be evaluated based on the effectiveness and efficiency on carrying out particular storyboarding tasks.

7.3.2 Data Results and Finding

In this section, the agile storyboarding process model is analyzed based on the three processing phases in the eSCOUT; the pre-processing, processing and post-processing. This agile process model is further analyzed in terms of effectiveness and efficiency.

7.3.2.1 Pre-processing Task

In this phase, participants expressed the actions taken using the Collaborative mapping can help them to visualize the content and structure which can be planned in storyboard design. The participants convey the ability to understand storyboard design plan through the concept mapping which can be visualized in structural manner. For task 3 which requires communication and collaboration task in the Collaborative Maps, the users expressed that they are able to coordinate their ideas and thoughts using the tool. The evaluators exhibit their ability to engage each other with visual of storyboard plan that can be shared.

Example of scripts such as:

This visual helps me to make meaningful connections between the main idea for storyboarding design and other information such as the pedagogical elements..

I find the task is good… help me to organize my thoughts and now I can understand how information can be shown this way

Constructing this visual map provides me a way to integrate many elements and help me to make decisions too.

I can organize and represent what I think is appropriate for storyboard in better way

7.3.2.2 Processing Task

In the processing phase, the evaluators expressed the actions taken using the Collaborative whiteboard helps them to draw and sketch storyboard design. The participants also exhibit the ability to share storyboard design and that helps them to design collaboratively. In performing task 3, the participants state that the facility to view the maps helps them to design the storyboard quickly due to the supporting guide map with the appropriate task.

Example of scripts such as:

I can quickly visualize and share my design using this tool

I love this one... I am able to collaborate through online and the best thing is it encourage me to design collaboratively with other designers

The visual of this storyboard design is good.. it can collaborate, a great way for me to explain my design to the multimedia designers

I can also go back to the maps that I have created or have been shared with me and do the changes.

Well, good enough. Can edit the map and go back to design.

7.3.2.3 Post-processing Task

In the post-processing phase, the participants expressed the actions taken using the Collaborative discussion and the Collaborative annotation tools helps them to review and comments on the storyboard design production. The participants also exhibit the ability to communicate with other designers what they view about particular piece of design elements in the virtual canvas of the storyboard. In particular, the participants support the facility to return the process from storyboard design production to the design process where they can do quick changes to the design.

Example of scripts such as:

This tool allows me to insert comments on specific portions in this storyboard design.. Very good

I think this tool is handy.. when I want to comment at anywhere, I just click there and write my comments

I like the functions.. I can create comments, delete comments and modify the comments as well. Also I can see the history of my comments that I have inserted in the storyboard design.

Well done, love this feature, I can do quick changes to the storyboard design that I have produced. It will be easy for me especially when suddenly new design comes in my mind...

7.3.2.4 Effectiveness and Efficiency

Figure 7.27 shows the graph representing the percentage of positive against negative questions for the agile storyboarding process

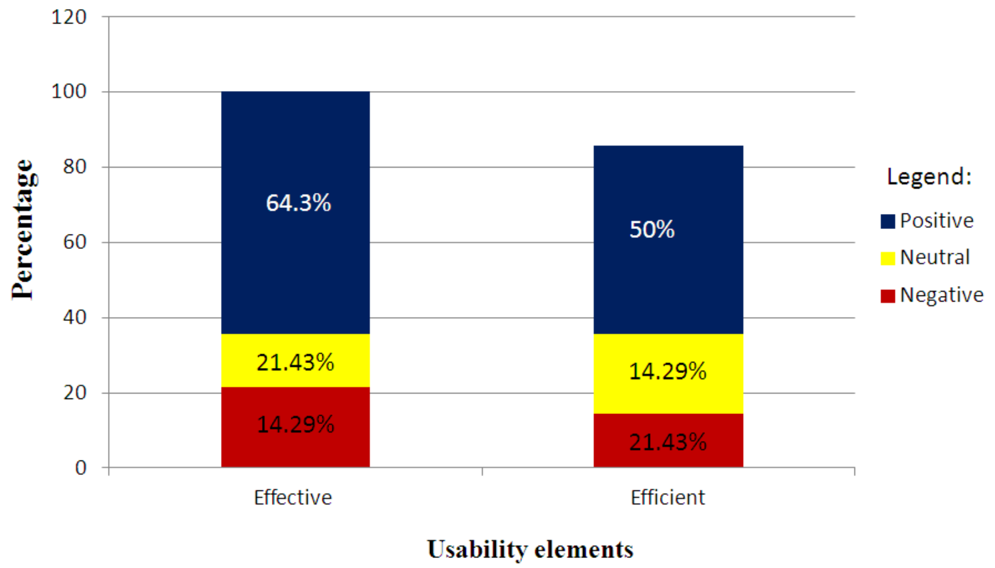


Figure 7.27: A graph representing the percentage of positive against negative questions for the agile storyboarding process

The result shows that the effectiveness of the agile storyboarding process is perceived as 64.3% compare to efficiency capabilities of the process which is only 50%. Conversely, it also shows that the agile storyboard process is not effective by a 14.29% of negative feedback. On the other hand, the inefficiency of the process model is perceived by 21.43%. Neutral feedback means no answer or no feedback obtained from the participants regarding the effectiveness and efficiency of the agile process model.

7.3.3 Discussion

The study shows that the agile storyboarding process model is effective and efficient in facilitating the flow of storyboard design and activities. In fact, the agility practices in the storyboarding process allow the users to be more flexible and adaptive to the planning of the storyboard design. For example, if designers need to respond to the changes of storyboard requirements, they can use the collaborative maps and do the changes for later use in storyboarding design task.

7.1 Evaluation Study 2: Usability Evaluation

PUTQ provides eight human factors principles that are relevant for HCI namely; compatibility, consistency, flexibility, learnability, minimal action, minimal memory load, perceptual limitation and user guidance. PUTQ is used in this usability evaluation because it has been cited in many publications in HCI. It is considered as having good construct and content validity which is derived from experimental study and theory of human information processing (Lin, Choong & Salvendy, 1997).

7.1.1 Evaluation Procedures and Design

The usability evaluation is conducted after the Cognitive Walkthrough session. Before the usability evaluation begins, the participants are given a break for 10 minutes. Then, the participants are given a short briefing about the evaluation procedures where they are asked to answer agree or disagree of each eSCOUT tool. Each of the questions is described with specific criteria as follows:

1. Compatibility – Is the tool compatible with user expectations?

   Note: Able to perform eLearning storyboard activities as per expected by users.

2. Consistent – Is the tool consistent with the user needs?

   Note: Consistent with what the user needs in each processing phase.

3. Flexibility – Is the tool provide flexibility in storyboarding task and activities?

   Note: Flexible in terms of sharing the data and performing eLearning tasks.

4. Learnability – Is the tool easy to learn?

   Note: Able to learn the functionalities.

5. Minimal action – Is the tool provide minimal actions to the steps in storyboarding task and activities?

   Note: Able to perform storyboarding task with less actions.

6. Minimal memory load - Is the tool provide minimal memory load when working on storyboarding task and activities?

Note: Able to understand the process or flow of the system easily

7. Perceptual limitation – Is the function of the tool distinctive?

   Note: The tools available are different from what the users have experienced in other storyboard system.

8. User guidance – Is the tool provide guidance such as indicators and explanations to users?

   Note: Able to guide the user to understand the tools in the eSCOUT.

It takes around 45 minutes to complete the evaluation activities.

7.1.2 Data Results and Finding

The findings are analyzed based on two groups of the eSCOUT tools which refer to the general and specific tools. This section presents description of the findings and results.

7.1.2.1 General tools of the eSCOUT

Figure 7.28 shows the graphic of evaluators' findings of the general tools of the eSCOUT, which refers to the storyboard manager, storyboard sorter and asset manager. These three tools are evaluated with respect to each of the usability aspects; compatibility, consistency, flexibility, learnability, minimal action, minimal memory load, perceptual limitation and user guidance. Blue bars correspond to positive evaluations, while red ones to negative evaluations. On the x-axis all the parameters evaluated for each category are presented.

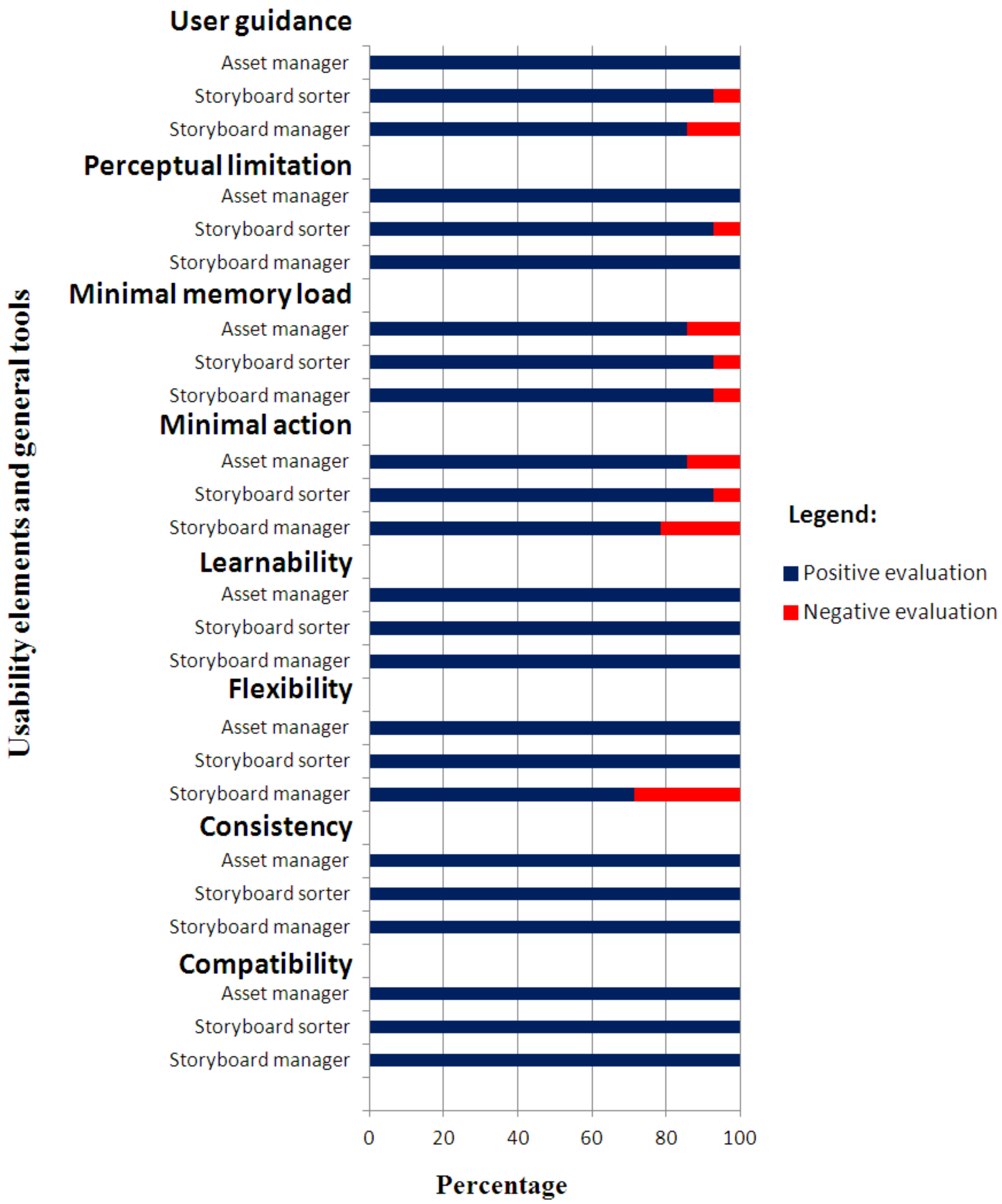


Figure 7.28: Usability evaluation results for the eSCOUT general tools

In these findings, 28.57% of the participants reported problems regarding the flexibility of the storyboard manager such as delete and copy the storyboard activities, in particular deleting and copying between frames and the whole storyboard. As reported by one of the evaluators:

I found the delete function is confusing. When I choose delete options, the system should be able to give options either to delete the frame one by one or to delete the whole storyboard.

14.29% of the participants also experienced problems with the asset manager tool such as managing the asset based on category. The participants also experience difficulties to find assets available in the asset manager. As one of the evaluators explained in his report:

Well, if I have many collections of assets such as created ones and images by default, how do I keep them? I think the system should be able to have functions to separate between default images/ videos and self-created ones.

On the other hand, 100% of the participants reported compatibility, consistency, and learnability of the three general tools of the eSCOUT.

7.1.2.2 Specific tools of the eSCOUT

Figure 7.29 shows the graphic of evaluators' findings of the specific tools of the eSCOUT, which refers to the collaborative map, collaborative whiteboard, collaborative discussion and collaborative annotation. Blue bars correspond to positive evaluations, while red ones to negative evaluations. On the x-axis all the parameters evaluated for each category are presented.

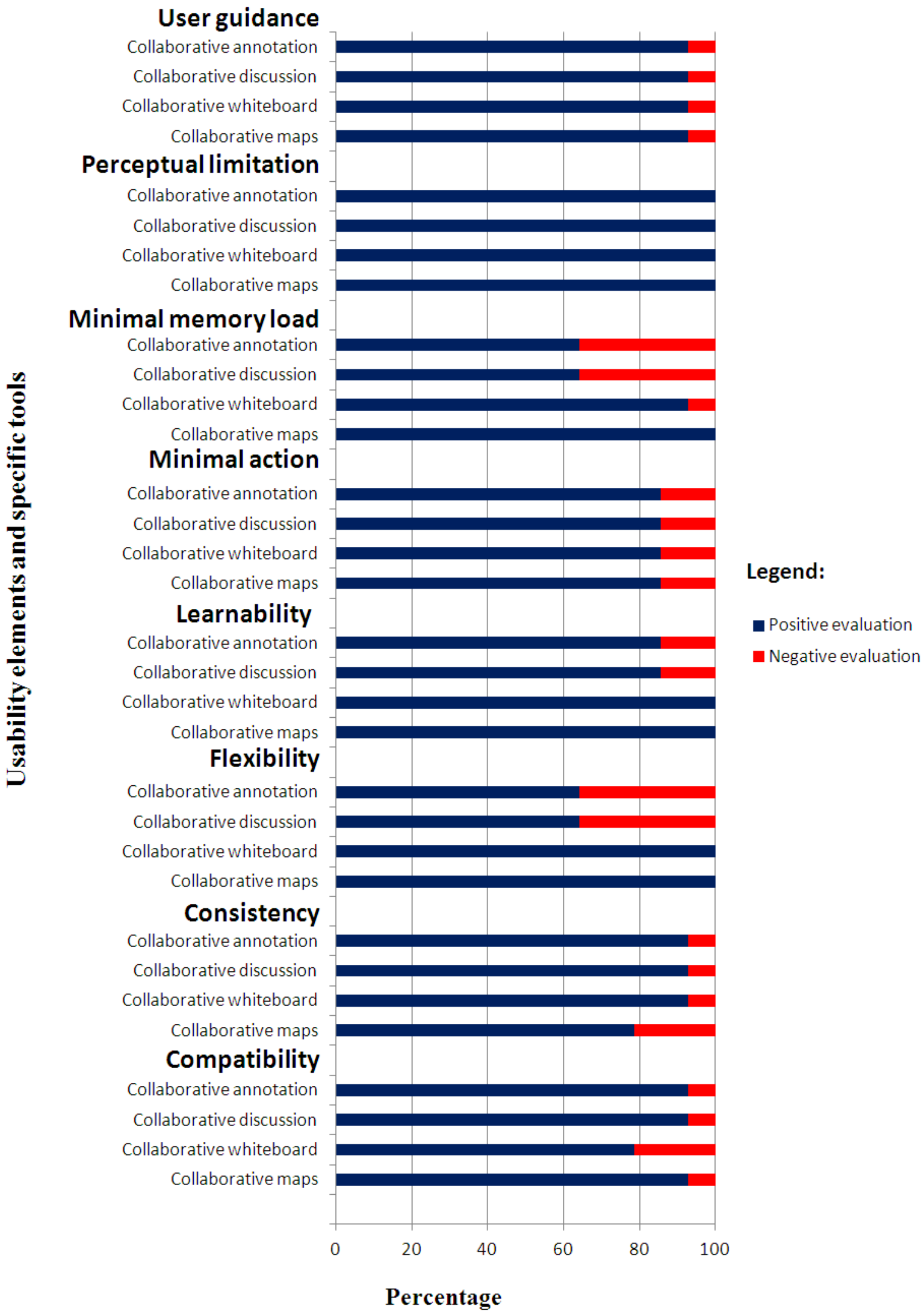


Figure 7.29: Usability evaluation results for the eSCOUT specific tools

In this findings, 35.71% of the participants reported problems regarding the flexibility and minimal memory load of two specific tools of the eSCOUT; the collaborative discussion and collaborative annotation. The participants expressed concerns in particular to the numbers of discussions and annotations which could be created in one storyboard. As reported by one of the evaluators:

The discussion and annotation functions are good to facilitate communication, but how if I have a lot of commentaries and annotations? How to read them all in the space?

21.43% of the participants also experienced difficulties regarding the compatibility of the collaborative whiteboard and consistency of the collaborative map tools. The collaborative whiteboard may seem incompatible with user expectations which could not generate the storyboard frames into a form of video. On the other hand, the collaborative maps seem inconsistent with user needs due to the inability to automate the requirements decision and migrate this requirement information in the collaborative whiteboard. As reported by two of the evaluators.

Why can't I generate the frames to video? If I design a storyboard this function should be available..Such as what it is found in some multimedia applications.

Well, I found it difficult because I need to click on the map icon here to see what is required and then only I can start to sketch. Can we have something more intelligent with this function?

7.1.3 Discussion

The evaluation also shows high usability level for both general and specific tools. General tools in the eSCOUT allows the users to perform casual storyboarding task such as create, move and sort storyboard frames as well as uploaded self-created multimedia elements. On the other hand, the specific tools provide better capabilities in terms of sharing and collaborating needed visualizations for instructional designers and subject-matter experts interaction. These tools helps to facilitate cognitive sharing of the task associated with storyboarding such as organizing the structure for storyboard design, recalling the analysis requirements before storyboarding, and evaluating the storyboard design production.

7.2 Evaluation Study 3: Shared Mental Model Measurement

The SMM measurement involves two kinds of SMM evaluations. First is to evaluate the degree of agreement in terms of shared understanding of the task, second is to evaluate the degree of shared understanding of similarity and accuracy of the shared data visualization. Using interactively elicited cause mapping technique, questionnaires are provided to the participants after they have interact with their partner in four interactive session. The questionnaires for each kinds of SMM evaluations can be referred to Appendix K. Next section explains the evaluations procedures and design using this technique.

7.2.1 Evaluation Procedures and Design

The SMM measurement is conducted after the usability evaluation has been completed. The participants are also given 10 minutes break before this study begins. Again, the participants are given a short briefing about the procedures where they are asked to form a team and choose a partner from a different domain. It means a design team should consist of one ID and one SME. Later they are asked to sit side-by-side at two work stations which have been arranged. Data collection takes place four interactive session under the three storyboarding phases as follows:

7.2.1.1 During Pre-processing Phase

- In session 1, the ID and SME are asked to work with partners in communicating and collaborating the requirements needed for storyboard content and provide the structural design for the storyboard. The design teams are asked to use the Collaborative Mapping tool to perform this activity without any verbal interaction. Time given is 15 minutes. Later, all the design teams are instructed to stop the task, and discuss with each other whether they have reach shared understanding about what actual requirements of the storyboard contents are and how the designs of the storyboard are structured. At the end of session 1, the participants are asked to judge the relatedness of four statements describing the content of the task with regards to similarity and accuracy.

7.2.1.2 During Processing Phase

- In session 2, the ID and SME continue to work with partners in communicating and collaborating the specifications needed for storyboard multimedia design. The design teams are asked to use another eSCOUT tool i.e. the Collaborative Whiteboard tool to perform this activity without any verbal interaction. Time given is 15 minutes. Later, all the design teams are instructed to stop the task, and discuss with each other whether they have reach the shared understanding about what the actual multimedia specifications of the storyboard are and how the multimedia specifications in the storyboard are designed. At the end of session 2, the participants are asked to judge the relatedness of four (4) statements describing the content of the task with regards to similarity and accuracy.

7.2.1.3 During Post-processing Phase

- In session 3, the ID and SME continue to work with partners in communicating and collaborating the commentaries or reviews of the storyboard design productions. The design teams are asked to use another eSCOUT tool i.e. the Collaborative Discussion tool to perform this activity without any verbal interaction. Time given is 15 minutes. Later, all the design teams are instructed to stop the task, and discuss with each other whether they have reached shared understanding about what the actual comments specifications of the storyboard are. At the end of session 3, the participants are asked to judge the relatedness of four (4) statements describing the content of the task with regards to similarity and accuracy.
- In session 4, the ID and SME continue to work with partners in communicating and collaborating the commentaries or reviews of the specific elements in the

storyboard design productions. The design teams are asked to use the last eSCOUT tool i.e. the Collaborative Annotation tool to perform this activity without any verbal interaction. Time given is 15 minutes. Later, all the design teams are instructed to stop the task, and discuss with each other whether they have reached shared understanding about what the actual commentaries or reviews of the specific elements in the storyboard design productions are. At the end of session 4, the participants are asked to judge the relatedness of four (4) statements describing the content of the task with regards to similarity and accuracy.

The complete lists of all the 16 items used in the pairwise comparisons are presented in Appendix K.

7.2.2 Data Results and Finding

This section presents the findings and results from the SMM experimental study. The findings are analyzed based on two kinds of evaluations, the TMM result and the findings of accuracy and similarity of understanding when using the four tools of the eSCOUT.

7.2.2.1 Task Mental Model

The task mental model evaluation is divided into four categories of tool applications. Each category of tool is evaluated based on the understanding of the shared content performed by the functionality of the tool, effective and efficient understanding of the shared content, as well as the overall satisfaction perceived from the shared content.

For example, in collaborative mapping tool, the SME/ID are evaluated whether the understanding of actual requirements of the storyboard contents and the structural designs of the storyboard has been achieved (SMM01), whether the understanding of structural design of storyboard can be reached effectively and efficiently (SMM02 and SMM03), as well as whether the overall understanding received from the SME/ID with regards to the structural designs of the storyboard has been satisfied (SMM04).

Figure 7.30 shows the data result from a total of 14 assessments.

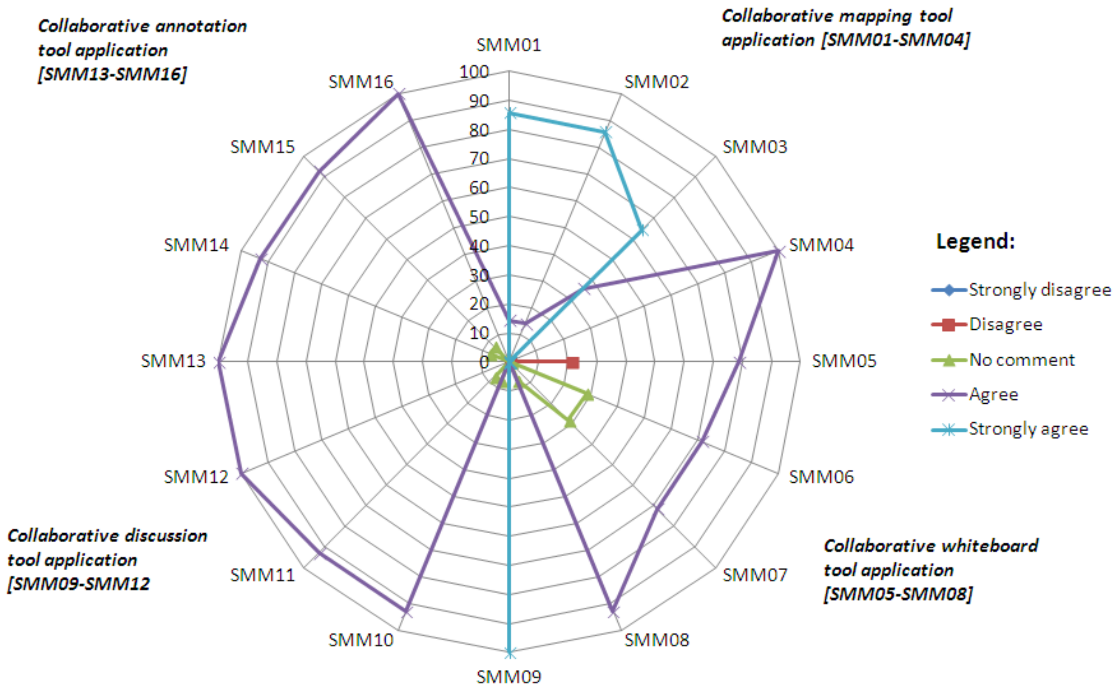


Figure 7.30: A graphical representing the TMM development using the four (4) visualization techniques

In the study, 85.71% of the participants strongly agree that his/her partner understands the actual requirements of the storyboard contents and how the designs of the storyboard are structured. 85.71% of them has also agree strongly that their shared understanding of the content can be reached effectively using the collaborative mapping tool. 64.28% of them agree strongly that they can reach the shared understanding of the structural design of storyboard efficiently. Finally, all of them agree that the overall understanding received from their design team partner is satisfied.

With regard to the collaborative whiteboard, 78.57% agree that his/her partner understands the specifications needed for storyboard multimedia design compare to 21.42% disagree. 71.42% also agree that understanding of the storyboard multimedia design specification can be reached effectively and efficiently. 92.85% judged satisfaction with the overall understanding received from their design team partner by using this tool.

On the other hand, all of the participants agree that his/her partners understand the comments specifications for the storyboard design production when using the collaborative discussion tool. 92.85% agree that the understanding of the comments specifications for the storyboard design production can be reached effectively and efficiently when using this tool. All of them also agree that overall understanding received from design team member is satisfied.

Finally, all of the participants agree that his /her partner understands the commentaries or reviews of the specific elements in the storyboard design production when using the collaborative annotation tool. Similarly, 92.85% also agree that the understanding of the commentaries or reviews of the specific elements in the storyboard design production can be reached effectively and efficiently. All of them also agree that overall understanding received from design team member is satisfied.

7.2.2.2 Similarity and Accuracy

Figure 7.31 shows the similarity and accuracy assessment which is resulted from the evaluation. In this study, 64.82% agree that the understanding of the actual requirements of the storyboard contents and how the designs of the storyboard are structured is accurate. Only 21.42% disagree and the rest gives no comments. 71.42% agree that understanding of the specifications needed for storyboard multimedia design is accurate whereas 28.57% provides no comments. 92.57% agree strongly that both the understanding of the comments specifications for the storyboard design production and the commentaries or reviews of the specific elements in the storyboard design production are accurate.

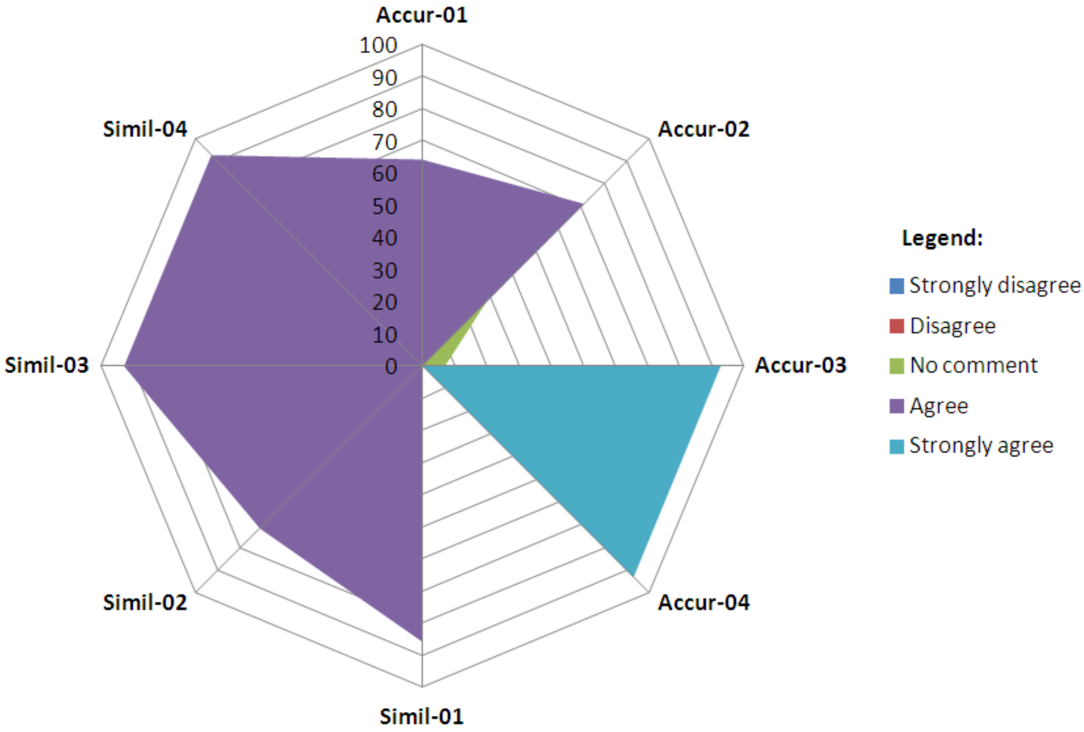


Figure 7.31: Similarity and accuracy of the tools

On the other hand, 85.71% agree that understanding of the actual requirements of the storyboard contents and how the designs of the storyboard are structured is similar while only 14.28% disagree. 71.42% agree that the understanding of the specifications needed for storyboard multimedia design is similar compare to only 28.57% assessed no comments. Finally, 92.85% of the participants agree that both the understanding of the comments specifications for the storyboard design production and the commentaries or reviews of the specific elements in the storyboard design production are similar, conversely 7.14% rated as no comments

7.2.3 Discussion

This evaluation study shows the results and findings from TMM and the aspects of accuracy and similarity. The study suggests that the collaborative discussion and collaborative annotation tools used in the eSCOUT provides better TMM development than what collaborative mapping and collaborative whiteboard can provide. It also suggests that the accuracy and similarity of the knowledge understanding can be reached better using the collaborative discussion and collaborative annotation tools than collaborative mapping and collaborative whiteboard. Based on the results, it is assumed that the collaborative discussion and collaborative annotation tools allows critical thinking and helps users to clarify ideas through discussion and debate (De Wever, Schellens, Valcke, & Van Keer, 2006), whereas the collaborative mapping offers only option to modify the maps when it is collaborated (Hanewald & Ifenthaler, 2014).

7.3 Summary

This chapter presents the system prototype development of the eSCOUT and three types of evaluations.

From the study, some information has been synthesized and concluded as follows:

- The first evaluation is conducted using cognitive walkthrough. It shows that the agile storyboarding process model is effective and efficient in facilitating the flow of storyboard design and activities as well as allowing flexibility and adaptively in design process.
- The second evaluation is conducted using usability evaluation method. It shows that general tools in the eSCOUT is effective in assisting users to perform casual storyboarding task, whereas the specific tools is effective in supporting shared cognitive user tasks.
- The final evaluation is conducted using SMM experimental study. It shows that TMM is developed, whereas the similarity and accuracy of the content which are produced using the eSCOUT tools are achieved.

Figure 7.32 shows achievement of research questions in chapter 7.

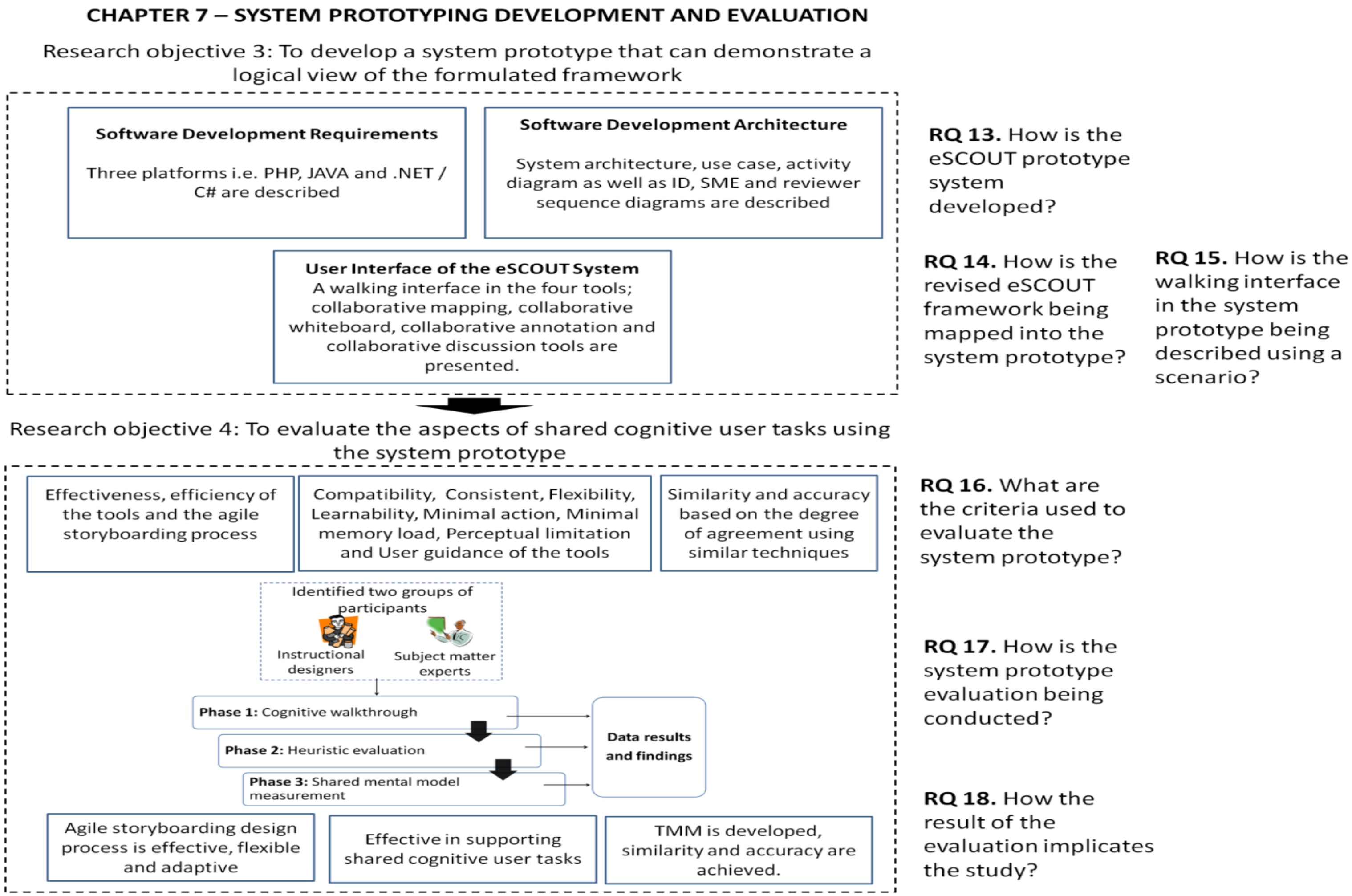


Figure 7.32: Achievement of research questions in chapter 7

CHAPTER 8 CONCLUSION

8.1 Introduction

This chapter discusses the overall work which can be concluded in this research. First, revisits the research objectives of the research which explains what and how the research is carried out. Second, it presents several research contributions of the study. Third, it explains some limitations of the study. Finally, it provides some recommendations to the future work.

8.2 Research Objectives Revisited

This section revisits the research objectives of this research.

8.2.1 Research Objective 1

The first objective is to identify the strategies and techniques in solving cognitive task difficulties using storyboard. In order to achieve the objective, two investigation studies have been conducted which are presented in Chapter 5. As described earlier, these two studies have led to the identification of particular findings.

8.2.2 Research Objective 2

The second objective is to formulate a framework that can support the SMM development between ID and SME in storyboard. The framework is developed in incremental steps, begins with the information gained from the analysis of literatures as well as the result showed in the two investigation studies. The activities that have been carried out to achieve this objective are presented in Chapter 6.

8.2.3 Research Objective 3

The third objective is to develop a system prototype which can demonstrate the logical view of the formulated framework. In Chapter 7, the system prototype is developed. User interface design of the system is described along the three storyboarding process in eLearning storyboard. Using an example of designing an eLearning course for a subject course entitles “Data Structures and Algorithms” and “Human-computer Interaction”, the system interface demonstrate the underlying process of the eSCOUT.

8.2.4 Research Objective 4

The final objective is to evaluate the prototyping of the framework which is also described in Chapter 7. The framework prototype is evaluated in two phases, which has led to the findings of effectiveness and efficiency of the agile storyboarding process, usability results of the general and specific tools and the shared mental development resulting from the application of shared visualizations.

8.3 Research Contributions

Throughout the literature reviews, investigations as well as framework and system prototyping development and evaluation works that have been conducted, this work offers some humble contributions to the study of instructional design and Human-Computer Interaction.

First, the differences between ID and SME can be distinguished in terms of roles and knowledge expertise. It is found that SMEs can reach highest level in learning process due to the unconscious way of their thinking process which cannot be performed by the ID. SME may know best about the subject matter, however they are not necessary able to communicate knowledge to the students effectively. It is also found that ID has better capabilities in designing instruction as well as allocating project resources which might not be done by the SMEs. The review concludes that these two groups are heterogeneous in terms of their knowledge expertise and roles. As such, divergence of their knowledge expertise should lead to effectiveness and efficiency in instructional design work.

Second, four issues and challenges in instructional design study to support ID and SME interaction have been identified. The first issue is pertaining to the support of ID and SME interaction as a part of CoP in instructional design. The second issue is pertaining to the SMM support of ID and SME as a part of multimedia design experts. The third issue is pertaining to the support of distributed instructional design for ID-SME's collaboration and the finally is pertaining to the designer-centeredness support for ID and SME as eLearning designers. It is found that there are three requirements needed to support ID and SME interaction: design representation (i.e. eLearning storyboard that support collaboration), design method (i.e. agility) and design-centeredness support (i.e. designers' community).

Third, storyboard tools have been categorized into domain independent, domain dependent, conceptual models and frameworks. Although this work is not exhaustive, it provides a useful overview of literature regarding some storyboard examples for each category as reference.

Fourth, analysis of two main shared cognitive approaches provides an important implication for designing appropriate model and framework in team cognition. This work can provide a guide for HCI researchers interested in studying team cognition; in particular to shows the ways of selecting the appropriate shared cognitive models for specific types of systems and applications.

Fifth, a review on shared visualization has been conducted systematically. The findings from this systematic review provide guidelines for future researchers seeking to design shared visualizations that can be used in socially shared cognitive systems and shared situation awareness systems.

Sixth, two empirical studies have been conducted. The first study identifies two types of difficulties faced by SME as novice storyboard designer i.e. cognitive task difficulties and inadequate skills in storyboarding. Within the context of cognitive task difficulties, the study has identified four sub-elements of eLearning storyboards which demand cognitive skills from the SME, namely: storyboard templates, VO scripts, graphics and animation, and review process. On the other hand, inadequate training in storyboarding has been found as the critical factor for the SME to perform storyboarding activities. As such, three recommendations are proposed which have led to the development of design guidelines of an eLearning storyboard to support ID and SME interaction. The second study has found that the roles of shared visualization and agile process are significant in eLearning storyboard in order to achieve particular common grounds between the ID and SME. Storyboarding activities which are performed in an iterative manner using different ways of shared visualizations strategies, have led to different results of time spent in different processing levels. The value of integrating shared multiple views with annotation in eLearning storyboard to achieve particular common grounds between the ID and SME, have demonstrated a significant finding. As such, an agile model of storyboarding process and cognitive data process of SMM in eLearning storyboard is recommended.

Seventh, framework has been developed. The initial framework is developed based on the literature reviews and results of empirical studies. This initial framework has been evaluated through expert evaluations and finally, revised eSCOUT framework has been developed based on the experts' feedback. The finding shows that the proposed eSCOUT framework has offered a new concept of interaction between IDs and SMEs in the design process of eLearning storyboard. It is a framework that describes a design communication that could achieve common ground of an eLearning course in the design team. It is clear that the eSCOUT framework is comprehensive and helps to support collaboration and communication to the ID and SME which are at two different locations.

Finally, system prototyping development has been developed to demonstrate proof-of-concept based on the revised eSCOUT framework. This system prototyping has offer a new concept of system that can support shared cognitive user task in eLearning storyboard. Based on the results of three evaluation phases of study, it shows that the agile storyboarding design process is effective and efficient in facilitating the flow of storyboard design and activities as well as allowing flexibility and adaptively in design process. It also shows that general tools in the eSCOUT is effective in assisting users to perform casual storyboarding task, whereas the specific tools is effective in supporting shared cognitive user tasks. Consequently, the system prototyping is able to demonstrate the support of shared cognitive user task through the result of TMM development in ID and SME as well as achievement of similarity and accuracy of the content which are produced using the eSCOUT tools.

8.4 Limitations of Study

The framework from which eSCOUT is derived from SMM theory and the two empirical studies. Theoretically, it can be applied to any human-computer interaction systems. However, both empirical studies are mainly focused on experts' cognitive task which requires specific visualization strategies and techniques to support the shared cognitive user task in eLearning storyboard. Cautions should be exercised when using the eSCOUT to support the novices in subject-matter and instructional design.

The cognitive walkthrough, usability evaluation and SMM measurement considered in the eSCOUT are limited to a small number of participants from MMU. Further works need to be done to extend the evaluations to participants from other institutions or eLearning industries, as well as to incorporate universal usability evaluation.

8.5 Recommendations for Future Work

Although the eSCOUT framework is proven to reduce the effort on sharing cognitive task activities between ID and SME, there is still much work to be done. Some of the work may provide steps forward to extend the research.

8.5.1 Enhanced eSCOUT distributed and collaborative visualization capabilities

Further research can be conducted to enhance the capabilities of distributed and collaborative visualization in the eSCOUT. According to Brodlie, Duce, Gallop, Walton and Wood (2004), distributed visualization has some resource allocation problems such as location of processing close to data for minimizing data traffic. Example of an enabling technology i.e. Grid Computing and the link to web services could provide better enhancement for distributed visualization in the eSCOUT, such as close coupling of simulations and visualizations in a real-time, interactive steering environment.

8.5.2 Increased eSCOUT visualization and multimedia output capabilities

The visualization and multimedia output capabilities in the eSCOUT can also be increased through sophisticated multimodal interaction. According to Oviatt and Cohen (2000), multimodal input facility in a system could give more powerful interfaces for the user to access and manipulate information. Example of future work may include designing multimodal inputs such as speech and handwritten recognition from the ID and SME. These recognition techniques should be able to read, interprete and translate integrated data inputs in a form of visualization can provide better multimodal interaction facility in the eSCOUT.

8.5.3 Extended shared data visualization support across different interfaces

On the other hand, the support for shared cognitive user task in the eSCOUT can be extending through the use of mobile-based application with particular interest to the shared visualization data. For example, the capability of the framework can be enhanced by allowing both desktop and mobile clients to simultaneously visualize the same data visualization in sharing a common view.

8.5.4 Multi-users participations

The eSCOUT should be further enhanced by incorporating different types of users such as multimedia designers, eLearning managers and programmer. Razak (2013) who had identified the SMM in graphic designers, instructional designers and subject-matter experts suggested a need for a multimedia tool which can identify interventions between the decision making process. This is especially important to assist the shared knowledge among the experts that influence team decision making and performance.

8.6 Summary

This chapter provides an overview of this research work. It concludes the work which has been done in developing the eSCOUT framework and activities which have been carried out to achieve the research objectives.

Last but not least, the eLearning course development for distance learning will continue to expand, and at the same time the expert IDs and SMEs will continue to evolve at the same pace as technological change. Since interaction between IDs and SMEs is significant for eLearning development, innovations and technology systems should contribute to the task of enhancing their expertise. The thesis is a work contributes for the areas in Instructional Design and Human-computer Interaction featuring the effective and efficient design and process of eLearning storyboards, leading to improved methods of interaction between IDs and SMEs.

REFERENCES

Abla, G., Kim, E. N., Schissel, D. P., & Flanagan, S. M. (2010). Customizable scientific web portal for fusion research. *Fusion Engineering and Design, 85*(3–4), 603-607. doi: http://dx.doi.org/10.1016/j.fusengdes.2010.02.030

Albi, Roberta S. (2007). Professors as instructional designers: lived experiences in designing and developing online instruction. Ph.D. Dissertation, Capella University, Minnesota, United States.

AMA Handbook of E-Learning : Effective Design, Implementation, and Technology Solutions. (2002). Saranac Lake, NY, USA: AMACOM Books.

Anderson, Terry, Rourke, Liam, Garrison, D. Randy, & Archer, Walter. (2001). Assessing teaching presence in a computer conferencing context. *Journal of asynchronous learning networks, 5*(2), 1-17.

Andrews, Anna A. (2001). Computer-based Instructional Systems Design Tools: Current State and Implications for the Future. University of Central Florida, Orlando, Florida.

Andrews, DeeH, & Goodson, LudwikaA. (1980). A comparative analysis of models of instructional design. *Journal of Instructional Development, 3*(4), 2-16. doi: 10.1007/bf02904348

Atkinson, Cliff. (2007). Beyond bullets points: using microsoft® office powerpoint® 2007 to create presentations that inform, motivate, and inspire. WA, USA: Microsoft Press Redmond.

Bachour, K., Kaplan, F., & Dillenbourg, P. (2010). An Interactive Table for Supporting Participation Balance in Face-to-Face Collaborative Learning. *Learning Technologies, IEEE Transactions on, 3*(3), 203-213. doi: 10.1109/tlt.2010.18

Badke-Schaub, Petra, Neumann, Andre, Lauche, Kristina, & Mohammed, Susan. (2007). Mental models in design teams: a valid approach to performance in design collaboration? *CoDesign, 3*(1), 5-20. doi: 10.1080/15710880601170768

Baek, Seung Lk. (1998). *Knowledge management for multimedia systems design: toward intelligent web-based collaboration.* Phd Dissertation, The George Washington University, Washington D.C.

Bailey, Brian P., & Konstan, Joseph A. (2003). *Are informal tools better?: comparing DEMAIS, pencil and paper, and authorware for early multimedia design*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Ft. Lauderdale, Florida, USA.

Bailey, Brian P., Konstan, Joseph A., & Carlis, John V. (2001). *DEMAIS: designing multimedia applications with interactive storyboards*. Paper presented at the Proceedings of the ninth ACM international conference on Multimedia, Ottawa, Canada.

Balakrishnan, Aruna D., Fussell, Susan R., Kiesler, Sara, & Kittur, Aniket. (2010). *Pitfalls of information access with visualizations in remote collaborative analysis*. Paper presented at the Proceedings of the 2010 ACM conference on Computer supported cooperative work, Savannah, Georgia, USA.

Beenen, Gerard, Ling, Kimberly, Wang, Xiaoqing, Chang, Klarissa, Frankowski, Dan, Resnick, Paul, & Kraut, Robert E. (2004). *Using social psychology to motivate contributions to online communities*. Paper presented at the Proceedings of the 2004 ACM conference on Computer supported cooperative work, Chicago, Illinois, USA.

Bergstrom, T., & Karahalios, K. (2012, 4-7 Jan. 2012). *Distorting Social Feedback in Visualizations of Conversation.* Paper presented at the 45th Hawaii International Conference on System Science (HICSS), 2012

Bohl, O., Scheuhase, J., Sengler, R., & Winand, U. (2002, 3-6th Dec). *The sharable content object reference model (SCORM) - a critical review.* Paper presented at the Proceedings of the International Conference on Computers in Education (ICCE'02), Auckland, New Zealand.

Borgatti, Steve, Everett, Martin, & Freeman, Lin. (2002). *Ucinet for Windows: Software for Social Network Analysis.* . Harvard, MA: Analytic Technologies.

Brandon, Bill. (2004). Storyboards Tailored to You: Do-It-Yourself Magic Arrows. *Learning Solutions Magazine* Retrieved 12th Dec., 2009, from http://www.learningsolutionsmag.com/articles/304/storyboards-tailored-to-you-do-it-yourself-magic-arrows

Brandt, D. Scott, & Uden, Lorna. (2003). Insight into mental models of novice Internet searchers. *Commun. ACM, 46*(7), 133-136. doi: 10.1145/792704.792711

Bratt, Sharon. (2011). *A Framework for Agile Instructional Development*. Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2011, Honolulu, Hawaii, USA. http://www.editlib.org/p/38993

Bratt, Sharon. (2013). *Agile Instructional Development Framework: Strategies for Increasing Learner and Instructional Designer Collaboration*. Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2013, Victoria, Canada. http://www.editlib.org/p/111999

Brewer, John, & Hunter, Albert. (2006). Formulating Research Problems *Foundations of Multimethod Research: Synthesizing Styles*. California: Sage Publications, Inc.

Brodlie, K.W., Duce, D.A., Gallop, J.R., Walton, J.P.R.B., & Wood, J.D. (2004). *Distributed and Collaborative Visualization.* Paper presented at the Computer Graphics Forum.

Bulterman, Dick. (2007). User-centered control within multimedia presentations. *Multimedia Systems, 12*(4), 423-438. doi: 10.1007/s00530-006-0065-6

Burtscher, Michael J., Kolbe, Michaela, Wacker, Johannes, & Manser, Tanja. (2011). Interactions of team mental models and monitoring behaviors predict team performance in simulated anesthesia inductions. *Journal of Experimental Psychology: Applied, 17*(3), 257-269. doi: 10.1037/a0025148

Cannon-Bowers, Janis A., & Salas, Eduardo. (2001). Reflections on shared cognition. [Article]. *Journal of Organizational Behavior, 22*(2), 195-202.

Cannon-Bowers, Janis A., Salas, Eduardo, & Converse, Sharolyn. (1993). Shared mental models in expert team decision making. Individual and group decision making: Current issues. . In N. John Castellan, Jr. (Ed.), *Individual and group decision making: Current issues* (pp. 221-246). Hillsdale, NJ, England: Lawrence Erlbaum Associates, Inc.

Caplan, Dean, & Graham, Rodger. (2008). The development of online courses. In Terry Anderson (Ed.), *The Theory and Practice of Online Learning (2nd Edition)* (pp. 257-259). Edmonton, AB, CAN: : Athabasca University Press. http://site.ebrary.com/lib/malaya/Doc?id=10290419&ppg=271.

Carroll, John M., Rosson, Mary Beth, Convertino, Gregorio, & Ganoe, Craig H. (2006). Awareness and teamwork in computer-supported collaborations. *Interacting with Computers, 18*(1), 21-46. doi: http://dx.doi.org/10.1016/j.intcom.2005.05.005

Castro-Figueroa, Anadel. (2009). Conflicts and communication: instructional designer and subject matter experts developing interdisciplinary online healthcare content. Ph.D. Dissertation, Capella University, Minnesota, United States.

Chapman, Bryan L. (2008). Tools for design and development of online instruction. In J. Michael Spector, M. David Merrill, Jeroen van Merrienboer & Marcy P Driscoll (Eds.), *Handbook of Research on Educational Communications and Technology* (pp. 671 - 684). New York, USA: Lawrence Erlbaum.

Choo Wou, Onn. (2007). Sistem pembangunan dan pengurusan kandungan automasi web (CMAS) : pendekatan kolaborasi multimedia (Content development and management automated web system: multimedia collaborative approach. Ph.D. Dissertation, Universiti Kebangsaan Malaysia, Bangi, Selangor Darul Ehsan, Malaysia.

Connelly, Micheal P. (2005). *How to make a movie with a very, very low budget* (2nd ed.). Los Angeles, the USA: A Uniconn book.

Crandall, Beth, Klein, Gary, & Hoffman, Robert R. (2006). *Working minds : A practitioner's guide to cognitive task analysis*. Cambridge, MA, USA: MIT Press.

Cristiano, Guiseppe. (2005). *Analyzing Storyboard* (2nd ed.): Iradidio Books.

Davis, Nicholas, Li, Boyang, O'Neill, Brian, Riedl, Mark, & Nitsche, Michael. (2011). *Distributed creative cognition in digital filmmaking*. Paper presented at the Proceedings of the 8th ACM conference on Creativity and cognition, Atlanta, Georgia, USA.

De Wever, B., Schellens, T., Valcke, M., & Van Keer, H. (2006). Content analysis schemes to analyze transcripts of online asynchronous discussion groups: A review. *Computers & Education, 46*(1), 6-28. doi: http://dx.doi.org/10.1016/j.compedu.2005.04.005

Deacon, Andrew E, Morrison, Andrew, & Stadler, Jane. (2005). Designing for learning through multimodal production: Film narrative and spectatorship in Director's Cut. *International Journal of Education and Development using ICT [Online], 1*(1). doi: http://ijedict.dec.uwi.edu/viewarticle.php?id=26.

Dick, Walter, & Carey, Lou. (1978). *The systematic design of instruction*. Michigan, USA: Scott Foresman

Dix, Alan, Finlay, Janet E., Abowd, Gregory D., & Beale, Russell. (2004). *Human-Computer Interaction (3rd Edition)* Edinburgh, England: Pearson Education.

Dohi, Shinichi, Sakurai, Yoshitaka, Tsuruta, Setsuo, & Knauf, Rainer. (2006). *Managing academic education through dynamic storyboarding.* Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2006, Honolulu, Hawaii, USA.

Douglas, Ian. (2006). Issues in Software Engineering of Relevance to Instructional Design. *TechTrends, 50*(5), 28-35. doi: 10.1007/s11528-006-0035-z

Dukes, Kais, Atwell, Eric, & Habash, Nizar. (2013). Supervised collaboration for syntactic annotation of Quranic Arabic. *Language Resources and Evaluation, 47*(1), 33-62. doi: 10.1007/s10579-011-9167-7

Eckel, N. (2010). . . (2010). Collaborating with subject matter experts. *Retrieved from Business Source Complete database., 65*(3), 76-77.

Eddy, M.F., Kribs, H.D., & Cowen, M.B. . (1999). Cognitive and behavioral task implications for three-dimensional displays used in combat information/direction centers (Technical report 1792): SPAWAR Systems Center.

Edmonds, GeraldS, Branch, RobertC, & Mukherjee, Prachee. (1994). A conceptual framework for comparing instructional design models. *Educational Technology Research and Development, 42*(4), 55-72. doi: 10.1007/bf02298055

Eduardo Salas, Nancy J. Cooke, & Michael A. Rosen. (2008). On Teams, Teamwork, and Team Performance: Discoveries and Developments. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 50*(3), 540-547. doi: 10.1518/001872008x288457

Ellwart, Thomas, Biemann, Torsten, & Rack, Oliver. (2011). Measurement of Team Knowledge in the Field: Methodological Advantages and Limitations. In Margarette Boos, Michaela Kolbe, Peter M. Kappeler & Thomas Ellwart (Eds.), *Coordination in Human and Primate Groups* (pp. 155 - 177). German: Springer-Verlag berlin Heidelberg.

Engelmann, Tanja, Dehler, Jessica, Bodemer, Daniel, & Buder, Jürgen. (2009). Knowledge awareness in CSCL: A psychological perspective. *Computers in Human Behavior, 25*(4), 949-960. doi: http://dx.doi.org/10.1016/j.chb.2009.04.004

Ericsson, K. Anders, & Smith, Jacqui. (1991). Chapter 1: Prospects and limits of the empirical study expertise: an introduction. In K. Anders Ericsson & Jacqui Smith (Eds.), *Toward a General Theory of Expertise: Prospects and Limits*. Melbourne, Australia: Cambridge University Press.

Ertmer, Peggy A., Stepich, Donald A., Flanagan, Sara, Kocaman-Karoglu, Aslihin, Reiner, Christian, Reyes, Lisette, . . . Ushigusa, Shigetake. (2009). Impact of guidance on the problem-solving efforts of instructional design novices. *Performance Improvement Quarterly, 21*(4), 117-132.

Eseryel, Deniz, & Ganesan, Radha. (2001). *Distributed Group Design Process: Lessons Learned*. Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2001, Norfolk, VA. http://www.editlib.org/p/8245

Espinosa, Alberto, Cadiz, Jonathan, Rico-Gutierrez, Luis, Kraut, Robert, Scherlis, William, & Lautenbacher, Glenn. (2000). *Coming to the wrong decision quickly: why awareness tools must be matched with appropriate tasks*. Paper presented at the Proceedings of the SIGCHI conference on Human Factors in Computing Systems, The Hague, The Netherlands.

Espinosa, J. Alberto. (2001). *Shared mental model: accuracy and visual representation*. Paper presented at the Seventh Americas Conference on Information Systems, Boston, Massachusetts, USA.

Fan, Weimiao, & Yan, Zheng. (2010). Factors affecting response rates of the web survey: A systematic review. *Computers in Human Behavior, 26*(2), 132-139. doi: http://dx.doi.org/10.1016/j.chb.2009.10.015

Farrington-Darby, Trudi, & Wilson, John R. (2006). The nature of expertise: A review. [doi: DOI: 10.1016/j.apergo.2005.09.001]. *Applied Ergonomics, 37*(1), 17-32.

Fischer, F., Bruhn, J., Gräsel, C., & Mandl, H. (2002). Fostering collaborative knowledge construction with visualization tools. *Learning and Instruction, 12*(2), 213-232. doi: http://dx.doi.org/10.1016/S0959-4752(01)00005-6

Flanagan, John C. . (1954). The critical incident technique. *Psychological Bulletin, 51*(4), 327-358. doi: 10.1037/h0061470

Furini, Marco, Geraci, Filippo, Montangero, Manuela, & Pellegrini, Marco. (2010). STIMO: STIll and MOving video storyboard for the web scenario. *Multimedia Tools and Applications, 46*(1), 47-69. doi: 10.1007/s11042-009-0307-7

Gagne, R.M. (1985). *The conditions of learning* (4th ed.). New York: Holt, Rinchart and Winston.

Gasson, Susan. (1998). *Framing design: a social process view of information system development*. Paper presented at the Proceedings of the international conference on Information systems, Helsinki, Finland.

Germani, Michele, Mengoni, Maura, & Peruzzini, Margherita. (2012). A QFD-based method to support SMEs in benchmarking co-design tools. *Computers in Industry, 63*(1), 12-29. doi: http://dx.doi.org/10.1016/j.compind.2011.10.007

Gibby, Scott, Quiros, Ondrea, Demps, Elaine, & Liu, Min. (2002). Challenges of being an instructional designer for new media development: a view from the practitioners. *Journal of Educational Multimedia and Hypermedia, 11*(3), 195-219.

Glebas, Francis. (2009). Directing the Story: Professional Storytelling and Storyboarding Techniques. Oxford, UK: Elsevier Inc.

Glithero, Sean. (2003). *The Challenges of Creating Storyboards for SCORM Conformant Multimedia Courseware.* Paper presented at the The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC): 25 Years: Enhancing Warfighter Performance.

Goldschmidt, Gabriela. (2007). To see eye to eye: the role of visual representations in building shared mental models in design teams. *CoDesign, 3*(1), 43-50. doi: 10.1080/15710880601170826

Grandhi, Sukeshini A., Schuler, Richard, & Jones, Quentin. (2011). *Telling calls: facilitating mobile phone conversation grounding and management*. Paper presented at the Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, Vancouver, BC, Canada.

Gray, Wayne D., & Salzman, Marilyn C. (1998). Damaged Merchandise? A Review of Experiments That Compare Usability Evaluation Methods. *Human–Computer Interaction, 13*(3), 203-261. doi: 10.1207/s15327051hci1303_2

Greenspan, Steve, Goldberg, David, Weimer, David, & Basso, Andrea. (2000). *Interpersonal trust and common ground in electronically mediated communication*. Paper presented at the Proceedings of the 2000 ACM conference on Computer supported cooperative work, Philadelphia, Pennsylvania, USA.

Gregor, Sallie, Hutson, Joseph, & Oresky, Colleen. (2002). Storyboard Process to Assist in Requirements Verification and Adaptation to Capabilities Inherent in COTS. In John Dean & Andrée Gravel (Eds.), *COTS-Based Software Systems* (Vol. 2255, pp. 132-141): Springer Berlin Heidelberg.

Griffiths, D., & Blat, J. (2005). The role of teachers in editing and authoring units of learning using IMS learning design. *Advanced Technology for Learning, 2*(4).

Grimstead, I. J., Walker, D. W., & Avis, N. J. (2005, 10-12 Oct. 2005). *Collaborative visualization: a review and taxonomy.* Paper presented at the Distributed Simulation and Real-Time Applications, 2005. DS-RT 2005 Proceedings. Ninth IEEE International Symposium on.

Gümüs, Salih, & Okur, M. Recep. (2010). Using multimedia objects in online learning environment. [doi: 10.1016/j.sbspro.2010.03.838]. *Procedia - Social and Behavioral Sciences, 2*(2), 5157-5161.

Gustafson, Kent. (2002). Instructional design tools: A critique and projections for the future. *Educational Technology Research and Development, 50*(4), 59-66. doi: 10.1007/bf02504985

Haesen, Mieke, Meskens, Jan, Luyten, Kris, & Coninx, Karin. (2010). *Draw me a storyboard: incorporating principles & techniques of comics*. Paper presented at the the Proceedings of the 24th BCS Interaction Specialist Group Conference, Dundee, United Kingdom.

Haeyong, Chung, Seungwon, Yang, Massjouni, N., Andrews, C., Kanna, R., & North, C. (2010, 25-26 Oct. 2010). *VizCept: Supporting synchronous collaboration for constructing visualizations in intelligence analysis.* Paper presented at the IEEE Symposium on Visual Analytics Science and Technology (VAST), 2010

Häkkinen, Päivi. (2002). Challenges for design of computer–based learning environments. *British Journal of Educational Technology, 33*(4), 461-469. doi: 10.1111/1467-8535.00282

Hanewald, Ria, & Ifenthaler, Dirk. (2014). Digital Knowledge Mapping in Educational Contexts. In Dirk Ifenthaler & Ria Hanewald (Eds.), *Digital Knowledge Maps in Education* (pp. 3-15): Springer New York.

Harada, Komei, Tanaka, Eiichiro, Ogawa, Ryuichi, & Hara, Yoshinori. (1996). *Anecdote: a multimedia storyboarding system with seamless authoring support*. Paper presented at the Proceedings of the fourth ACM international conference on Multimedia, Boston, Massachusetts, United States.

Hardinge, N. . (2000). Cognitive Task Analysis of Decision Strategies of Submarine Sonar and Target Motion Analysis Operators: Phase 1. Office of Naval Research, Final Technical Report, Contract No. N00014-99-1044 (2000). (The ACTA method is applied to the analysis of decision strategies of submarine sonar and target motion analysts).

Hartson, H. Rex, Andre, Terence S., & Williges, Robert C. (2001). Criteria For Evaluating Usability Evaluation Methods. *International Journal of Human-Computer Interaction, 13*(4), 373-410. doi: 10.1207/s15327590ijhc1304_03

Hashim, Ummi Raba'ah bt, Kadir, Aida Fazliana Abdul, Alias, Azrita, & Hassan, Elia Erwani. (2009, 7-8 Dec. 2009). *Development of learning object for engineering courses in UTeM.* Paper presented at the Engineering Education (ICEED), 2009 International Conference on.

Heer, Jeffrey, & Agrawala, Maneesh. (2008). Design Considerations for Collaborative Visual Analytics. *Information Visualization, 7*(1), 49-62. doi: 10.1057/palgrave.ivs.9500167

Hevner, Alan R., March, Salvatore T., Park, Jinsoo, & Ram, Sudha. (2004). Design science in information systems research. *MIS Q., 28*(1), 75-105.

Hodis, Eran, Schreiber, Gideon, Rother, Kristian, & Sussman, Joel L. (2007). eMovie: a storyboard-based tool for making molecular movies. *Trends in Biochemical Sciences, 32*(5), 199-204. doi: http://dx.doi.org/10.1016/j.tibs.2007.03.008

Hoffman, Robert R., Sharbolt, Nigel R., Burton, A. Mike, & Klien, Gary. (1995). Eliciting Knowledge from Experts: a methodological analysis. *Organizational Behaviour and Human Decision Processes, 62*(2 (May)), 129-158.

Hoffman, Robert, Neville, Kelly, & Fowlkes, Jennifer. (2009). Using cognitive task analysis to explore issues in the procurement of intelligent decision support systems. *Cognition, Technology & Work, 11*(1), 57-70. doi: 10.1007/s10111-008-0120-5

Holzl, J. (1997). Twelve tips for effective PowerPoint presentations for the technologically challenged. *Medical Teacher, 19*(3), 175-179. doi: doi:10.3109/01421599709019377

Hundhausen, C., & Douglas, S. (2000). *SALSA and ALVIS: a language and system for constructing and presenting low fidelity algorithm visualizations.* Paper presented at the IEEE International Symposium on Visual Languages, Seattle, WA.

Igbrue, Claudia, & Pathak, Pramod. (2008). *A framework for creating multiple intelligences informed content for e-learning*. Paper presented at the World

Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008, Las Vegas, Nevada, USA. http://www.editlib.org/p/29876

Isenberg, Petra, Elmqvist, Niklas, Scholtz, Jean, Cernea, Daniel, Ma, Kwan-Liu, & Hagen, Hans. (2011). Collaborative visualization: Definition, challenges, and research agenda. *Information Visualization, 10*(4), 310-326. doi: 10.1177/1473871611412817

Ismail, Johan. (2001). The design of an e-learning system: Beyond the hype. [doi: DOI: 10.1016/S1096-7516(01)00069-0]. *The Internet and Higher Education, 4*(3-4), 329-336.

Jakkilinki, R., Sharda, N., & Ahmad, I. (2006). MUDPY ontology: a tool for multimedia project planning, design and development. [DOI: 10.1108/17410390610645067]. *Journal of Enterprise Information Management, 19*(2), 165-174.

Johnson, S., Healey, A., Evans, J., Murphy, M., Crawshaw, M., & Gould, D. (2006). Physical and cognitive task analysis in interventional radiology. *Clinical Radiology, 61*(1), 97-103. doi: 10.1016/j.crad.2005.09.003

Jonassen, David H. (2008). Instructional design as design problem solving: An iterative process. *Educational Technology, 48*(3), 21.

Jury, Thomas W. (2007). *Electronic performance support for e-learning analysis and design.* 3348986 Ph.D., Nova Southeastern University, United States -- Florida. Retrieved from http://search.proquest.com/docview/304717132?accountid=28930 ProQuest Dissertations & Theses Full Text; ProQuest Education Journals database.

Kam, Roy. (2008). Elearning development in practice – making the best use of interactions among subject matter expert, instructional designer and multimedia developer. Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008, Las Vegas, Nevada, USA. http://www.editlib.org/p/29590

Kasowitz, Abby. (2000). Tools for Automating Instructional Design. *Educational Media and Technology Yearbook, 25*, 49-52.

Keengwe, Jared, Kidd, Terry, & Kyei-Blankson, Lydia. (2009). Faculty and Technology: Implications for Faculty Training and Technology Leadership. *Journal of Science Education and Technology, 18*(1), 23-28. doi: 10.1007/s10956-008-9126-2

Kenny, Richard F., Zhang, Zuochen, Schwier, Richard A., & Campbell, Katy. (2005). A Review of What Instructional Designers Do:Questions Answered and Questions Not Asked *Canadian Journal of Learning and Technology, 31*(1).

Keppell, Micheal J. (1997). Development and pilot-testing of a method to assist instructional designers elicit unfamiliar content from subject matter experts. PhD Dissertation, University of Calgary Calgart, Alberta.

Keppell, Mike. (2001). Optimising Instructional Designer - Subject Matter Expert Communication in the Design and Development of Online and Multimedia Projects. *Journal of Interactive Learning Research, Volume 12*(2/3), 209 - 227

Klein, Gary, & Militello, Laura. (2001). 4. Some guidelines for conducting a cognitive task analysis *Advances in Human Performance and Cognitive Engineering Research,* (Vol. 1, pp. 163-199): Emerald Group Publishing Limited.

Klein, Gary, Calderwood, R., & MacGregor, D. (1989). Critical decision method for eliciting knowledge. *Systems, Man and Cybernetics, IEEE Transactions on, 19*(3), 462-472.

Kleinberger, Thomas, Holzinger, Andreas, & Müller, Paul. (2008). Adaptive multimedia presentations enabling universal access in technology enhanced situational learning. *Universal Access in the Information Society, 7*(4), 223-245. doi: 10.1007/s10209-008-0122-3

Koohang, Alex, & Harman, Keith. (2007). *Learning Objects and Instructional Design*. California, the USA: Information science press.

Kruse, Kevin. (2001). Creating scripts and storyboards for e-learning Retrieved 10th October, 2009, from http://www.e-Learningguru.com/articles/art2_5.htm

Landay, J. A., & Myers, B. A. (2001). Sketching interfaces: toward more human interface design. *Computer, 34*(3), 56-64.

Lang, Sherman Y. T., Dickinson, John, & Buchal, Ralph O. (2002). Cognitive factors in distributed design. *Computers in Industry, 48*(1), 89-98. doi: 10.1016/s0166-3615(02)00012-x

Lauesen, Soren. (2007). *User Interface Design: A Software Engineering Perspective*. Essex, England: Pearson - Addison Wesley.

Lazar, Jonathan, Feng, Jinjuan Heidi, & Hochheiser, Harry. (2010). *Research Methods in Human-Computer Interaction*. West Sessex, United Kingdom: John Wiley & Sons Ltd.

Lee, Chien-Sing, & Chong, Hwee-Reei. (2005). *Automated eclectic instructional design: design factors*. Paper presented at the Proceedings of the 5th WSEAS International Conference on Distance Learning and Web Engineering, Corfu Island, Greece.

Lee, William W. (1994). Subject matter experts and instructional designers: Making distinctions. *Performance + Instruction, 33*(8), 23-25. doi: 10.1002/pfi.4160330807

Leigh, H. Ma, & Tracey, M. PhD. (2010). A review and new framework for instructional design practice variation research. *Performance Improvement Quarterly, 23*(2), 33.

Liang, ChaucerChaoyun. (2000). Patterns of expert ID practitioners in the corporate world: A literature review. *TechTrends, 44*(1), 16-18. doi: 10.1007/bf02818204

Liaw, Shu-Sheng, Huang, Hsiu-Mei, & Chen, Gwo-Dong. (2007). Surveying instructor and learner attitudes toward e-learning. *Computers & Education, 49*(4), 1066-1080. doi: 10.1016/j.compedu.2006.01.001

Lim, Beng-Chong, & Klein, Katherine J. (2006). Team mental models and team performance: a field study of the effects of team mental model similarity and accuracy. *Journal of Organizational Behavior, 27*(4), 403-418. doi: 10.1002/job.387

Lin, Han X., Choong, Yee-Yin, & Salvendy, Gavriel. (1997). A proposed index of usability: A method for comparing the relative usability of different software systems. *Behaviour & Information Technology, 16*(4-5), 267-277. doi: 10.1080/014492997119833

Loll, Frank, & Pinkwart, Niels. (2013). LASAD: Flexible representations for computer-based collaborative argumentation. *International Journal of Human-Computer Studies, 71*(1), 91-109. doi: http://dx.doi.org/10.1016/j.ijhcs.2012.04.002

Low, Andy Lock Yen, Low, Kevin Lock Teng, & Koo, Voon Chet. (2003). Multimedia learning systems: a future interactive educational tool. *The Internet and Higher Education, 6*(1), 25-40. doi: http://dx.doi.org/10.1016/S1096-7516(02)00160-4

Maceachren, Alan M., & Brewer, Isaac. (2004). Developing a conceptual framework for visually-enabled geocollaboration. *International Journal of Geographical Information Science, 18*(1), 1-34. doi: 10.1080/13658810310001596094

Malizia, A., Bellucci, A., Diaz, P., Aedo, I., & Levialdi, S. (2011). eStorys: A visual storyboard system supporting back-channel communication for emergencies.

Journal of Visual Languages and Computing, 22(2), 150-169. doi: 10.1016/j.jvlc.2010.12.003

Marie, Georgianna, & Klein, Jayne. (2008). *Developing effective detailed design documents and WBT/CBT storyboards.* Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2008, Las Vegas, Nevada, USA.

Marks, Michelle A., Sabella, Mark J., Burke, C. Shawn, & Zaccaro, Stephen J. (2002). The impact of cross-training on team effectiveness. *Journal of Applied Psychology, 87*(1), 3-13. doi: 10.1037/0021-9010.87.1.3

Mathieu, John E., Heffner, Tonia S., Goodwin, Gerald F., Salas, Eduardo, & Cannon-Bowers, Janis A. (2000). The influence of shared mental models on team process and performance. [doi: 10.1037/0021-9010.85.2.273]. *Journal of Applied Psychology, 85*(2), 273-283.

Mayer, Richard E. (2002). Cognitive theory and the design of multimedia instruction: an example of the two-way street between cognition and instruction. *New Directions for Teaching and Learning, 89*, 55 - 71.

Mayer, Richard E., & Moreno, Roxana. (2002). Aids to computer-based multimedia learning. *Learning and Instruction, 12*(1), 107-119. doi: 10.1016/s0959-4752(01)00018-4

McComb, Sara A. (2008). Shared Mental Models and Their Convergance. In Michael P. Letsky, Norman W. Warner & Stephen M. Fiore (Eds.), *Macrocognition in Teams : Theories and Methodologies*. Abingdon, Oxon, GBR: Ashgate Publishing Group.

McGrath, Will, Bowman, Brian, McCallum, David, Ramos, Juan David Hincapi ́e, Elmqvist, Niklas, & Irani, Pourang. (2012). *Branch-explore-merge: facilitating real-time revision control in collaborative visual exploration*. Paper presented at the Proceedings of the 2012 ACM international conference on Interactive tabletops and surfaces, Cambridge, Massachusetts, USA.

McGraw, K. L., & Seale, M. R. (1988). Knowledge elicitation with multiple experts: considerations and techniques. *Artificial Intelligence Review, 2*(1), 31-44. doi: 10.1007/bf00139624

Mcintyre, Robert M., & Salas, Eduardo. (1995). Measuring and managing for team performance: Emerging principles from complex environments. In Richard A. Guzzo & Eduardo Salas (Eds.), *Team effectiveness and decision making in organizations*. Michigan, USA: Jossey-Bass.

McKenney, Susan, Nieveen, Nienke, & van den Akker, Jan. (2002). Computer support for curriculum developers: CASCADE. *Educational Technology Research and Development, 50*(4), 25-35. doi: 10.1007/bf02504982

McLaughlin, Denis (Producer). (2013, 14th January 2013). Identyfying the research problem. [Slides Powerpoint]

McNeese, MichaelD. (2004). How video informs cognitive systems engineering: making experience count. *Cognition, Technology & Work, 6*(3), 186-196. doi: 10.1007/s10111-004-0160-4

Merriënboer, Jeroen J.G. van, & Martens, Rob. (2002). Computer-Based Tools for Instructional Design: An Introduction to the Special Issue. *Educational Technology Research and Development, 50*(4), 5-9.

Midieum, Shin, Byung-soo, Kim, & Jun, Park. (2005). *AR storyboard: an augmented reality based interactive storyboard authoring tool.* Paper presented at the Mixed and Augmented Reality, 2005. Proceedings. Fourth IEEE and ACM International Symposium on.

Militello, L.G., & Hutton, J.B. (2000). Applied Cognitive Task Analysis (ACTA): A practitioner's toolkit for understanding cognitive task demands'. In J. Annett & N.S Stanton (Eds.), *Task Analysis* (pp. 90-113). London: Taylor and Francis.

Militello, Laura G., & Hutton, Robert J.B. (1998). Applied Cognitive Task Analysis (ACTA): A Practitioner's Toolkit for Understanding Cognitive Task Demands. *Ergonomics, 41*(11), 1618 - 1641.

Militello, Laura G., & Hutton, Robert J.B. (2000). Applied cognitive task analysis (ACTA): a practitioner's toolkit for understanding cognitive task demands. In John Annet & Neville Anthony Stanton (Eds.), *Task Analysis* (pp. 90). London, GBR: CRC Press.

Militello, Laura G., Hutton, Robert J. B., Pliske, Rebecca M., Knight, Betsy J., & Klein, Gary. (1997). Applied cognitive task analysis (ACTA) methodology. San Diego, California: Klein Associates Inc.

Miller, Richard L., & Benz, Joseph J. (2008). Techniques for Encouraging Peer Collaboration: Online Threaded Discussion or Fishbowl Interaction. *Journal of Instructional Psychology, 35*(1), 87-93.

Miller, T. E., Copeland, R. R., Phillips, Jennifer K., . . . A, M. J. (1999). Cognitive Approach to Developing Planning Tools to Support Air Campaign Planners. Air Force Research Laboratory, Information Directorate. Rome, NY (August 1999). The ACTA method and the Critical Decision Method are used to capture strategies and tactical concerns of air campaign planners for use in the development of a software decision support tool.

Misanchuk, E.R. (1992). *Preparing instructional text: Document design using desktop publishing*. Englewood Cliffs, NJ: Educational Technology Publications.

Misanchuk, E.R. (1994). Print tools in distance education. In B. Willis (Ed.), *Distance education: Strategies and tools* (pp. 109-129). Englewood Cliffs, NJ: Educational Technology Publications.

MITRE, Corporation. (2010). Mental models:applications of methods to systems engineering phases Retrieved 12th Dec, 2010, from http://mentalmodels.mitre.org/cog_eng/ce_sys_eng_phases_matrix.htm

Mohammed, Susan, Ferzandi, Lori, & Hamilton, Katherine. (2010). Metaphor No More: A 15-Year Review of the Team Mental Model Construct. *Journal of Management, 36*(4), 876-910. doi: 10.1177/0149206309356804

Mohammed, Susan, Klimoski, Richard, & Rentsch, Joan R. (2000). The Measurement of Team Mental Models: We Have No Shared Schema. *Organizational Research Methods, 3*(2), 123-165. doi: 10.1177/109442810032001

Moller, L. (1995). Working with subject matter experts. *TechTrends, 40*(6), 26–27.

Mustaro, Pollyana Notargiacomo, Silveira, Ismar Frango, Omar, Nizam, & Stump, Sandra Maria Dotto. (2007). Structure of storyboard for interactive learning objects development. In Alex Koohang & Keith Harman (Eds.), *Learning objects and instructional design* (pp. 253). Santa Rosa, California, USA: Informing Science Press.

Muszyńska, Karolina. (2009, Novemeber 23-24, 2009). *Collaborative Software For Supporting Communication And Cooperation In Project Teams.* Paper presented at the Advanced Information Technologies for Management (AITM2010), Wroclaw University of Economics.

National Science Foundation's Visualization. (1987). Scientific Computing Workshop Report.

Nekvinda, Christopher D. (2011). *Designing electronic performance support systems: Models and instructional strategies employed.* 3479061 Ph.D., Capella University, United States -- Minnesota. Retrieved from http://search.proquest.com/docview/902941528?accountid=28930 ProQuest Dissertations & Theses Full Text database.

Nesbit, John, Belfer, Karen, & Vargo, John. (2002). A Convergent Participation Model for Evaluation of Learning Objects. *Canadian Journal of Learning and Technology, 28*(3).

Newman, Mark W., Lin, James, Hong, Jason I., & Landay, James A. (2003). DENIM: an informal web site design tool inspired by observations of practice. *Hum.-Comput. Interact., 18*(3), 259-324. doi: 10.1207/s15327051hci1803_3

Nielsen, Janni, Clemmensen, Torkil, & Yssing, Carsten. (2002). *Getting access to what goes on in people's heads?: reflections on the think-aloud technique*. Paper presented at the Proceedings of the second Nordic conference on Human-computer interaction, Aarhus, Denmark.

Nisbett, Richard E., & Wilson, Timothy D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84*(3), 231-259. doi: 10.1037/0033-295X.84.3.231

Norling, Emma. (2008). *What should the agent know?: the challenge of capturing human knowledge*. Paper presented at the Proceedings of the 7th international joint conference on Autonomous agents and multiagent systems - Volume 3, Estoril, Portugal.

Ogi, T., Yamada, T., Hirose, M., Fujita, M., & Kuzuu, K. (2003, 22-26 March 2003). *High presence remote presentation in the shared immersive virtual world.* Paper presented at the Proceedings of IEEE Virtual Reality, 2003. , Orlando, Florida.

Okur, M. Recep, & Gümüs, Salih. (2010). Storyboarding issues in online course production process. [doi: DOI: 10.1016/j.sbspro.2010.03.755]. *Procedia - Social and Behavioral Sciences, 2*(2), 4712-4716.

Online Oxford English Dictionary. Retrieved 7th November 2013 http://www.oed.com/view/Entry/192713#eid20062366

Oviatt, Sharon, & Cohen, Philip. (2000). Perceptual user interfaces: multimodal interfaces that process what comes naturally. *Communications of the ACM, 43*(3), 45-53. doi: 10.1145/330534.330538

Paradowski, Michael, & Fletcher, Adam. (2004). Using task analysis to improve usability of fatigue modelling software. *International Journal of Human-Computer Studies, 60*(1), 101-115. doi: 10.1016/j.ijhcs.2003.09.004

Pardew, Les. (2004). *Beginning Illustration and Storyboarding for Games*. Boston, MA, USA: Course Technology.

Parsons, Ann M. (2008). *A Delphi study of best practices of online instructional design practices in Malaysia.* Ph.D. 3320829, Capella University, United States -- Minnesota. Retrieved from http://search.proquest.com/docview/304821821?accountid=28930 ProQuest Dissertations & Theses (PQDT) database.

Payne, Stephen J. (2003). Mental Models in Human-Computer Interaction. In Andrew Sears & Julie A . Jacko (Eds.), *The Human-Computer Interaction Handbook. Fundamentals, Evolving Technologies and Emerging Applications, Second Edition* (pp. 63-75). Mahwah, New Jersey: Lawrence Erlbaum Associates, Inc.

PEMANDU: Performance Management & Delivery Unit. (2013). The Annual Report of Economic Transformation Programme. Retrieved 11th January 2013, from http://etp.pemandu.gov.my/

Petre, Marian. (2004). Team coordination through externalized mental imagery. *International Journal of Human-Computer Studies, 61*(2), 205-218. doi: http://dx.doi.org/10.1016/j.ijhcs.2003.12.013

Phillips, Jennifer, McDermott, Patricia L., Thordsen, Marvin, McCloskey, Micheal, & Klein, Gary. (1998). Cognitive Requirements for Small Unit Leaders in Military Operations in Urban Terrain. Research Report 1728: U.S. Army Research Institute for Behavioural and Social Science.

Picciano, Anthony G., & Dziuban, Charles D. (2007). *Blended learning: Research perspectives*. The US: The Sloan-Consortium.

Piskurich, George M. (2003). *The AMA Handbook of E-Learning: Effective Design, Implementation, and Technology Solutions* Saranac Lake, NY, USA: AMACOM. [Books24x7 version] http://common.books24x7.com/book/id_5201/book.asp. .

Piskurich, George M., Beckschi, Peter, & Hall, Brandon. (2000). *ASTD Handbook, of Training Design and Delivery : A Comprehensive Guide to Creating and Delivering Training Programs-Instructor-Led, Computer-Based, or Self-Directed*. Blacklick, OH, USA: McGraw-Hill Professional Publishing.

Piskurich, George M., Beckschi, Peter, & Hall, Brandon. (2000). ASTD Handbook, of Training Design and Delivery : A Comprehensive Guide to Creating and Delivering Training Programs-Instructor-Led, Computer-Based, or Self-Directed. Blacklick, OH, USA: McGraw-Hill Professional Publishing.

Plass, JanL, & Salisbury, MarkW. (2002). A living-systems design model for web-based knowledge management systems. *Educational Technology Research and Development, 50*(1), 35-56. doi: 10.1007/bf02504960

Polson, P.G., Lewis, C., Rieman, J., & Wharton, C. (1992). Cognitive walkthroughs: a method for theory based evaluation of user interfaces. *International Journal of Man-Machine Studies, 36*, 741-773.

Power, Michael. (2009). *Designer's Log: Case Studies in Instructional Design*. Edmonton, AB, CAN: Athabasca University Press (AU Press).

Power, Michael. (2009). *Designer's Log: Case Studies in Instructional Design*. Edmonton, AB, CAN: Athabasca University Press (AU Press).

Raja Maznah, Raja Hussain. (2004). E-Learning in Higher Education Institutions in Malaysia Retrieved 14th October 2010, 2010, from http://www.e-mentor.edu.pl/_xml/wydania/7/102.pdf

Razak, Rafiza Abdul, & Palanisamy, Punithavathy. (2010). The development of M-LODGE for training instructional designers. *Procedia - Social and Behavioral Sciences, 9*(0), 1906-1912. doi: 10.1016/j.sbspro.2010.12.422

Razak, Rafiza Abdul. (2013). Shared Knowledge among graphic designers, instructional designers and subject matter experts in designing multimedia-based instructional media. *The Turkish Online Journal of Educational Technology, 12*(3).

Resick, Christian J., Dickson, Marcus W., Mitchelson, Jacqueline K., Allison, Leslie K., & Clark, Malissa A. (2010). Team composition, cognition, and effectiveness: Examining mental model similarity and accuracy. *Group Dynamics: Theory, Research, and Practice, 14*(2), 174-191. doi: 10.1037/a0018444

Robinson, A. C. (2008, 19-24 Oct. 2008). *Collaborative synthesis of visual analytic results.* Paper presented at the Visual Analytics Science and Technology, 2008. VAST '08. IEEE Symposium on.

Roytek, Margaret A. (2010). Enhancing instructional design efficiency: Methodologies employed by instructional designers. *British Journal of Educational Technology, 41*(2), 170-180. doi: 10.1111/j.1467-8535.2008.00902.x

Rubio, Doris McGartland, Berg-Weger, Maria, Tebb, Susan S, Lee, E Suzanne, & Rauch, Shannon. (2003). Objectifying content validity: Conducting a content validity study in social work research. *Social Work Research, 27*, 2.

Sarah, W. Fraser. (2003). Project Storyboards: Catalysts for Collaborative Improvement. [DOI: 10.1108/09526860310495688]. *International Journal of Health Care Quality Assurance, 16*(6), 300-305.

Saroyan, Alenoush. (1992). Differences in expert practice: a case from formative evaluation. *Instructional Science, 21*(6), 451-472. doi: 10.1007/bf00118558

Saroyan-Farivar, Alenoush. (1989). The review process in formative evaluation of instructional text: The role of content experts and instructional designers. PhD Dissertation, McGill University Montreal, Canada.

Schraagen, Jan Maarten, Chipman, Susan F., & Shute, V.J. (2000). State-of-the-art review of cognitive task analysis techniques. In Jan Maarten Schraagen, Susan F. Chipman & V.J Shute (Eds.), *Cognitive Task Analysis* (pp. 467-489). Mahwah, NJ: Erlbaum Associates.

Scozzi, B., Crowston, K., Yeliz Eseryel, U., & Qing, Li. (2008, 7-10 Jan. 2008). *Shared Mental Models among Open Source Software Developers.* Paper presented at the Hawaii International Conference on System Sciences, Proceedings of the 41st Annual.

Sears, Andrew, & Jacko, Julie A. (2009). *Human-computer interaction. Fundamentals*. Boca Raton: CRC Press, Taylor & Francis Group.

Sellen, Abigail, & Harper, Richard. (1997). *Paper as an analytic resource for the design of new technologies.* Paper presented at the Proceedings of the ACM SIGCHI Conference on Human factors in computing systems.

Sharp, Helen, Rogers, Yvonne, & Preece, Jenny. (2007). *Interaction Design: Beyond Human-Computer Interaction* (2nd ed.). West Sussex, England: John Wiley & Sons, Ltd.

Shea, Peter. (2007). Towards A Conceptual Framework for Learning in Blended Environments. In Anthony G. Picciano & Charles D. Dziuban (Eds.), *Blended learning: Research perspectives* (pp. 19-36). The US: The Sloan-Consortium.

Shneiderman, Ben. (2003). *Leonardo's Laptop: Human Needs and the New Computing Technologies*. The USA: Massachusetts Institute of Technology.

SIGCHI, ACM. (1992). Curricula for Human-Computer Interaction. New York: ACM Special Interest Group on Computer-Human Interaction Curriculum Development Group.

Simon, Herbert. (1969). The Sciences of the artificial.

Simon, Mark. (2007). *Storyboard: Motion in Art* (3rd ed.). Oxford, UK: Elsevier Inc.

Smith, Patricia L., & Ragan, Tillman J. (2005). *Instructional design* (3rd ed.). USA: Wiley Jossey-Bass Education.

Smith, Patricia L., & Ragan, Tillman J. (2005). *Instructional design* (3rd ed.). USA: Wiley Jossey-Bass Education.

Solomonson, W. . (2008). Toward fluent instructional design in the context of people. *Performance Improvement, 47*(7), 12-19. doi: 10.1002/pfi.20012.

Sommerville, Ian. (2011). *Software Engineering* (9th ed.). Boston, Massachusettes, USA: Pearson Education, Inc

Spector, J. (2002). Knowledge management tools for instructional design. *Educational Technology Research and Development, 50*(4), 37-46. doi: 10.1007/bf02504983

Spector, J. Michael, & Ohrazda, Celestia. (2004). Automating Instructional Design: Approaches and Limitations. In Jonanssen D. H. (Ed.), *Handbook of research on educational communications and technology* (pp. 685-700). Mahwah, NJ Lawrence Erlbaum.

Stanton, Neville, Salmon, Paul, & Walker, Guy. (2005). *Human factors methods : a practical guide for engineering and design*. Abingdon, Oxon, , GBR: Ashgate Publishing Group.

Stoyanova, Neli, & Kommers, Piet. (2002). Concept Mapping as a Medium of Shared Cognition in Computer-Supported Collaborative Problem Solving. *Journal of Interactive Learning Research, 13*(1/12), 111-133.

Susi, Tarja, & Ziemke, Tom. (2001). Social cognition, artefacts, and stigmergy: A comparative analysis of theoretical frameworks for the understanding of artefact-mediated collaborative activity. *Cognitive Systems Research, 2*(4), 273-290. doi: http://dx.doi.org/10.1016/S1389-0417(01)00053-5

Suthers, D. D. (2005, 03-06 Jan. 2005). *Collaborative Knowledge Construction through Shared Representations.* Paper presented at the System Sciences, 2005. HICSS '05. Proceedings of the 38th Annual Hawaii International Conference on.

Thouvenin, I., Lenne, D., Guenand, A., & Aubry, S. (2005, 24-26 May 2005). *Knowledge integration in early design stages for collaboration on a virtual mock up.* Paper presented at the Proceedings of the Ninth International Conference on Computer Supported Cooperative Work in Design, 2005. .

Thronesbery, C., Molin, A., & Schreckenghost, D. L. (2007). *A Storyboard Tool to Assist Concept of Operations Development.* Paper presented at the IEEE Aerospace Conference, Big Sky, MT.

Thronesbery, Carroll, Schreckenghost, Debra, & Molin, Arthur. (2009). Concept of Operations Storyboard Tool. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 53*(24), 1830-1834. doi: 10.1177/154193120905302403

Ting, Choo-Yee, Chong, Yen-Kuan, Ooi, Wen-Fong, Tan, Boon-Siang, Chuah, Shang-Jun, & Saw, Kee-Leng. (2005). eStoryBoard: an intelligent SCROM compliant authoring tool. *Malaysian Online Journal of Instructional Technology, 2*(August), 1-16.

Tory, M., & Moller, T. (2005). Evaluating visualizations: do expert reviews work? *Computer Graphics and Applications, IEEE, 25*(5), 8-11.

Truong, Khai N., Hayes, Gillian R., & Abowd, Gregory D. (2006). *Storyboarding: an empirical determination of best practices and effective guidelines*. Paper presented at the Proceedings of the 6th conference on Designing Interactive systems, University Park, PA, USA.

Tumminello, Wendy. (2005). *Exploring storyboarding* (1st ed.). Canada: Thomson-Delmar Learning.

Umar, Irfan N., & Su-Lyn, Yong. (2011). Instructional Design Practitioners in Malaysia: Skills and Issues. *World Academy of Science, Engineering and Technology* 1413 - 1417.

Undre, Shabnam, Sevdalis, Nick, Healey, Andrew N., Darzi, Sir Ara, & Vincent, Charles A. (2006). Teamwork in the operating theatre: cohesion or confusion? *Journal of Evaluation in Clinical Practice, 12*(2), 182-189.

Van der Lelie, Corrie. (2006). The value of storyboards in the product design process. *Personal Ubiquitous Computing, 10*(2-3), 159-162. doi: http://dx.doi.org/10.1007/s00779-005-0026-7

Venkatesh, Viswanath, Brown, Susan A., & Bala, Hillol. (2013). Bridging the qualitative-quantitative divide: guidelines for conducting mixed methods research in information systems. *MIS Q., 37*(1), 21-54.

Vicente, Kim J. (1999). Cognitive work analysis: Toward safe, productive, and healthy computer-based work. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Wahid, Shahtab, Branham, Stacy M, Cairco, Lauren, Mccrickard, D Scott, & Harrison, Steve. (2009). *Picking Up Artifacts: Storyboarding as a Gateway to Reuse.* Paper presented at the Proceedings of the 12th IFIP TC 13 International Conference on Human-Computer Interaction: Part II.

Wahid, Shahtab, Branham, Stacy, Harrison, Steve, & McCrickard, Scott. (2009). Collaborative Storyboarding: Artifact-Driven Construction of Shared Understanding. *Computer Science Technical Report TR-09-02*. England: University of Southampton.

Wan Adli Ridzwan, Wan Hassan. (2007). *An application for creating e-learning content storyboard based on instructional design principles.* Masters in Computer Science, University Malaya, Kuala Lumpur.

Wang, Lihui, Shen, Weiming, Xie, Helen, Neelamkavil, Joseph, & Pardasani, Ajit. (2002). Collaborative conceptual design—state of the art and future trends. *Computer-Aided Design, 34*(13), 981-996. doi: http://dx.doi.org/10.1016/S0010-4485(01)00157-9

Wang, Xuemei, Dannenhoffer, John F., Davidson, Barry D., & Spector, J. Michael. (2005). Design Issues in a Cross-institutional Collaboration on a Distance Education Course. *Distance Education, 26*(3), 405-423. doi: 10.1080/01587910500291546

Wei, J., & Salvendy, G. (2004). The cognitive task analysis methods for job and task design: review and reappraisal. *Behaviour & Information Technology, 23*(4), 273 - 299.

Wenger, Etienne. (1998). *Communities of Practice: learning, meaning and identity*. United Kingdom: Cambridge University Press.

Willard, Carolyn A. (1995). A descriptive analysis of how subject matter experts-turned-designers/trainers approach an instructional design problem. Ed.D., Southern Illinois University at Edwardsville.

Wong, ChuiYin, & Khong, CheeWeng. (2007). Quantifying the Narration Board for Visualising Final Design Concepts by Interface Designers. In JulieA Jacko (Ed.), *Human-Computer Interaction. Interaction Design and Usability* (Vol. 4550, pp. 273-282): Springer Berlin Heidelberg.

Wu, Anna, Convertino, Gregorio, Ganoe, Craig, Carroll, John M., & Zhang, Xiaolong. (2013). Supporting collaborative sense-making in emergency management through geo-visualization. *International Journal of Human-Computer Studies, 71*(1), 4-23. doi: http://dx.doi.org/10.1016/j.ijhcs.2012.07.007

Xiao, Yan, Schenkel, Stephen, Faraj, Samer, Mackenzie, Colin F., & Moss, Jacqueline. (2007). What Whiteboards in a Trauma Center Operating Suite Can Teach Us About Emergency Department Communication. *Annals of Emergency Medicine, 50*(4), 387-395. doi: http://dx.doi.org/10.1016/j.annemergmed.2007.03.027

Yancey, Challey. (1996). The ABCs of working with SMEs. *Performance + Instruction, 35*(1), 6-9. doi: 10.1002/pfi.4170350104

Yang, J. T. D., Chiung-Hui, Chiu, Chun-Yen, Tsai, & Tsung-Hsien, Wu. (2004, 30 Aug.-1 Sept. 2004). *Visualized online simple sequencing authoring tool for SCORM-compliant content package.* Paper presented at the IEEE International Conference on Advanced Learning Technologies (ICALT'04).

Yang, Ya-Ting C., & Chan, Chia-Ying. (2008). Comprehensive evaluation criteria for English learning websites using expert validity surveys. *Computers & Education, 51*(1), 403-422. doi: http://dx.doi.org/10.1016/j.compedu.2007.05.011

Ying, Zhou, & Erping, Wang. (2010). Shared mental models as moderators of team process-performance relationships [Article]. *Social Behavior & Personality: An International Journal, 38*(4), 433-444.

You, Peter, & Teclehaimanot, Berhane. (2010). Instructional designers' role in assisting instructors in the implementation of best practices in distance learning course design and delivery in higher education: instructors' perspectives. Paper presented at the World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education 2010, Orlando, Florida, USA. http://www.editlib.org/p/35656

Yusoff, Nor'ain Mohd, & Salim, Siti Salwah. (2014, 2nd - 5th September 2014). *Social-based versus shared situation awareness-based approaches to the understanding of team cognitive research in HCI.* Paper presented at the (i-USEr 2014) 3rd International Conference on User Science and Engineering, Shah Alam, Malaysia.

Zhang, Dai, Shaw, Steven, & Strobel, Johannes. (2006). *Embedding Instructional Design Supports in Course Management System - Implications from Literature Review*. Paper presented at the World Conference on Educational Multimedia, Hypermedia and Telecommunications 2006. http://www.editlib.org/p/23110

Zou, Tracy, & Lee, W. B. (2010). A Study of the Similarity in Mental Models and Team Performance. [Article]. *Proceedings of the International Conference on Intellectual Capital, Knowledge Management & Organizational Learning*, 536-544.

LIST OF APPENDICES

APPENDIX A

COLLECTION PAPERS ON SYSTEMATIC REVIEW (2000-2013, N=15)

Authors	Type of Paper	System Name	Research Objective
(Greenspan, Goldberg, Weimer, & Basso, 2000)	Solution proposal	PhoneChannel	a) To understand the influence of different communication media on interpersonal attributions, e.g. trust, as well as on task oriented variables, e.g., efficiency; b) To explore the use of these technologies in business-to-household communication.
(Ogi, Yamada, Hirose, Fujita, & Kuzuu, 2003)	Development and evaluation	A remote presentation system	- To realize a high presence remote presentation in the shared immersive virtual world.
(Maceachren & Brewer, 2004)	Development and evaluation	GeoVE	a) To outline a conceptual framework for visually-enabled collaboration with geospatial information through geospatial technologies (an activity which is labeled as “geo collaboration”) b) To demonstrate application of this framework to a pair of case studies from their ongoing research.
(Thouvenin, Lenne, Guenand, & Aubry, 2005)	Development and evaluation	The MATRICS	- To support collaboration between distant groups working on a joint project based on virtual reality possibilities
(Engelmann, Dehler, Bodemer, & Buder, 2009)	Solution proposal	KIA	a) To present a specific group awareness approach for computer-supported collaborative learning (CSCL) settings, namely knowledge awareness. b) To illustrate how the knowledge awareness tools work in three different tasks using presentation of three application scenarios
(Abla, Kim, Schissel, & Flanagan, 2010)	Solution proposal	DIII-D web portal environment	a) To describe the software architecture of this scientific web portal b) To present its implementation which include deployment experiences during the 2009 DIII-D Experimental Campaign.
(Bachour, Kaplan, & Dillenbourg, 2010)	Development and evaluation	Reflect	- To describe an interactive table designed for supporting face-to-face collaborative learning
(Balakrishnan, Fussell, Kiesler, & Kittur, 2010)	Solution proposal	Remote collaboration systems	a) To examine remote analyst pairs collaborating on the serial killer task. b) To examine how the distribution of evidence and the availability of visualization tools change how the pairs discuss the evidence and their problem solving success.

(Haeyong et al., 2010)	Development and evaluation	VizCept	a) To present a new web-based visual analytics system, this is designed to support fluid, collaborative analysis of large textual intelligence datasets. b) To combine individual workspace and shared visualization in an integrated environment.
(Grandhi, Schuler, & Jones, 2011)	Solution proposal	Telling Calls	a) To describe Telling Calls, a mobile phone application which allows users to provide and receive information. b) To conducted a qualitative field study and a quantitative field study of Telling Calls use.
(Bergstrom & Karahalios, 2012)	Solution proposal	Conversation Clock	a) To evaluate the effect of visual feedback on collaboration, by purposefully distorted the apparent balance in the Conversation Clock. b) To present a pilot study examining various distortion strategies
(Germani, Mengoni, & Peruzzini, 2012)	Development and evaluation	CO-ENV	- To describe and evaluate a method that defines a co-design platform dedicated to SMEs in the mechanical product field.
(McGrath et al., 2012)	Development and evaluation	BEM	a) To describe a protocol based on managing revisions for each collaborator exploring a dataset. b) To perform a qualitative user study involving a real estate dataset.
(Loll & Pinkwart, 2013)	Development and evaluation	LASAD	a) To describe LASAD, a collaborative argumentation framework that can be flexibly parameterized b) To evaluate the impact of using an argumentation system with different argument representations and with collaborative vs. individual use on the outcomes of scientific argumentation
(Wu, et al., 2013)	Development and evaluation	CIVIL.	a) To describe a multi-view, role-based design to help team members analyze geo-spatial information, share and integrate critical information, and monitor individual activities. b) To describe design rationale, iterative design of visualization tools, prototype implementation, and system evaluation.

APPENDIX B

THE ACTA TOOLKIT METHODS

Source: Latorella, Pliske, Hutton & Chrenka (2001)

ACTA - TASK DIAGRAM

Purpose: The Task Diagram is intended to serve as a road map to the rest of the CTA.

The Task Diagram acts as an advance organizer, providing an overview of the task and identifying the cognitively complex elements of the task.

How to get started: Before you begin, have clearly in mind what the task is you intend to investigate. In this interview, you want to find out about the interviewee's processes as they perform the task of interest.

CONDUCTING THE TASK DIAGRAM INTERVIEW

* Write the Task of Interest at top of whiteboard.
* Elicit the steps required to do the task. Record them across the board from left to right in chronological order. Use arrows to indicate the order in which the steps occur.
   - Ask your SME, *"Think about what you do when you (Task of Interest). Can you break this task down into between three and six steps?"*

* Elicit information regarding which of the steps require cognitive skills. Circle the elements that require cognitive skills.
   - Ask your SME, *"Of the steps you have just identified which require difficult cognitive skills? By cognitive skills I mean judgments, assessments, and problem solving – thinking skills."*

At this point, you should have a very broad overview of the task, with an indication of where the complex cognitive skills lie. If the task seems too big or the steps you have identified are too broad for further investigation, you may choose to focus on one or two of the subtasks you have identified as requiring cognitive skills. In this case, you should complete a Task Diagram on the step(s) you have chosen to focus the rest of the cognitive task analysis.

TIPS FOR DOING THE TASK DIAGRAM INTERVIEW

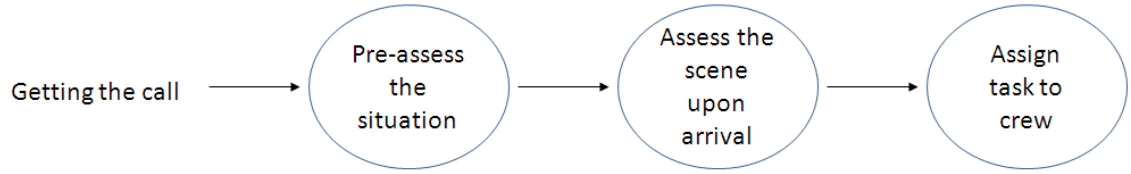
- Your interviewee may immediately start talking at a very fine level of detail. Make it clear early on that you are looking for a very broad overview with this interview. You will be interested in hearing lots of stories and details later in the session (with the Knowledge Audit and the Simulation Interview).

- If your interviewee begins listing things to consider rather than the steps of the task, help reframe the topic for him/her. "What do you do when you (Task of Interest)?"

• This may be a new way for the interviewee to think about the job. Give him/her time to think. You may need to repeat or rephrase the question.

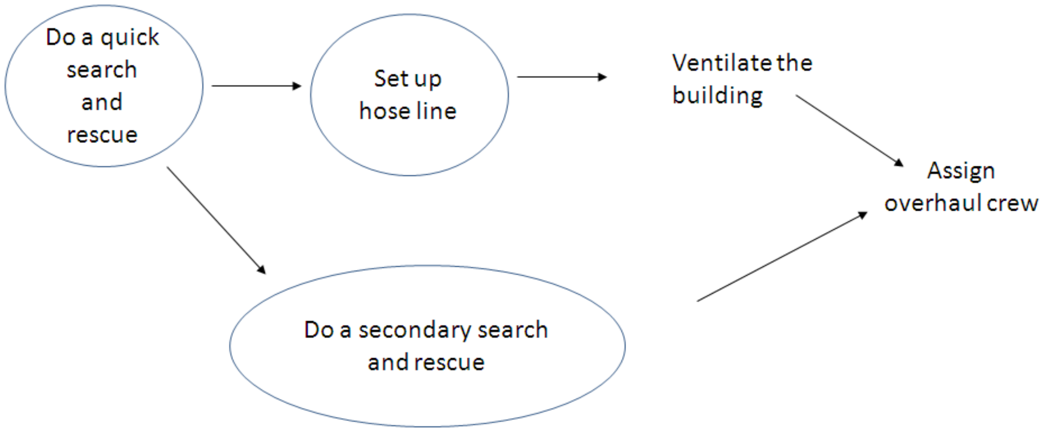
• The Task Diagram serves as a road map to the rest of the cognitive task analysis. You are not trying to elicit detailed, specific cognitive information with this interview. You are trying to get a sense of which parts of the task require complex cognitive skills.

EXAMPLE: Task Diagram of Fire ground Commander's Job in Commanding Crew



The interviewer decides this is too broad - really wants to focus on the assignment of tasks during an incident.

EXAMPLE: Task Diagram of Assign Tasks



ACTA - KNOWLEDGE AUDIT

Purpose: The Knowledge Audit provides details and examples of cognitive elements of expertise; it contrasts what experts know and novices don't.

How to get started: You used the Task Diagram to identify parts of the job that require skilled judgment, decision-making and evaluation. In the

Knowledge Audit you will elicit the expertise necessary to do each of those tasks. Use the Task Diagram to help you decide which tasks and subtasks you want to explore with the Knowledge Audit. Go into the Knowledge Audit interview knowing what you want to analyze.

CONDUCTING THE KNOWLEDGE AUDIT

* Write the Task of Interest at top, center of whiteboard.
* Divide the space below into three columns; label as shown.

Task of Interest		
Example	**Cues and Strategies**	**Why Difficult?**
Past and Future Example….		
Big Picture Example…		
Noticing Example…		

* Elicit an example of one element of expertise, using the definitions and probes provided. Start with the first probe, (e.g., *"Is there a time when you walked into the middle of a situation and knew exactly how things got there and where they were headed*?)

* Elicit information for the remaining two columns before proceeding to another element:

- Ask your SME, *"In this situation, how would you know this? What cues and strategies is you relying on?" Record answers in middle column under "Cues and Strategies."*
- Ask your SME, *"In what way would this be difficult for a less-experienced person?" What makes it hard to do?"*

Record answers in final column under "Why Difficult?"

* It is important that you cover the six basic Knowledge Audit probes; you may alsowant to use some or all of the optional probes.

TIPS FOR DOING THE KNOWLEDGE AUDIT

- Examples allow you to get at specifics and help you understand the task better. Ask for an example for each element of expertise.
- Don't try to write everything; but write enough so you will know later what was said and meant. With practice you will develop a sense of the level of detail you need.
- Some of the questions may take a few minutes for the SME to answer thoughtfully; don't rush; give the SME time to think over what you are asking about.
- Confusion about what to write and in which columns may be a signal that the SME has misunderstood your question; the information you are getting is not what you expect. You may want to take a timeout, restate the question, and check that your SME understands what you are trying to get at.

ELICITING INFORMATION WITH THE KNOWLEDGE AUDIT

Provide an explanation of the type of information you want; then ask the probe questions. You can read the definitions below or paraphrase them.

BASIC PROBES:

*** Past & Future**

Experts can figure out how a situation developed, and they can think into the future to see where the situation is going. Among other things, this can allow experts to head off problems before they develop.

Is there a time when you walked into the middle of a situation and knew exactly how things got there and where they were headed?

*** Big Picture**

Novices may only see bits and pieces. Experts are able to quickly build an understanding of the whole situation - the Big Picture view. This allows the expert to think about how different elements fit together and affect each other.

Can you give me an example of what is important about the Big Picture for this task? What are the major elements you have to know and keep track of?

*** Noticing**

Experts are able to detect cues and see meaningful patterns that less-experienced personnel may miss altogether.

Have you had experiences where part of a situation just "popped' out at you; where you noticed things going on that others didn't catch? What is an example?

*** Job Smarts**

Experts learn how to combine procedures and work in the most efficient way possible. They don't cut corners, but they don't waste time and resources either.

When you do this task, are there ways of working smart or accomplishing more with less - that you have found especially useful?

*** Opportunities**

Experts are comfortable improvising - seeing what will work in his particular situation; they are able to shift directions to take advantage of opportunities.

Can you think of an example when you have improvised in this task or noticed an opportunity to do something better?

*** Self**

Experts are aware of their performance; they check how they are doing and make Monitoring adjustments. Experts notice when their performance is not what it should be (this could be due to stress, fatigue, high workload, etc.) and are able to adjust so that the job gets done.

Can you think of a time when you realized that you would need to change the way you were performing in order to get the job done?

OPTIONAL PROBES:

*** Anomalies**

Novices don't know what is typical, so they have a hard time identifying what is atypical. Experts can quickly spot unusual events and detect deviations. And, they are able to notice when something that ought to happen, doesn't.
Can you describe an instance when you spotted a deviation from the norm, or knew something was amiss?

*** Equipment**
Equipment can sometimes mislead. Novices usually believe difficulties. Whatever the equipment tells them; they don't know when to be skeptical.
Have there been times when the equipment pointed in one direction, but your own judgment told you to do something else? Or when you had to rely on experience to avoid being led astray by the equipment?

ACTA - SIMULATION INTERVIEW

Purpose: The Simulation Interview provides a view of the expert's problem-solving processes in context. The interview provides specific detailed information on expert cognitive processes.

How to get started: You will need to obtain a simulation of the task. The simulation you choose should address difficult, challenging elements of the job. It does not have to be high fidelity; it can be a paper and pencil simulation, a video depicting a scenario, or whatever is available. It is important that the simulation you choose presents a challenging scenario.

CONDUCTING THE SIMULATION INTERVIEW

- Divide a whiteboard into five columns, labeled as shown on the next page.

- Have the SME experience (i.e. read, watch, interact with) the simulation.
  - Tell the SME, *"As you experience this simulation, imagine you are the (Job you are investigating) in the incident. Afterwards, I am going to ask you a series of questions about how you would approach this situation."*

- Elicit a list of the major events in the simulated incident and record in the first column.
  - Ask your SME, *"Think back over the scenario. Please list the major events that occurred during the incident. These events could include judgments or decision points. As you name them, I am going to list them in the left column of the board."*

- Begin with the first major event and elicit information for the remaining four columns before proceeding to the next major event.
  - Ask your SME, *"As the (Job you are investigating) in this scenario, what actions, if any, would you take at this point in time?"*
  Record answers in the second column under **Actions.**

  - Ask your SME, *"What do you think is going on here? What is your assessment of the situation at this point in time?"*
  Record answers in the third column under **Situation Assessment**.

- Ask your SME, *"What pieces of information led you to this situation assessment and these actions?"*
Record answers in the fourth column under **Critical Cues.**

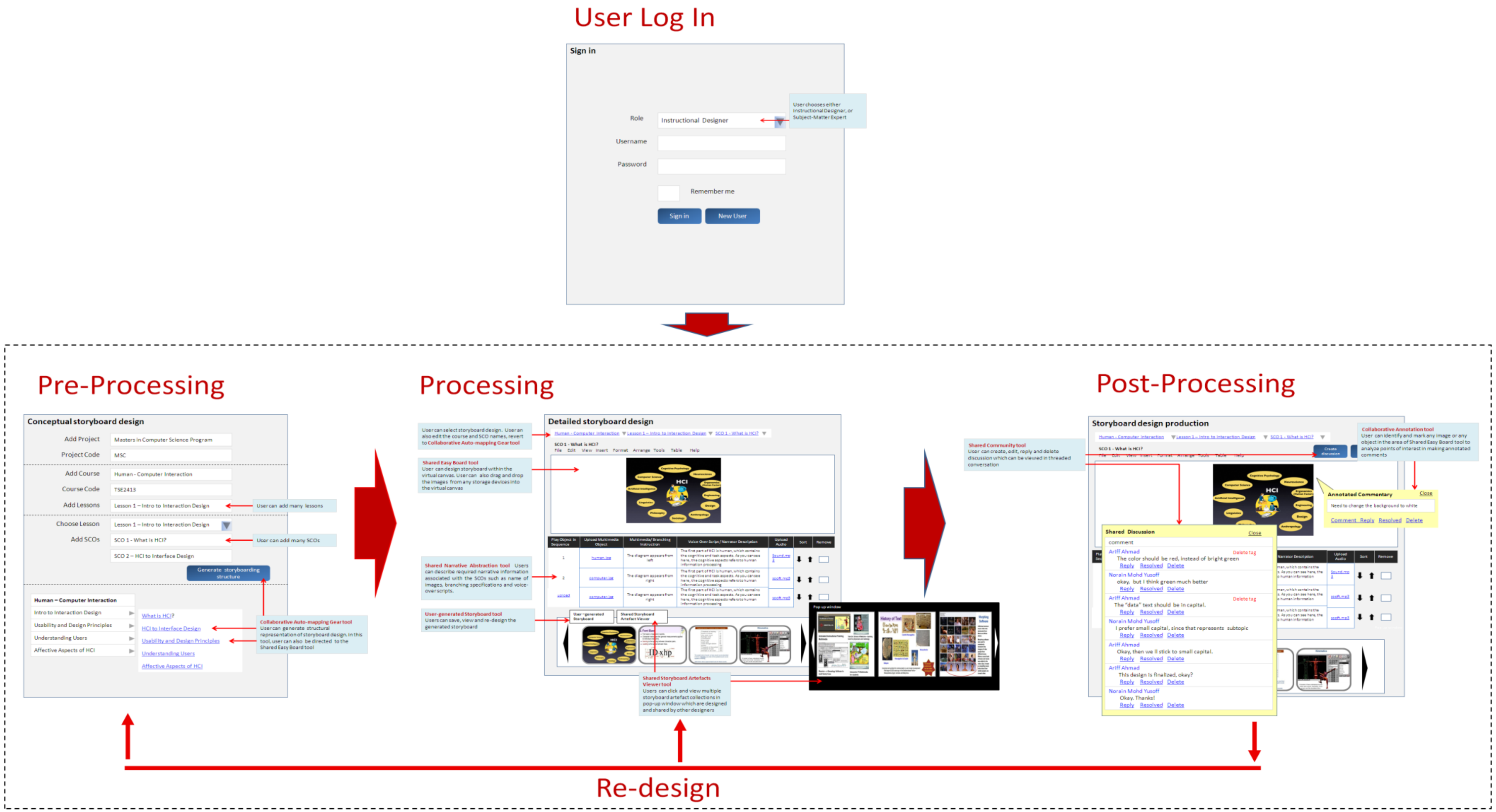
- Ask your SME, *"What errors would an inexperienced person be likely to make in this situation?"*
Record answers in the fifth column under **Potential Errors.**

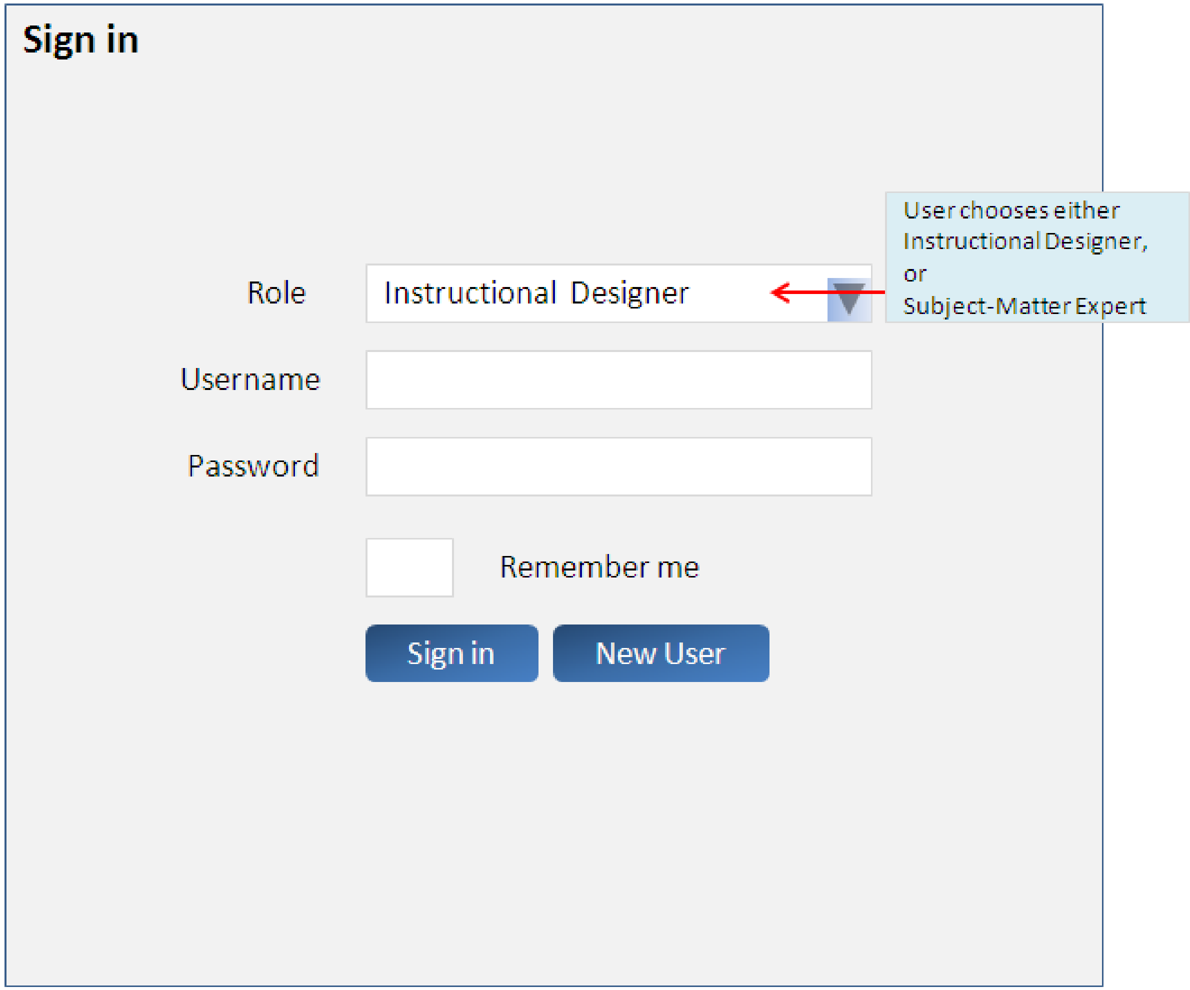
TIPS FOR DOING THE SIMULATION INTERVIEW

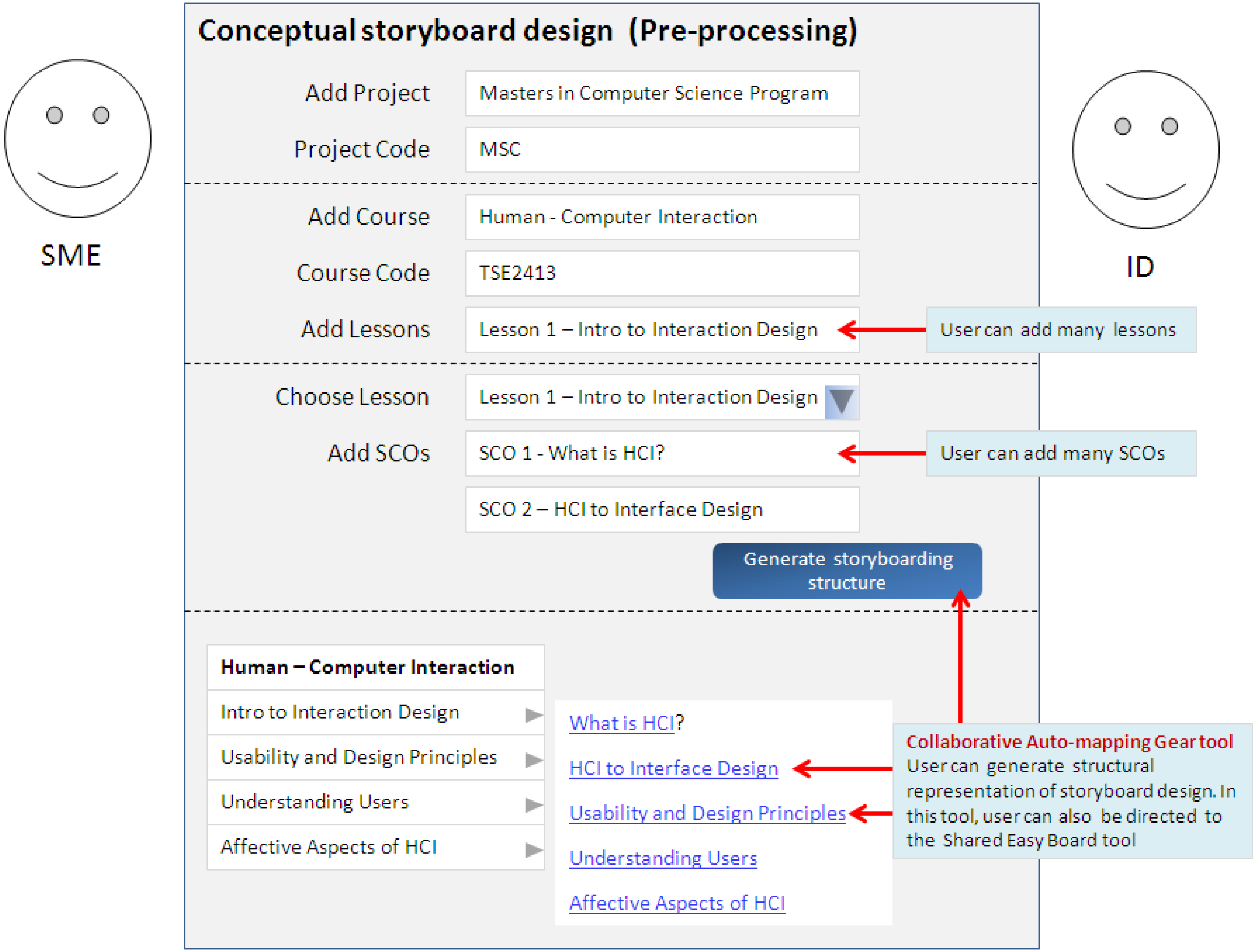
- Eliciting major events are critical to this interview. The major events should be turning points or segments of the story. You do NOT want a recount of the entire scenario.
- People often want to critique the simulation. Assure your interviewee that you are interested in their critique, but that for the first part of the interview, you would like to work with the scenario as it has been presented. Be sure to follow up and ask for a critique at the end.
- Don't try to write everything; but write enough so you will know later what was said and meant. With practice you will develop a sense of the level of detail you need.
- Confusion about what to write and in which columns may be a signal that the SME has misunderstood your question; the information you are getting is not what you expect. You may want to take a timeout, restate the question, and check that your SME understands what you are getting at.

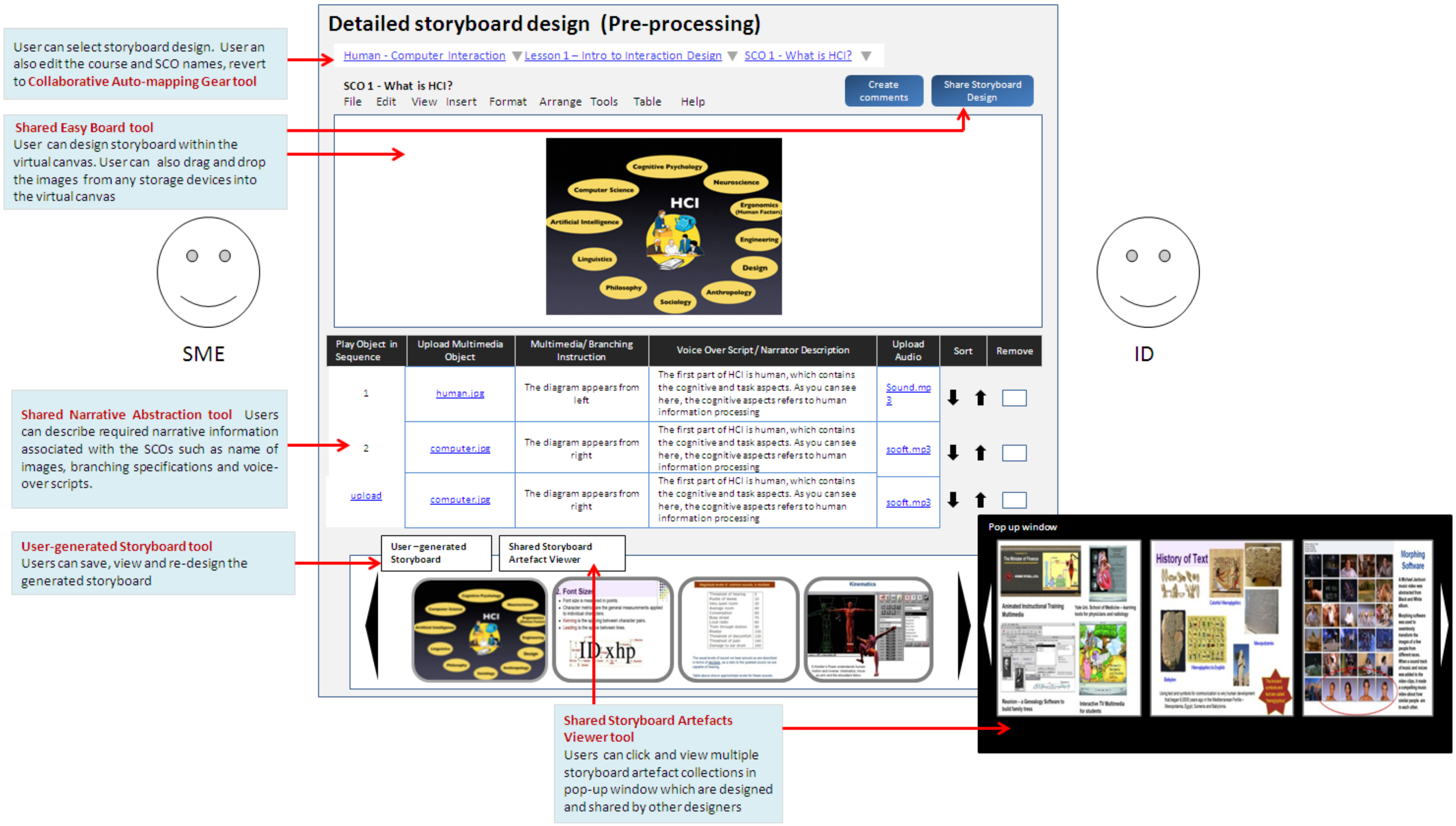
APPENDIX C

THE FIVE VIRTUAL WINDOWS DESIGN

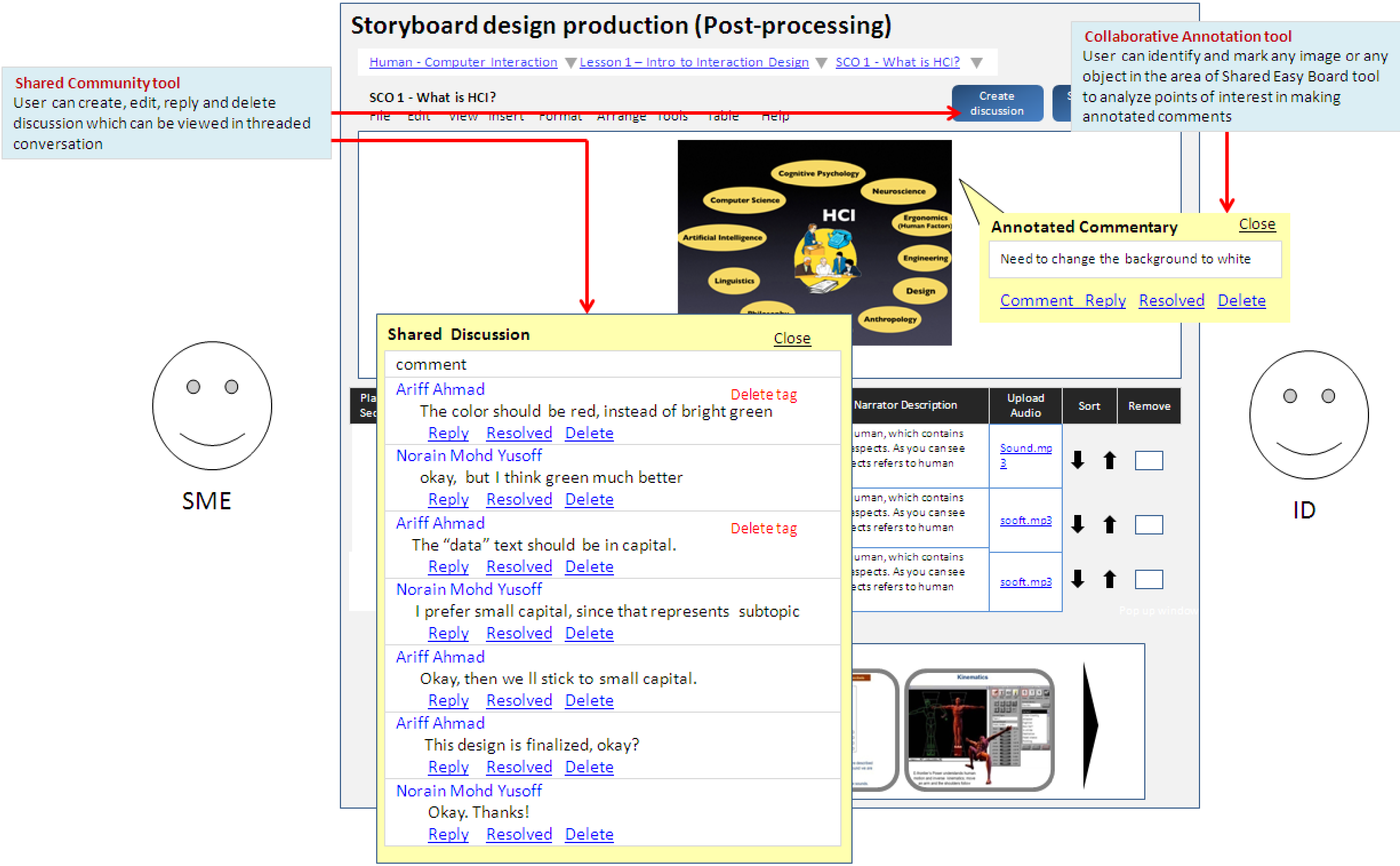



Sign in
User chooses either
Instructional Designer,
or
Subject-Matter Expert
Role
Instructional Designer
Username
Password
Remember me
Sign in
New User


Conceptual storyboard design (Pre-processing)
SME
ID
Add Project
Masters in Computer Science Program
Project Code
MSC
Add Course
Human - Computer Interaction
Course Code
TSE2413
Add Lessons
Lesson 1 – Intro to Interaction Design
User can add many lessons
Choose Lesson
Lesson 1 – Intro to Interaction Design
Add SCOs
SCO 1 - What is HCI?
User can add many SCOs
SCO 2 – HCI to Interface Design
Generate storyboarding structure
Human – Computer Interaction
Intro to Interaction Design
Usability and Design Principles
Understanding Users
Affective Aspects of HCI
What is HCI?
HCI to Interface Design
Usability and Design Principles
Understanding Users
Affective Aspects of HCI
Collaborative Auto-mapping Gear tool
User can generate structural representation of storyboard design. In this tool, user can also be directed to the Shared Easy Board tool



Detailed storyboard design (Pre-processing)
Human - Computer Interaction
Lesson 1 – Intro to Interaction Design
SCO 1 - What is HCI?
SCO 1 - What is HCI?
File Edit View Insert Format Arrange Tools Table Help
Create comments
Share Storyboard Design
HCI
Cognitive Psychology
Neuroscience
Computer Science
Ergonomics (Human Factors)
Artificial Intelligence
Engineering
Linguistics
Design
Philosophy
Anthropology
Sociology
Play Object in Sequence
Upload Multimedia Object
Multimedia/ Branching Instruction
Voice Over Script / Narrator Description
Upload Audio
Sort
Remove
1
human.jpg
The diagram appears from left
The first part of HCI is human, which contains the cognitive and task aspects. As you can see here, the cognitive aspects refers to human information processing
Sound.mp3
2
computer.jpg
The diagram appears from right
The first part of HCI is human, which contains the cognitive and task aspects. As you can see here, the cognitive aspects refers to human information processing
sooft.mp3
upload
computer.jpg
The diagram appears from right
The first part of HCI is human, which contains the cognitive and task aspects. As you can see here, the cognitive aspects refers to human information processing
sooft.mp3
User –generated Storyboard
Shared Storyboard Artefact Viewer
User can select storyboard design. User an also edit the course and SCO names, revert to Collaborative Auto-mapping Gear tool
Shared Easy Board tool
User can design storyboard within the virtual canvas. User can also drag and drop the images from any storage devices into the virtual canvas
SME
ID
Shared Narrative Abstraction tool Users can describe required narrative information associated with the SCOs such as name of images, branching specifications and voice-over scripts.
User-generated Storyboard tool
Users can save, view and re-design the generated storyboard
Pop up window
History of Text
Morphing Software
Shared Storyboard Artefacts Viewer tool
Users can click and view multiple storyboard artefact collections in pop-up window which are designed and shared by other designers



Storyboard design production (Post-processing)
Human - Computer Interaction
Lesson 1 – Intro to Interaction Design
SCO 1 - What is HCI?
SCO 1 - What is HCI?
Create discussion
File Edit View Insert Format Arrange Tools Table Help
Shared Community tool
User can create, edit, reply and delete discussion which can be viewed in threaded conversation
Collaborative Annotation tool
User can identify and mark any image or any object in the area of Shared Easy Board tool to analyze points of interest in making annotated comments
HCI
Cognitive Psychology
Neuroscience
Computer Science
Ergonomics (Human Factors)
Artificial Intelligence
Engineering
Linguistics
Design
Anthropology
Annotated Commentary
Close
Need to change the background to white
Comment Reply Resolved Delete
Shared Discussion
Close
comment
Ariff Ahmad
Delete tag
The color should be red, instead of bright green
Reply Resolved Delete
Norain Mohd Yusoff
okay, but I think green much better
Reply Resolved Delete
Ariff Ahmad
Delete tag
The “data” text should be in capital.
Reply Resolved Delete
Norain Mohd Yusoff
I prefer small capital, since that represents subtopic
Reply Resolved Delete
Ariff Ahmad
Okay, then we ll stick to small capital.
Reply Resolved Delete
Ariff Ahmad
This design is finalized, okay?
Reply Resolved Delete
Norain Mohd Yusoff
Okay. Thanks!
Reply Resolved Delete
Narrator Description
Upload Audio
Sort
Remove
Sound.mp3
sooft.mp3
sooft.mp3
Kinematics
SME
ID

APPENDIX D

A TEMPLATE OF EMAIL INVITATION TO THE PRE-RECRUITED ACADEMIC EXPERT

Dear (addressed to the pre-recruited expert panelists),

My name is Ms Nor'ain M. Yusoff, a graduate student from the Faculty of Computer Science and Information Technology, University of Malaya, Malaysia. I would like to invite you to evaluate a framework of a computer-based instructional design tool called eSCOUT.

Looking at your rich background in academic and research expertise in the area of Human-Computer Interaction, I would like to humbly solicit your opinions, suggestions and recommendations to validate and/or improve our initial framework of the eSCOUT.

The eSCOUT (acronym for eLearning Storyboard for Shared Cognitive User Task) is a framework of a storyboard that aims to encourage SMM development between the instructional designers (ID) and subject-matter experts (SME). The main objective of this framework is to support SME as novice designers in storyboarding activities, and at the same time, speed up the instructional design process at the early phase. The purpose of the evaluation should be to provide comments as well as necessary inputs to the basis process, structural and shared visualization technique and strategies of the eSCOUT. On top of that, I would also seek your recommendations and suggestions to improve the framework.

Enclosed, please find Web links /URL which will direct you to the eSCOUT questionnaires: https://www.surveymonkey.com/s/eSCOUT

The evaluation will take place approximately around 30 minutes. I have also attached a slide presentation that has described a clear flow of the eSCOUT for your reference.

Please let me know when you have completed the evaluation. I would need to provide you with a token of appreciation. If you have any queries, do not hesitate to contact my supervisor: Professor Dr Siti Salwah Salim (at salwa@um.edu.my)

Your input as the knowledge expert in this field of study will be very much appreciated and I would be really honored if you can do this evaluation accordingly.

Thank you for your time and cooperation in this study
* Feel free to whatsapp or call me (at 013-3811188) to verify the authentication of this email.

Sincerely,

Nor'ain, Mohd Yusoff
PhD Candidate
Faculty of Computer Science and Information Technology,
University of Malaya,
50603 Kuala Lumpur, Malaysia

APPENDIX E

QUESTIONNAIRE ITEMS FOR ACADEMIC EXPERTS

Question_ID	Question No	Questions Items
A01	1	Agreement to participate in Framework Evaluation study
A02	2	Current designation
A03	3	Company Name/Cost centre
A04	4	Academic qualification
A05	5	Areas of research specialization
A06	6	Years of experience in the areas of specialization
A07	7	Number of publications produced:
A08	nil	nil
A09	nil	nil
A10	nil	nil
A11	nil	nil
A12	nil	nil
B01	8	Does the shared visualization technique (i.e. The Collaborative Mapping belongs to the appropriate storyboard design process (pre-processing phase)?
B02	nil	nil
B03	9	Do the shared visualization strategies (i.e. Shared board, Shared storyboard artefact viewer, Shared user-generated storyboard, Shared narrative abstraction) belong to the appropriate storyboard design process (i.e. Processing phase)?
B04	nil	nil
B05	10	Do the shared visualization technique (i.e. Collaborative discussion and Collaborative Annotation tools) belong to the appropriate storyboard design process (i.e. Post-Processing phase)?
B06	nil	nil
B07	11	Does the agile design process (i.e. Re-design phase) allows modification or alteration of storyboarding information and

		design?
C01	12	Is this shared visualization technique (Collaborative mapping) and its functionality stand for the right representation and emergence for reaching common plan of the topic involving shared conceptual storyboard design activities such as planning of the structure and contents of the course and lessons which are important?
C02	13	Is the shared visualization technique (Collaborative mapping) and functionality important for the corresponding processing phase?
C03	14	Is the shared visualization technique (Collaborative mapping) and its functionality clear enough for you to understand?
C04	nil	nil
C05	15	Is this shared visualization strategy (Shared Board) stands for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C06	16	Is the shared visualization strategy (Shared Board) important for the corresponding processing phase?
C07	17	Is the shared visualization strategy (Shared Board) clear enough for you to understand?
C08	nil	nil
C09	18	Is this shared visualization strategy (Shared user-generated storyboard) stand for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C10	19	Is the shared visualization strategy (Shared user-generated storyboard) and functionality important for the corresponding processing phase?
C11	20	Is the shared visualization strategy (Shared user-generated storyboard) and its functionality clear enough for you to understand?
C12	nil	nil
C13	21	Is this shared visualization strategy (Shared Storyboard Artefact Viewer) stand for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C14	22	Is the shared visualization strategy (Shared Storyboard Artefact Viewer) functionality important for the corresponding processing phase?

C15	23	Is the shared visualization strategy (Shared Storyboard Artefact Viewer) clear enough for you to understand?
C16	nil	nil
C17	24	Is this shared visualization strategy (Shared Narrative Abstraction) stand for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C18	25	Is the shared visualization strategy (Shared Narrative Abstraction) important for the corresponding processing phase?
C19	26	Is the shared visualization strategy (Shared Narrative Abstraction) clear enough for you to understand?
C20	nil	nil
C21	27	Is this shared visualization technique (Collaborative discussion) stand for the right representation and emergence for reaching a common decision from the shared storyboarding design production which is important?
C22	28	Is the shared visualization technique (Collaborative discussion) important for the corresponding processing phase?
C23	29	Is the shared visualization technique (Collaborative discussion) clear enough for you to understand?
C24	nil	nil
C25	30	Is this shared visualization technique (Collaborative Annotation) stand for the right representation and emergence for reaching a common decision from the shared storyboarding design production which is important?
C26	31	Is the shared visualization technique (Collaborative Annotation) important for the corresponding processing phase?
C27	32	Is the shared visualization technique (Collaborative Annotation) clear enough for you to understand?
C28	nil	nil
D01	33	Please rate the overall structural and functional design for the eSCOUT
D02	34	Overall, are the tools and functionalities representing the needs for each of the processing phase?
D03	35	Do you find any advantages of the eSCOUT?
D04	36	Do you find any disadvantages of the eSCOUT?
D05	37	What are the areas that need to be improved?
D06	38	What are the areas that need to be removed?
D07	39	How can these problems be solved?
D08	40	Finally, do you have any other opinions/suggestions/recommendations to improve the eSCOUT?

APPENDIX F

A TEMPLATE OF EMAIL INVITATION TO PRACTITIONERS

Dear (addressed to the professionals or practitioners),

My name is Ms Nor'ain M. Yusoff, a graduate student from the Faculty of Computer Science and Information Technology, University of Malaya, Malaysia. I would like to invite you to evaluate a framework of a computer-based instructional design tool called eSCOUT.

For your information, your name is recommended to me by (addressed the name of the recommender). Looking at your rich background in the instructional design and eLearning, I would like to humbly solicit your opinions, suggestions and recommendations to validate and/or improve our initial framework of the eSCOUT.

The eSCOUT (acronym for eLearning Storyboard for Shared Cognitive User Task) is a framework of a storyboard that aims to encourage SMM development between the instructional designers (ID) and subject-matter experts (SME). The main objective of this framework is to support SME as novice designers in storyboarding activities, and at the same time, speed up the instructional design process at the early phase. The purpose of the evaluation should be to provide comments as well as necessary inputs to the basis process, structural and shared visualization technique and strategies of the eSCOUT. On top of that, I would also seek your recommendations and suggestions to improve the framework.

The purpose of the evaluation should be to provide comments as well as necessary inputs to the process, structural, functionalities and proposed tools of the eSCOUT. On top of that, we also seek your recommendations and suggestions to improve the framework. Enclosed, please find Web links /URL which will direct you to the eSCOUT questionnaires: https://www.surveymonkey.com/s/eSCOUT-for-practitioner

The evaluation will take place approximately around 30 minutes. I have also attached a slide presentation that has described a clear flow of the eSCOUT for your reference.Please let me know when you have completed the evaluation. I would need to provide you with a token of appreciation.If you have any queries, do not hesitate to contact my supervisor: Professor Dr Siti Salwah Salim (at salwa@um.edu.my)

Your input as aprofessional as well as an instructional design practitioner in this field of study will be very much appreciated.

Thank you for your time and cooperation in this study
* Feel free to whatsapp or call me (at +6013-3811188) to verify the authentication of this email.

Sincerely,

Nor'ain, Mohd Yusoff
PhD Candidate
Faculty of Computer Science and Information Technology,
University of Malaya, 50603 Kuala Lumpur, Malaysia

APPENDIX G

QUESTIONNAIRE ITEMS FOR PRACTITIONERS

Question_ID	Question No	Questions Items
A01	1	Agreement to participate in Framework Evaluation study
A02	2	Current designation
A03	3	Company Name/Cost centre
A04	4	Academic qualification
A05	nil	nil
A06	nil	nil
A07	nil	nil
A08	5	Briefly describe your eLearning experience and skills
A09	6	At which phase do you involve in storyboarding?
A10	7	What is/are your professional skills?
A11	8	Years of experience in eLearning / storyboarding:
A12	9	Number of storyboard produced:
B01	10	Does the shared visualization technique (Collaborative mapping) correspond to the real tasks in storyboard design process (pre-processing phase)?
B02	11	Can storyboarding tasks (in this pre-processing phase) be supported with this window?
B03	12	Do the shared visualization technique and strategies (Shared board, Shared storyboard artefact viewer, Shared user-generated storyboard, Shared narrative abstraction) correspond to the real tasks in storyboard design process (i.e. Processing phase)?
B04	13	Can storyboarding tasks (in this processing phase) be supported with this window?
B05	14	Do the shared visualization technique (Collaborative discussion and Collaborative Annotation) correspond to the real tasks in storyboard design process (i.e. Post-Processing phase)?
B06	15	Can storyboarding tasks (in this Post-processing phase) be supported with this window?
B07	16	Does the agile design process (i.e. Re-design phase) allows modification or alteration of storyboarding information and design?

C01	17	Is this shared visualization technique (Collaborative mapping) stand for the right representation and emergence for reaching common plan of the topic involving shared conceptual storyboard design activities such as planning of the structure and contents of the course and lessons which are important?
C02	18	Is the shared visualization technique (Collaborative mapping) important for the corresponding processing phase?
C03	19	Is the shared visualization technique (Collaborative mapping) being explained clearly?
C04	20	Do you understand the shared visualization technique (Collaborative mapping) and its functionality?
C05	21	Is this shared visualization strategy (Shared board) stand for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C06	22	Is the shared visualization strategy (Shared board) important for the corresponding processing phase?
C07	23	Is the shared visualization strategy (Shared board) being explained clearly?
C08	24	Do you understand the shared visualization strategy (Shared board) and its functionality?
C09	25	Is this shared visualization strategy (Shared user-generated storyboard) stand for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C10	26	Is the shared visualization strategy (Shared user-generated storyboard) important for the corresponding processing phase?
C11	27	Is the shared visualization strategy (Shared user-generated storyboard) being explained clearly?
C12	28	Do you understand the shared visualization strategy (Shared user-generated storyboard) and its functionality?
C13	29	Is this shared visualization strategy (Shared storyboard artefact viewer) stand for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C14	30	Is the shared visualization strategy (Shared storyboard artefact viewer) important for the corresponding processing phase?
C15	31	Is the shared visualization strategy (Shared storyboard artefact viewer) being explained clearly?
C16	32	Do you understand the shared visualization strategy (Shared storyboard artefact viewer) and its functionality?
C17	33	Is this shared visualization strategy (Shared Narrative Abstraction) stand for the right representation and emergence for reaching common understanding from the shared detailed storyboarding design requirements of the eLearning lesson involving the

		acquisition of the sketching activities of the multimedia content, narrative description and storyboarding artefacts which is important?
C18	34	Is the shared visualization strategy (Shared Narrative Abstraction) important for the corresponding processing phase?
C19	35	Is the shared visualization strategy (Shared Narrative Abstraction) being explained clearly?
C20	36	Do you understand the shared visualization strategy (i.e. Shared Narrative Abstraction) and its functionality?
C21	37	Is this shared visualization technique (Collaborative discussion) stand for the right representation and emergence for reaching a common decision from the shared storyboarding design production which is important?
C22	38	Is the shared visualization technique (Collaborative discussion) important for the corresponding processing phase?
C23	39	Is the shared visualization technique (Collaborative discussion) being explained clearly?
C24	40	Do you understand the shared visualization technique (Collaborative discussion) and its functionality?
C25	41	Is this shared visualization technique (Collaborative Annotation) stand for the right representation and emergence for reaching a common decision from the shared storyboarding design production which is important?
C26	42	Is the shared visualization technique (Collaborative Annotation) important for the corresponding processing phase?
C27	43	Is the shared visualization technique (Collaborative Annotation) being explained clearly?
C28	44	Do you understand the shared visualization technique (Collaborative Annotation) and its functionality?
D01	45	Please rate the overall structural and functional design for the virtual windows in the eSCOUT
D02	46	Overall, are the tools and functionalities representing the needs for each of the processing phase?
D03	47	Do you find any advantages of the eSCOUT?
D04	48	Do you find any disadvantages of the eSCOUT?
D05	49	What are the areas that need to be improved?
D06	50	What are the areas that need to be removed?
D07	51	How can these problems be solved?
D08	52	Finally, do you have any other opinions/suggestions/recommendations to improve the eSCOUT / virtual windows?

APPENDIX H
PARTICIPATING ACADEMICIANS' PROFILES

Expert No	Expert Name	Designation	Affiliation	Areas of specialization
1	Dr. Zulikha Jamaludin	Professor and Deputy Director.	University Teaching and Learning Centre and School of Computing, University Utara Malaysia.	New learning technologies, ICT[19]
2	Dr. Norshuhada Shiratuddin	Professor and The Dean	School of Multimedia Technology and Communications, University Utara Malaysia	Multimedia, software engineering, mobile application and mobile learning[20]
3	Dr. Mohamed Ally	Professor and Researcher	Centre for Distance Education and Technology Enhanced Knowledge Research Institute (TEKRI), Athabasca University, Canada.	Mobile learning, eLearning, distance education, workplace learning, the use of emerging technologies in education and training, and use of ICT for Education for All[21]
4	Dr Abtar Kaur	Professor and Director	Faculty of Education and Languages and Open and Distance Learning Pedagogy Centre, Open University Malaysia	Web-based learning[22]
5	Dr. Hanafi Atan	Professor and Coordinator	School of Distance Education, and Coordinator of e-Learn@USM, University	Open and Distance Education, Instructional Technology, eLearning[23]

[19]http://www.soc.uum.edu.my/index.php/main-office/our-experts/computer-science-department
[20]http://scholar.google.com.my/citations?user=K0mKLp4AAAAJ&hl=en
[21]http://cde.athabascau.ca/faculty/mohameda.php
[22]http://www.pnclink.org/pnc2008/english/cv/05_CV_eLearning1_0930.pdf
[23]http://www.scorea.com.my/SCOREA-ITEACHER/profile/proprofile.cfm

			Science Malaysia	
6	Dr. Nazlena Mohamad Ali	Associate Professor and Senior Research Fellow	Institute of Visual Informatics and Center for Academic Development, National University of Malaysia	Interaction Design, User Evaluation and Usability, Information Visualization, Interactive Multimedia System, User Engagement[24]
7	Dr Kinshuk	Professor and Associate Dean	Faculty of Science and Technology, School of Computing and Information Systems, Athabasca University, Canada	Adaptive and personalized learning, learning analytics, learning technologies, mobile, ubiquitous and location aware learning systems, cognitive profiling, and interactive technologies[25]
8	Dr Robert D. Tennyson	Professor , Program Coordinator, Editor of Computers in Human Behavior	Department of Educational Psychology, The University of Minnesota, The USA	Cognitive learning and complex cognitive processes, intelligent systems, complex-dynamic simulations, testing and measurement, instructional design, and advanced learning technologies.[26]
9	Dr. Murni Mahmud	Associate Professor	Department of Information Systems, Kulliyyah of Information and Communication Technology, International Islamic University Malaysia	Human Computer Interaction, Evaluation Method[27]
10	Dr. Alvin Yeo Wee	Associate Professor and Director	Faculty of Computer Science & Information Technology and Institute of Social Informatics and Technological Innovations,	Human computer interaction, ICT for rural development , language technologies , usability and

[24] http://www.ftsm.ukm.my/nma/nazlena-website-ftsm.html
[25] http://scis.athabascau.ca/scis/staff/faculty.php?id=kinshuk)
[26] http://www.cehd.umn.edu/edpsych/people/Faculty/Tennyson.html
[27] http://irep.iium.edu.my/profile/murni

			University Malaysia Sarawak	culture , internationalization and localisation[28]
11	Dr. Supyan Hussin	Associate Professor	School of Language Studies and Linguistics, Faculty of Social Sciences and Humanities, National University of Malaysia	Teacher education, eLearning, computer-assisted language learning, mobile learning, and pedagogical approaches in materials development[29]
13	Dr Shakeel Ahmad Khoja	Professor and Adjunct Researcher	Institute of Business Administration (IBA) Karachi, Pakistan and Learning Societies Lab (LSL), School of Electronics and Computer Science (ECS), University of Southampton, The U.K.	Learning Technologies, Usage of Web Technologies in to learning, Multimedia Systems, Digital Video/Image Processing and Storage, Internet programming[30]
14	Dr Mohamed Amin Embi	Professor * Recipient of the ISESCO Science Laureate 2010 & National Academic Award 2006	Technology-enhanced Learning at the Faculty of Education, National University of Malaysia	Education, Educational Technology, ELearning, Web 2.0, Instructional Design, Online Learning, Mobile Learning, Blended Learning, Web 2.0 tools, Language Learning Strategies, Personal Learning Environments, Virtual Learning, and Personal Learning Environment[31]

[28] http://scholar.google.com/citations?user=MInITAkAAAAJ&hl=en
[29] http://cvsupyanhussin.wordpress.com/
[30] http://iba.edu.pk/Faculty_CV/CV_Dr_Shakeel_030212.pdf
[31] http://ukm.academia.edu/MohamedAminEmbi

APPENDIX I

PARTICIPATING PRACTITIONERS' PROFILES

No	Practitioners' Names	Designation	Affiliation	eLearning Development and Storyboarding Experiences
1	Mdm. Tengku Puteri Norishah Tenku Shariman	Instructional Systems Designer	Faculty of Creative Multimedia, Multimedia University Malaysia	1) Worked in eLearning company prior to working in MMU2) Head of Internet-based Degree Programme3) Currently teaching ISD in Master in Multimedia (ELearning programme)
2	Mdm. Nadirah Hamdan	Head of Product Development and Research	Joota.com	Have experience in all stages of development of eLearning project. (ID, design, programming, deployment, training, LMS development). Past projects include Smart School, Petronas eLearning courseware and system, Telekom Malaysia (TM) eLearning courseware, Royal Malaysian Navy courseware, Bank Rakyat eLearning courseware, banking eLearning courseware.
3	Mdm. Norma Suriana Mamat	Instructional Designer	Multimedia Synergy Cooperation Sdn. Bhd	Content writing: -Work with Subject Matter Experts to identify what students need to learn -Develop objectives and ensure content matches those objectives -Revise and rewrite content to shape it for learning needs -Structure content and activities for student learning -Create media to support learning -Develop assessments
4	Mdm. Haslinda Rasip	Instructional Designer	PETRONAS-ICT	Has been exposed to eLearning since 2005 and has been actively developing eLearning content and storyboards since 2011.

5	Mdm. Hazna Ahmad	Instructional Designer	ACS (M) Sdn Bhd, a Xerox Company	Web-based Trainings(WBTs) and Information and Learning Technologies (ILTs)
6	Mdm. Hamimi Burkhan	Manager	An Airlines Company	10 Years of ID related experiences from designing to managing eLearning projects in various industries; education, bank, training, oil, gas and airline.
7	Mdm. Faizah Mohd Asmara	Multimedia Designer	Multimedia Production Innovation Unit, IT Services Division, Multimedia University Malaysia	Have successfully developed eLearning for MOE (Ministry of Education), several projects with TM.
8	Mdm. Farah Izza Shafik	Multimedia Designer cum Instructional Designer	Multimedia Production Innovation Unit, Information Technology Services Division, Multimedia University Malaysia	Widely experience in designed and developed the eLearning material for MMU and TM.
9	Mr. Khairul Nizat Lajis	Former Instructional Designer	Faculty of Information Science and Technology, Multimedia University Malaysia	Involved in designing and developing Learning Object for Comp App course and uploaded to MMLS system(2001-2005)
10	Mr. Yusran Zafran Mohd Lazam	Head of Multimedia Production Innovation Unit	Multimedia Production Innovation Unit, IT Services Division, Multimedia University	Previously, was an Instructional Designer for 5 years involving with multiple eLearning projects

			Malaysia	
11	Mr. Zaid Al-Sagoff	eLearning Manager	International Medical University Malaysia	Having hands-on experience with eLearning in higher education since 2001. I have done research in several key eLearning areas, including social media, web 2.0, open educational resources (OER), educational gaming, role-play simulation, virtual classrooms, learning (content) management systems, eLearning standards, instructional design and courseware development. In addition, I have two (2) years experience in courseware development (as an Instructional Designer), and an educational background in Psychology and IT management. My strengths include online facilitation, content development, instructional design, system analysis (and visualization), analytical thinking, creative thinking, writing eLearning proposals, conducting workshops, giving presentations, interpersonal communication and pro-activeness.
12	Mr. Hasnain Baloch	Senior Instructional Designer	International Medical University Malaysia	Senior Instructional designer at IMU. He has more than ten years' hands-on experience with implementing eLearning in higher education. He has done research in several key eLearning areas, including mobile collaborative learning, Story boarding, Hospital Information System, Student Information System, social media, web 2.0, educational gaming, role-play simulation, virtual classrooms, learning (content) management systems, eLearning standards, instructional design and courseware development.

13	Mdm. Zuriana Abdul Malik	Deputy General Manager	Meteor Technology and Consultancy Sdn. Bhd.	experienced instructional designer in learning material development (print and e-content) and system consultant for learning management system design, development, customization and implementation.
14	Mdm. Hassiyah Salleh	Instructional Designer	Multimedia Production Innovation Unit, IT Services Division, Multimedia University Malaysia	8 years working experience in content development; developed a number of modules for MBA, degree, and diploma eLearning programmes as well as training modules for organizations.

APPENDIX J
QUALITATIVE FEEDBACK FROM THE EXPERTS

Experts' feedback on the pre-processing phase

The Pre-processing Phase

Feedback categories	**Academicians**	**Practitioners**
Compliments	"This is a critical phase, and the strategy/technique certainly belongs to the storyboard design process. The interaction between SME and ID from the beginning is the key to success"	- Not available -
Criticisms	"The outcome of the design does not look like a standard storyboard"	- Not available -
Further improvements	"Additionally the learning outcomes will assist both the SME and ID" "Several comments to improve the design: i. The roles of ID and SME at this stage must be clarified. Which functionalities are dedicated to SME and which functionalities dedicated to ID. I would believe too the SME would like to know what ID model the ID is using (Gagne Nine events or Dick and Carey, etc) because this is going to effect the subsequent design process"	"This is ok for storyboard, but both SME & ID should at least understand and capture the big question of WHY this story is needed? I.e. what's the problem statement? The TNA? Who's the target audience? Some history background? What other intervention is available apart from the courseware i.e. face to face for certain topics? User should not be freely adding as many as lesson/SCOs as they wish, should have a limit or the content will be too long, how many learning hours is needed going through the whole course? What's the last box representing? Is that the whole course structure? Perhaps can add chat box here too to kick start this very important process?" "Should be as simple as PowerPoint or Google Docs" "Perhaps the chat function would help. Or HELP button for FAQs? Any next and back button going to be added here? For easy reference, should add name of ID and name of SME plus the version for continuity and quality assurance"

Experts' feedback on the processing phase

The Processing Phase

Feedback categories	**Academicians**	**Practitioners**
Compliments	"Yes because it allows for multimedia"	- Not available -
Criticisms	"Will the community be able to also get images that are self created?" "The strategy/techniques used are appropriate. But again the role of ID and SME in this design is not clear. The SME input the contents whereas the ID ensure that the instructional event take place in sequence. The system has 'object in sequence', 'upload multimedia object', 'multimedia branching', 'narration', 'upload audio', 'sort', 'and remove'. These are basically content mapping strategy/techniques and collaborative strategy/techniques. Which strategy/techniques that allow the ID to move the content & activities that conform to the sequence of instructional event?" "Can users set the time? Is there a time allocation? Is it controlled by the program?"	"It is quite restrictive; only suitable for linear content subjects" "Strategy/techniques 1, 2, 3 explanation sound like its one strategy/technique but in 2 different modes. The viewer mode and editing mode. For example User-generated storyboard strategy/technique view and edit storyboard design contents which previously generated by the Shared Board strategy/technique but Shared Board strategy/technique is explain as "The design in this electronic virtual canvas can be saved, generated and shared with other users for viewing or editing.". Breaking this into separate function trigger may confused the users" "It provides ease for ID because the authoring strategy/techniques are useful however there's quite a lot of information to be digested in one go. Hence, it might take some time to get used to this strategy/technique"
Further improvements	"It is, perhaps elements on the interface have to be reduced so it will not clutter the interface "If feedback through annotations at specific points of user interface (UI) would be useful"	"One important function is missing, the SEARCH function. How does the user-generated storyboard strategy/technique appear? Is this window intelligent enough to display items related to HCI? The SCOs can be as small as a text in a circle, how is the meta-data being utilized here?" "WYSIWYG (What-You-See-Is-What-You-Get) environment with less clicks" "Add status field on the screen. This will helps users in understand the status of the design process" "My concern in regards to this strategy/technique is whether user has to seek permission from the original 'content provider' when altering or editing the content and design" "Can on a certain extent, add in the chat and search function plus next and back button"

Experts' feedback on the post-processing phase

The Post Processing Phase

Feedback categories	**Academicians**	**Practitioners**
Compliments	- Not available -	"Definitely! Getting agreed storyboard (between SME and ID) has always been the biggest challenge due to the lead time in communication. This feature will indeed speed-up the entire development process"
Criticisms	-Not available -	-Not available -
Further improvements	"Though the intention is to get deep cognitive feedback, for formats and such, maybe the standard operating procedures can apply so that focus can be on more important issues" "The strategy/technique is appropriate. However, it is just a collaborative strategy/technique between the SME and ID. Is there a strategy/technique which allow the ID to design the instruction i.e. arranging the content and activities that prescribed to the designated ID principle such as learning/performance objectives, recall of prior knowledge, formative assessment, etc" "I felt the model should be simplified - take one step on each storyboard"	-Not available -

Experts' feedback on the re-design phase

The Re-design Phase

Feedback categories	Academicians	Practitioners
Compliments	-Not available -	-Not available -
Criticisms	"The divided of roles between SME and ID is not clear. How ID undertake his/her task must be clearly shown. Which part that shows the ID would be able to put the content (provided by SME) into activation (prior knowledge), demonstration or delivery of content, application, assessment, etc? Is the system integrating the role of language editor as well? If not why? Otherwise the finished product is not 'finished' and need to send for editing" "One thing is not clear whether there is opportunity for SME and ID to view the SCOs in context of the course. Visualizing individual SCOs and editing/revising them is fine, but that would not give full impression unless they are visualized in the context of other SCOs as they would appear in the course itself" "Why the strategy/technique is not required? But it allows modification?"	-Not available -
Further improvements	-Not available -	"This phase should be embedded and don't need to have another process which is called redesign. Just straight away put in the SIGN OFF Certificate and submit button to complete"

Experts' feedback on the collaborative mapping technique

Collaborative mapping technique

Feedback categories	**Academicians**	**Practitioners**
Compliments	-Not available -	"Helps in providing a clear picture of the content architecture"
Criticisms	"The story board was too complicated"	"As much as I love the idea of online communication ability, I am also an advocate of one-to-one, face-to-face communication. The real human experience. Hence it's just a personal preference that contribute to the "Appropriate" rating" "I have to re-read it a few times to get the whole picture of who's able to alter what"
Further improvements	"I believe there are other pedagogical elements which may be required, suggest getting feedback from any Education SME as well…"	"Add in the background information of this courseware" "Story boarding should empower doodling and visualization using tablets" "Write simpler, shorter sentences to make the instruction clearer" "Comment or chat button can begin here too" "It will be more effective if the mapping can be represented in visual manner which can give everyone the overall structure of the course"

Experts' feedback on the shared board strategy

Shared Board strategy

Feedback categories	**Academicians**	**Practitioners**
Compliments	-Not available -	-Not available -
Criticisms	"I would prefer to experiencing using this strategy/technique rather than looking at the slides. I would prefer the researcher to demo it first" "Probably could be clearer if there is a face-to-face meeting and explanation"	"Too restrictive" "Will the graphic designers be invited to the discussion too? Or ID will be the liaison?" "Some redundant features as per comment in previous segment" "Understand, but I need to see the system itself"
Further improvements	-Not available -	"Learn from GoAnimate and PowToon" "The search button for meta-data should be added"

Experts' feedback on the shared user-generated storyboard strategy

Shared user-generated storyboard strategy

Feedback categories	**Academicians**	**Practitioners**
Compliments	-Not available -	-Not available -
Criticisms	"From my standpoint yes, conceptually feasible. However, probably can test drive get the users to evaluate effectiveness completing an actual task, …" "The role of SME and ID are not so clear in the system. Look like no division of roles" "I can see the sequence in which the SCOs will appear, but the relationship among them is not clear"	"How does this thing work actually? There will be thousands of SCO uploaded worldwide..."
Further improvements	-Not available -	"It should be as simple as PowerPoint. If not, might as well use PowerPoint"

Experts' feedback on the shared storyboard artefact viewer strategy

Shared Storyboard Artefact Viewer strategy

Feedback categories	**Academicians**	**Practitioners**
Compliments	-Not available -	-Not available -
Criticisms	"The roles of SME and ID in using the functionalities are not clear"	"Ok for a start, can animation files be uploaded? Any issues on copyrighted materials?"
Further improvements	"I am not sure about the viewing of multiple storyboards in pop-up window. Use of pop-up windows is for temporary view, while a more permanent viewing of whole context would be more effective"	"Should have a publish button so that users can see the output right away"

Experts' feedback on the shared narrative abstraction strategy

Shared Narrative Abstraction strategy

Feedback categories	**Academicians**	**Practitioners**
Compliments	-Not available -	-Not available -
Criticisms	"Not so clear who are using the strategy/techniques. SME or ID or both?"	-Not available -
Further improvements	-Not available -	-Not available -

Experts' feedback on the collaborative discussion technique

Collaborative discussion technique

Feedback categories	**Academicians**	**Practitioners**
Compliments	-Not available -	"Shared Discussion provides live feedback on content and design" "I like the live feedback feature" "Most innovative feature in a storyboarding design strategy/technique"
Criticisms	"Unthreaded discussions are fine for simple communication, but they do not work well when people would talk about multiple topics, as would be the case here" "Not so clear in terms of the role"	-Not available -
Further improvements	"Discussion strategy/technique should be more prominent"	"Great! date of thread must be captured and documented"

Experts' feedback on the collaborative annotation technique

Collaborative Annotation technique

Feedback categories	**Academicians**	**Practitioners**
Compliments	"This is important as feedback is crucial in any collaboration" "It is clear and every effort must be made to ensure this phase gives maximum good feedback"	"Necessary function to improve communication"
Criticisms	-Not available -	"Define user, Are programmers included?” "If there are many annotated comments, would the space on the board suffice? Would it make the board too crowded and cause discomfort to users especially the ID who has to view the storyboard for an extensive period of time?"
Further improvements	"Inclusion of shared discussion is highly necessary, but perhaps would better be translated into "participatory design", where you know the detail age/gender/background/expertise of the discussants" "Can the different comments be ordered into classified "resolved" "commented/replied". It also allow feedback in terms of priority of the changes to be made"	"Suggestion: (1) Linking the annotated commentary to share discussion. Reason: This is provide a central commentary reference point and also provide and comprehensive discussion documentation. (2) Add new comment indicator so that user knows. For example, https://dl.dropboxusercontent.com/u/12394144/eSCOUT/commentary.png" "This is great idea. Do add in the dates of the thread to mark the sign off. Perhaps to add that as automated since this phase usually drags and can go on and on. Should have 3 review phases only" "Objects, Roles, LO are missing rest its good strategy/technique for resolving the conflicts among the team members using discussion strategy/techniques" "Can add in a software to record narration automatically"

Experts' feedback on the advantages of the eSCOUT

Advantages of the eSCOUT

Academicians	Practitioners
"Perfect"	"Easier for users who have no ID background"
"It allows for collaboration which could improve the efficiency of the design process"	"1) Enable effective ID and SME collaboration in producing storyboard. 2) Reduce misunderstanding with the usage of visual, 3) Centralize repository of all assets and designs"
"If all goes as planned it will be a great support strategy/technique for content development with right instructional elements sourced from expert IDs and SME"	"It is good for story boarding that contains 2 way communication within ID and SME"
"The collaboration is the key advantage. The sharing is embedded within the whole system. Very good!"	"A comprehensive strategy/technique for storyboarding. Just make sure that all the needed storyboard designs/templates are incorporated into the strategy/technique and interchangeable, should there's a change of mind where the design in concerned"
"Certainly. It would provide a very effective process"	"Yes. Good strategy/technique to collaborate when the SME and ID are at two different locations"
"Sufficient detail that allows user to select necessary activities given the specific situation"	"Simple and easy to understand the process"
"It will be able to guide the users/people to generate a system for creating storyboard"	"Simplified the ID task to develop the storyboard and save much more time"
"Guided and clear interesting work. The component in eSCOUT seems covers the whole process. All strategy/techniques seems useful"	"Yes, saving time in designing the storyboard"
"A nice framework to organize content"	"Communication could be a lot easier between SME and ID as both need time to find and have a discussion"
	"Nice diagram and ideas"
	"Good collaborative working environment"
	"The system will enable new ID/non ID person to create content using guided id framework and principle. it also allows all team members to actively participate and collaborate in the development of the content by referring to a standard template"
	"The Shared Community Strategy/technique, Collaborative Annotation Strategy/technique and other strategy/techniques integrated within one environment would definitely smooth out /quicken the entire process"

Experts' feedback on the disadvantages of the eSCOUT

Disadvantages of the eSCOUT

Academicians	Practitioners
"Not to an expert, but may be to a novice" "Not all SME may use eSCOUT" "Thus far no until I try it out" "Given the scope of activities a user might be intimidated before even starting" "It is too complicated in the representation - perhaps it needs clear explanation/presentation" "May stifle flexibility"	"Restrictive, suitable for certain subjects that are linear based" "Should have limitation in reviewing and do amendment base on the comment" "Slow and installation of required software" "Not yet, need to see the full program running" "Have to get involved in using the strategy/techniques, then can find out disadvantages. So far the idea is very good" "Too technical. Some SME may be high tech. Work could also be more tedious as they need to be done in an application, plus everything need to be type down" "Too many clicks and boxes for real application. Today people want the storyboard or collaborative storyboard to be touch-based and more visualized" "Steps and work flow is not clear. It would be nice if we could get the actually system or prototype access and explore more" "If the system could fully support its intended function and use, then there should be no disadvantage"

Experts' feedback for the eSCOUT improvements

Areas to be improved

Academicians	Practitioners
"Further detail explanation to new designers"	"More options of templates"
"Will need to use the run-time system to provide feedback"	"1) Adding the LO might help to ensure the effort is based on the correct objective, 2) A process to close and ends the storyboard design process. This may be the formal sign off or informal 3) Version control management for easy traceability."
"The framework shown in the system framework. But readers need to understand from which ID principle is being used in formulating this frame work. Otherwise, the system framework looks like a sharable workspace with content mapping and collaborative strategy/techniques only and devoid of crucial ID strategy/techniques"	"Review session must have to do by three times only and the amendment will do according to the comment in review session. It can cut off the time duration on development"
"Copyright issue in sharing"	"1) Permission to alter design or content.2) Annotated comments might be filling the board space."
"I have provided various suggestions in earlier parts of the survey"	"It looks pretty comprehensive"
"Perhaps a range of examples based on time and funding"	"Need to get some 'WOW' design, hopefully have to design the interface more interface to attract the user"
"Overall presentation of the framework and how it links to the systems/applications"	"Should use an icons to represent the strategy/techniques for the Shared Easy Board Strategy/technique. Example, hands free drawing can use pencil icon"
"Some interaction design needs to be improve"	"Instructional design & pedagogy"
"Re-design component should be properly investigated. I am not clear how re-design will work"	"In terms of the theory, everything seems to be quite in order"
	"The eSCOUT model is good, but the visualization of technology behind it seems 10 years old. If you are not required to program, then use your imagination to build some prototype that is click and box free"
	"Define LO, Objects and Role"
	"Asset management, user management - need to be defined and set-up properly so that the whole content development team can seamlessly work together using the strategy/technique"
	"1.System must be able to support the features.2.More graphics/file formats allowed"

Experts' feedback in removing certain areas in the eSCOUT

Areas to be removed

Academicians	Practitioners
"Will need to use the run-time system to provide feedback" "Less emphasis on collaboration but more on how the ID principle are being integrated into the system" "I would not remove any activities" "Perhaps try link the loose end - I think generally is acceptable however, from this survey the purpose and explanation is not clear"	"All areas should be there" "Nothing. All covered areas are essentially important in storyboarding" "Not yet, need to see the full program running" "A-Z in terms of system design. The collaborative learning space should empower communication through existing strategy/techniques such as Skype or WizIQ" "So far all features seems very applicable, usable and important in the design process, so nothing to remove"

Experts' feedback on specific addressed problems

Other specific problems to be solved

Academicians	Practitioners
"Perfect" "Will need to use the run-time system to provide feedback" "The story board can be made into sections where each section represents the instructional events. So the SME can just put in the subject content into the sections and the ID ensure the contents being put in are appropriate to the instructional events" "An appendix with a variety of examples" "Need to think of a way to flow the whole presentation of this survey - the explanation is too lengthy" "Is Copyright issue addressed in the sharing process among the 3 groups?"	"Test with instructional designers who are practitioners in the field" "ID and SME need to collaborate, discuss, and communicate each other to solve the problem. Have to limit the 'self-needs', focus on the main objective of SB development" "Limit authority or prompt to seek permission for big alteration" "Make it simple and easy add more colors and pictures as guide" "Need to see this application running and after that we can notice the problem" "Focus on the framework and let your imagination go wild. The moment you think programming, everything falls apart, unless you are an exceptional programmer with vision" "Just need to have more detailed features and functionality of eSCOUT" "Add user management and asset management module" "The platform (system) must be able to support this to make it fully operable"

Experts' feedback for other kinds of suggestions, opinions and recommendation for the eSCOUT

Other suggestions/opinions/recommendations

Academicians	Practitioners
"The run-time system should be evaluated by experts" "Maybe to get maximum benefit of feedback, you can have a round of focus group interaction" "As it is, the system is good but need to clearly define which strategy/techniques belong to SME (content input) and which strategy/techniques belong ID (structural input of the content conform to designated ID principle) and which strategy/techniques are sharable (collaborative strategy/techniques)" "The interface design and background can still be improved so the end product will look more concrete" "Good work!" "Budget is a major factor in decision making. Examples might help illustrate the concept" "I am wondering if evaluation could be done on the generated storyboard." "Seems workable; suggest you use face to face validation with the experts to get their feedback" "Online evaluation a bit difficult, especially there may be items that needs clarifications..." "I would prefer to have use this strategy/techniques and will experiencing it more easily to provide feedback. Some of the interface quite confusing in design and it influence me ... to understand the process flow better. If the researcher could visit the expert and explain the overall work with why the work is carried out then it would be much better to have overall feedback. Good luck" "I could have been more easy to understand if a scenario was provided"	"Good job" "Overall, I think this a good strategy/technique for storyboarding" "Improve the user interface" "Improve the explanation part" "Great stuff. Make it as basic and simple possible. Can't wait for the output" "Need to get some 'WOW' design, hopefully have to design the interface more interface to attract the user" "I would like to give a suggestion which is to improve the interface of eSCOUT layout to be more attractive to the user. Put more icons and interesting choices of color" "I think it is a good application overall. It would be most beneficial to IDs for recording purposes and manual recording could be quite a hassle" "All the best! Anything is possible, Insya-Allah!" "Work flow and steps of story boarding need to improve" "Develop a working prototype and test it with added features/modules suggested" "No. Seems like it is a good framework with several innovative strategy/techniques which can eliminate some of the hassles in storyboard design process. Look forward to test it in the real platform!"

APPENDIX K

FULL VERSION OF SYSTEM PROTOTYPE EVALUATION SCRIPTS

Welcome to the Evaluation Study for the eSCOUT System!

We are conducting this study under the grant of the Ministry of Higher Education, collaboration between the University Malaya and Multimedia University.

The eSCOUT system is developed with the aim to support Instructional Designers (ID) and Subject-Matter Experts (SME) in developing eLearning course effective and efficiently. The main purpose is to help ID and SME in designing, communicating and sharing knowledge of the storyboarding task.

While the technique of storyboarding has been widely used by the ID and SME for design communication, yet they are facing difficulties to communicate and share certain types of knowledge contents such as storyboard design, design artifacts as well retrieving comments, input and suggestions from each other. These problems are impeding ID and SME to reach consensus in making design decision. As a result, the actual time plan for the storyboarding design and development process need to be expanded, often leading to frustration.

The eSCOUT system is based on the eSCOUT framework which stands for "An Agile Storyboard for Shared Cognitive User Task". The framework which can be viewed in the accompanying slide has been transformed into a logical view in a form of prototyping system. Please bear in mind that due to the characteristics of the eSCOUT system which is a merely a prototyping at this stage, the system is only partially working. In other words, eSCOUT prototype is not yet a real system as it will be one day, if all goes well hopefully, Insha'Allah.

The eSCOUT is a mash-up web-based system where its part is embedded with Coggle and Google Drive that allows designers to manage, store, and share storyboarding structure and design contents. With these applications, designers are able to create, edit, allocate and share storyboard structure and design. Moreover, the Coggle's and Google's clouds which provides high reliability and high capacity in storage capacity supports faster way for ID and SME to communicate the design knowledge, speeding up the convergence to achieve consensus.

Now, let me introduce to you the facilities which are provided by the eSCOUT. The eSCOUT tools are divided into two types; the general tools and specific tools as shown in the slide. You will be exposed to the concept and functionalities of the eSCOUT tools throughout the evaluation session.

We have chosen you specifically and specially to participate in the study because we believe you represent one of the most important types of potential users of eSCOUT system. Therefore, we appreciate a form of your constructive input and feedback during this evaluation study.

Your participation will be very much useful to us in improving the services to best meet your needs as a potential user. For the sake of privacy, your identity will be treated as anonymous.

Please be informed that we humbly seek your cooperation to remain with us until the end of this evaluation. Should you have any queries, kindly send us your questions before we commence the evaluation session. Thank you.

Evaluation Session

A. The beginning of the session

There are three sessions of evaluation:
Session 1 refers to the type of evaluation study called Cognitive Walkthrough.
This session is aimed to evaluate the effectiveness and efficiency of agile storyboarding process model as a part of the eSCOUT.
Session 2 refers to the type of evaluation study called Usability Evaluation.
This session is aimed to evaluate the Compatibility, Consistent, Flexibility, Learnability, Minimal action, Minimal memory load, Perceptual limitation and User guidance of the tools in the eSCOUT
Session 3 refers to the type of evaluation study called SMM Experimental Study
This session is aimed to measure the TMM as well as similarity and accuracy in terms of specific task content which is produced by pairing ID and SME.

Now let us begin the first phase of evaluation: (the researcher will show step by step the working flow of the eSCOUT)

B. Session 1 - Cognitive Walkthrough

The purpose of the evaluation is to seek for your feedback whether the agile storyboarding process in the eSCOUT system is effective and efficient compare to a typical linear way/process in designing storyboard. An agile storyboarding process in this eSCOUT is treated as a quick and well-coordinated in movement of instructional design process. It means the agile storyboarding process in the eSCOUT would be able to reduce overheads in the storyboarding process (e.g. by limiting documentation) and to be able to respond quickly to the changing requirements without excessive rework.

Please provide your sincere opinion by thinking aloud your feedback in verbally during the question session.

We will give a specific and realistic task and ask you to carry it out using the eSCOUT system. If you have any problem in performing the task, the research assistant is around to help you with the system.

The scenario is as follows:
An eLearning project is initiated to develop several course subjects into eLearning courseware. The project consists of a design team who work for eLearning course development. To begin the project, two key persons have to communicate and collaborate about the requirement that is / are needed in the eLearning storyboard. The first person is the personnel from an eLearning unit who is called instructional designer. The other person is a subject matter expert in a course who is an academic faculty member.

Assume that you are the instructional designer / the subject matter expert. Both of you are distance apart, but need to work together to produce a design of an eLearning storyboard. However, both of you are not familiar with each other discipline and maybe you only have a little knowledge about his / her discipline.

Pre-processing Phase

Task description:

Assume that you need to communicate and collaborate your knowledge about the requirements for content and structural design of the storyboard. The tasks that you need to do are as follows:

Task 1.1: Begin storyboarding task
Action sequence:

Step 1.	Create new storyboard, give name and describe briefly about the storyboard and click submit.
Step 2.	Select the current date and the name of reviewer. Key in course title/ number, module title/number and lesson title/number and click save.
Step 3.	View the storyboard template. You should see the information that you have key in.

Please answer the following questions:

1. What effect was the user trying to achieve by selecting this action?

2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

Task 1.2: Create mapping of contents and structure
Action sequence:

Step 1.	Tick from the list of components that you require for the storyboard design.
Step 2.	Create a new mapping for each of the components that you have ticked.
Step 3.	In the mapping, add the content and organize the structure that you want for a storyboard design. Save the mapping structure.
Step 4.	View the mapping you have created.

Please answer the following questions:

1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

*Task 1.3:*Communicate and collaborate the mappings of the components
Action sequence:

Step 1.	Open the a map you have created, and click the collaboration session at the top of the page
Step 2.	Select the available names and invite your working partner to collaborate
Step 3.	You can initiate discussion with your working partner
Step 4.	You may also join or leave the collaboration session
Step 5.	You can save the collaborative maps that both of you have updated.
Step 6.	You can view the history of collaborative maps that you have worked with your partner

Please answer the following questions:

1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

Processing Phase

Task description:

Assume that you need to communicate and collaborate a storyboard design based on the mappings. The tasks that you need to do are as follows:

Task 2.1: Begin to design in a storyboarding
Action sequence:

Step 1.	Select the storyboard name, modules and/or lessons
Step 2.	Add any images or start to sketch
Step 3.	Key in script notes
Step 4.	You can choose and view the maps to guide on your design.
Step 5.	Save the storyboard design
Step 6.	View the storyboard design

Please answer the following questions:

1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

*Task 2.2:*Communicate and collaborate the design of storyboard
Action sequence:

Step 1.	Open the storyboard design that you have created, and click the collaboration session at the top of the page
Step 2.	Select the available names and invite your working partner to collaborate
Step 3.	You can initiate discussion with your working partner
Step 4.	You may also join or leave the collaboration session
Step 5.	You can save the collaborative storyboard design that both of you have updated.
Step 6.	You can view the history version of collaborative storyboard design that you have worked with your partner

Please answer the following questions:

1. What effect was the user trying to achieve by selecting this action?

2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.
1. Do you find the process is effective?
2. Do you find the process is efficient?

Task 2.3: Change the content and structural design requirements of the storyboard
Action sequence:

Step 1.	Select the storyboard name, modules and/or lessons
Step 2.	Choose from the list of components
Step 3.	Click on the maps
Step 4.	Change the contents or structure of the maps
Step 5.	Save the map
Step 6.	View the map

Please answer the following questions:
1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.
1. Do you find the process is effective?
2. Do you find the process is efficient?

Post Processing Phase

Task description:

Assume that you need to communicate and collaborate a storyboard design production. You need to arrive at the common storyboard design with your partner. The tasks that you need to do are as follows:

Task 3.1: Open a storyboard design production
Action sequence:

Step 1.	Open a storyboard design production by its name, modules and/or lessons
Step 2.	View the storyboard
Step 3.	Play the storyboard

Please answer the following questions:
1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things

were going?

Now, please tell us what you think about this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

*Task 3.2:*Perform discussion the storyboard design production
Action sequence:

Step 1.	Open the storyboard design production which have been shared with you and click the discussion session at the top of the page
Step 2.	Select the available names and invite your working partner to start the discussion
Step 3.	You may also join or leave the discussion session
Step 4.	You can save the discussion of the storyboard design production that both of you have updated.
Step 5.	You can view the history of discussion of the storyboard design production that you have worked with your partner

Please answer the following questions:

1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

Task 3.3: Perform annotation the storyboard design production
Action sequence:

Step 1.	Open the storyboard design production which have been shared with you and click the annotation session at the top of the page
Step 2.	Select the area or images to start the annotation
Step 3.	You can share the annotation with your partner
Step 4.	You can save the annotation of the storyboard design production that you have updated.
Step 5.	You can view the history of annotation of the storyboard design production that you have worked with your partner

Please answer the following questions:

1. What effect was the user trying to achieve by selecting this action?
2. Did the selected action achieve the desired effect?
3. When the action was selected, could the user determine how things were going?

Now, please tell us what you think about this process.

1. Do you find the process is effective?
2. Do you find the process is efficient?

We have finished the first phase of evaluation.

Now we will proceed to the second phase of evaluation: (the researcher will show step by step the working flow of the eSCOUT)

B. Session 2– Usability Evaluation

This evaluation needs no scenario to be presented.

The purpose of the evaluation is to seek for your feedback about the tools and functionalities in the eSCOUT system in terms of compatibility, consistency, flexibility, learnability, minimal action, minimal memory load, perceptual limitation and user guidance.

Please provide your sincere opinion by giving your feedback in the online questionnaires
We have finished the second phase of evaluation.

Now we will proceed to the third and final phase of evaluation: (the researcher will show step by step the working flow of the eSCOUT)

C. Session 3 –Shared Mental Model Experimental Study

The purpose of the evaluation is to seek for your feedback whether the process, facility and functionalities of the eSCOUT system can facilitate shared cognitive activities between ID and SME. Shared cognitive activities in this eSCOUT is treated as any form of knowledge which is perform during the storyboarding activities that is able to be shared, thus will lead to shared understanding and reach consensus in design decision. Examples are the ability to share, understand, and agree (reaching consensus) to the content of the storyboarding design, storyboarding task, design comments, storyboarding structure, by making use of the facilities offered by the eSCOUT.

We will give a specific task and ask you to demonstrate using the eSCOUT system. If you have any problem in performing the task, the research assistant is around to help you with the system.

After performing the tasks, we need to you judge the relatedness of pairs of statements. Specifically, you are asked to rate how related are these statements to the similarity and accuracy which may be produced from the shared understanding of the contents. Please find the list of items to assess the task work of your design team partner.

Task work Mental Model Survey Items

Survey Items for Session 1

Code	Description
SMM-01	The SME/ID understands the actual requirements of the storyboard contents and how the designs of the storyboard are structured.
SMM-02	The understanding of the content can be reached effectively
SMM-03	The understanding of the structural design of storyboard can be reached efficiently
SMM-04	The overall understanding received from the SME/ID is satisfied

Survey Items for Session 2

Code	Description
SMM-05	The SME/ID understands the specifications needed for storyboard multimedia design.
SMM-06	The understanding of the storyboard multimedia design specification can be reached effectively
SMM-07	The understanding of the storyboard multimedia design specification can be reached efficiently
SMM-08	The overall understanding received from the SME/ID is satisfied

Survey Items for Session 3

Code	Description
SMM-09	The SME/ID understands the comments specifications for the storyboard design production
SMM-10	The understanding of the comments specifications for the storyboard design production can be reached effectively
SMM-11	The understanding of the comments specifications for the storyboard design production can be reached efficiently
SMM-12	The overall understanding received from the SME/ID is satisfied

Survey Items for Session 4

Code	Description
SMM-13	The SME/ID understands the commentaries or reviews of the specific elements in the storyboard design production
SMM-14	The understanding of the commentaries or reviews of the specific elements in the storyboard design production can be reached effectively
SMM-15	The understanding of the commentaries or reviews of the specific elements in the storyboard design production can be reached efficiently
SMM-16	The overall understanding received from the SME/ID is satisfied

Next you will also need to judge the relatedness of shared data visualization as follows:

Accuracy and Similarity Survey Items

Code	Description
Accur-01	The understanding of the actual requirements of the storyboard contents and how the designs of the storyboard are structured is accurate
Accur-02	The understanding of the specifications needed for storyboard multimedia design is accurate
Accur-03	The understanding of the comments specifications for the storyboard design production is accurate
Accur-04	The understanding of the commentaries or reviews of the specific elements in the storyboard design production is accurate

Code	Description
Simil-01	The understanding of the actual requirements of the storyboard contents and how the designs of the storyboard are structured is similar
Simil-02	The understanding of the specifications needed for storyboard multimedia design is similar
Simil-03	The understanding of the comments specifications for the storyboard design production is similar
Simil-04	The understanding of the commentaries or reviews of the specific elements in the storyboard design production is similar

D. Session 4: General Comments – Open Discussion

We have arrived to the final session.

Now discussion and comments are opened to the participants.

Please be informed that every conversation will be video-taped and recorded.

This conversation will not be treated to assess your job performance or job qualifications as the position as you hold; rather it will be used to support the enhancement and improvement for the eSCOUT development.

That's for now. We appreciate your time taken and participation in this evaluation study. Please accept out humble token of appreciation which is given in a form of cash to every participant.

Thank you very much.