DESIGNING A SCAFFOLDING PEER LEARNING TOOL FOR THE ONLINE COMPONENT OF BLENDED LEARNING

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ABSTRACT

Blended learning involves the combination of face-to-face with online component instructions and is considered the most effective and most popular mode of instruction adopted by today's educational institutions due to its perceived effectiveness in providing flexible, timely and continuous learning. However, the inclusion of technology into instruction thereby creating the online component has brought some level of unease to students, teachers and educational institutions. Several studies have reported the various problems that students, teachers and educational institutions face with the online component of blended learning. The leading challenge associated with the online component of blended learning is students' inability to proper self-regulate their learning activities due to the numerous types of challenges associated with online studying. Research on scaffolding students' self-regulation in the online component of blended learning has not proposed a unified scaffolding solution to enable students to overcome these various challenges as well as engaging them in proper self-regulation in their online components. Several studies have proclaimed peer learning as a learning strategy that is capable of alleviating online component challenges thereby enabling students to fully realize the benefits of blended learning instruction. As such, a deductive methodological approach was adopted which involves investigating and carefully understanding the practices and key elements of peer learning from various research domains in order to understand how to engage students to a peer-learning self-regulation strategy for scaffolding their online component of blended learning. The first stage involves designing online peer learning groups based on learning potential and affinity models, leveraging the design of learning system features to instigate group dynamic elements for facilitating and motivating small group peer learning, and fostering pro-social behaviors by offering indirect

incentives for combating the inherent problems of reluctance to students' peer-learning participation. Then, a learning system prototype is implemented to ascertain the identified peer learning key features and elements to enable the applicability of the peer learning scaffolding approach in real-life scenarios. An experiment involving 120 undergraduate university students using the widely adopted experimental and control group evaluation method shows significant improvement in students' learning achievements by using the proposed peer learning scaffolding approach. The main contribution of this research is a peer learning framework for educational institutions to adopt as a tool in order to revise their blended learning instruction for scaffolding their student's online component studying.

Key words: Blended learning, flipped classrooms, online learning, self-regulated learning, peer learning

MEREKA BENTUK ALAT PEMBELAJARAN RAKAN SEBAYA SCAFFOLDING UNTUK KOMPONEN DALAM TALIAN PEMBELAJARAN TERADUN

ABSTRAK

Pembelajaran teradun melibatkan gabungan arahan bersemuka dengan komponen dalam talian, dan dianggap sebagai mod pengajaran paling berkesan dan paling popular yang diguna pakai oleh institusi pendidikan hari ini kerana keberkesanannya yang dirasakan dalam menyediakan pembelajaran yang fleksibel, tepat pada masanya dan berterusan. Walau bagaimanapun, kemasukan teknologi ke dalam pengajaran seterusnya mewujudkan komponen dalam talian telah membawa sedikit keresahan kepada pelajar, guru dan institusi pendidikan. Beberapa kajian telah melaporkan pelbagai masalah yang dihadapi oleh pelajar, guru dan institusi pendidikan dengan komponen pembelajaran teradun dalam talian. Walau bagaimanapun, cabaran utama yang dikaitkan dengan komponen pembelajaran teradun dalam talian ialah ketidakupayaan pelajar untuk mengawal selia kendiri aktiviti pembelajaran mereka dengan betul disebabkan oleh pelbagai jenis cabaran yang berkaitan dengan pembelajaran dalam talian. Penyelidikan tentang pengawalan kendiri pelajar dalam komponen pembelajaran teradun dalam talian belum mencadangkan penyelesaian perancah bersatu untuk membolehkan pelajar mengatasi pelbagai cabaran ini yang menghalang mereka daripada mengawal selia kendiri dengan betul dalam komponen dalam talian mereka. Beberapa kajian telah mengisytiharkan pembelajaran rakan sebaya sebagai strategi pembelajaran yang mampu mengurangkan cabaran komponen dalam talian dan banyak lagi. Oleh yang demikian, pendekatan metodologi deduktif telah diguna pakai yang melibatkan penyiasatan dan pemahaman yang teliti tentang amalan pembelajaran rakan sebaya dan elemen utama daripada pelbagai domain penyelidikan untuk memahami cara menarik minat pelajar kepada strategi kawal selia kendiri pembelajaran rakan sebaya untuk memperancah komponen pembelajaran gabungan dalam talian mereka. Peringkat pertama melibatkan mereka bentuk kumpulan

pembelajaran rakan sebaya dalam talian berdasarkan model potensi pembelajaran dan pertalian, memanfaatkan reka bentuk ciri sistem pembelajaran untuk mencetus elemen dinamik kumpulan untuk memudahkan dan memotivasikan pembelajaran rakan sebaya kumpulan kecil, dan memupuk tingkah laku pro-sosial dengan menawarkan insentif tidak langsung untuk memerangi masalah yang wujud iaitu keengganan terhadap penyertaan rakan-pembelajaran pelajar. Kedua, prototaip sistem pembelajaran dilaksanakan untuk memastikan ciri dan elemen utama pembelajaran rakan sebaya yang dikenal pasti bagi membolehkan kebolehgunaan pendekatan perancah pembelajaran rakan sebaya dalam senario kehidupan sebenar. Eksperimen yang melibatkan 120 pelajar universiti ijazah pertama menggunakan kaedah penilaian eksperimen dan kumpulan kawalan yang diterima pakai secara meluas menunjukkan peningkatan ketara pencapaian pembelajaran pelajar dengan menggunakan pendekatan perancah pembelajaran rakan sebaya yang dicadangkan. Sumbangan utama penyelidikan ini adalah rangka kerja pembelajaran rakan sebaya untuk diterima pakai oleh institusi pendidikan untuk menyemak semula arahan pembelajaran teradun mereka untuk memperancah komponen pembelajaran dalam talian pelajar mereka.

Kata kunci: Pembelajaran teradun, bilik darjah terbalik, pembelajaran dalam talian, pembelajaran kendiri, pembelajaran rakan sebaya

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CHAPTER 1: INTRODUCTION

In this introduction chapter, the concept, background, structure and other associated introduction sections of this thesis are presented in a detailed manner. First, the advent and emergence of blended learning instruction, the types and variants of blended learning, definitions of terms, general research progress and research productivity are discussed. This becomes necessary in order to understand the various types, research elements and aspects that have been investigated in the blended learning domain by students, teachers, educational institutions and other stakeholders that play key roles in blended learning instruction over the years. The chapter continues by discussing self-regulation in blended learning which has been the most evident challenge that students face in today's blended learning institutions. The chapter further discussed this thesis's research motivation, the problem statement, the research hypothesis, the research aim, objectives and research questions, enumeration and outlines of the research methodology, thesis roadmap, thesis scope and outline of the thesis chapters.

1.1 Background

Over the last two decades, educational institutions have progressively introduced and used technological devices for instruction. This has come as a result of the widespread, popularity and affordances of technologies which made it possible for educational institutions to adopt and effectively use them for teaching and learning purposes. With the help of such technologies and the power and accessibility of the internet, instructions could be tailored in both face-to-face physical classrooms and also take place out of the physical classrooms (online). Blended learning instruction is the combination of these two instructional components - face-to-face and technology-mediated instruction (Wendy et al., 2014). Much research on blended learning was done using different terminologies

such as “mixed mode”, “hybrid learning” “flipped classrooms or inverted classrooms” etc., referring to blended learning. However, the commonly and well-established terms that consistently remain in use in blended learning literature are blended learning and flipped classrooms.

1.1.1 Definition of Blended learning

Blended learning has several definitions such as “combining online and face-to-face instruction”, and “combining instructional methods” (Graham, 2006; Osguthorpe & Graham, 2003). However, one of the most prominent definitions given to blended learning is by Garrison and Kanuka (2004) that say “ *blended learning is a thoughtful integration of classroom face-to-face learning experiences with online experiences*”.

1.1.2 Definition of Flipped classrooms

The flipped classroom or sometimes called inverted classroom is a new and popular innovative pedagogical approach that focuses on learner-cantered instruction. The flipped classroom is a blended learning type or variant in which activities traditionally conducted in the classroom (e.g., content presentation) become home activities, and activities normally constituting homework become classroom activities (Bergmann & Sams, 2012; Sohrabi & Iraj, 2016). In the flipped classroom, the teacher helps the students instead of merely delivering information, while the students become responsible for their own learning process and must govern their own learning pace (Lai & Hwang, 2016). Since classroom time is not used to transmit knowledge to students from their teachers, teachers are able to engage with students by means of other learning activities such as discussions, solving problems proposed by the students, hands-on activities, and general guidance on a subject. Today, the concept of the flipped classroom has been implemented in various

disciplines (math, social sciences, humanities, etc.) and universities around the world (Hao, 2016).

Blended learning has been the most successful instructional model in today's educational institutions (Universities and higher educational institutions), and has received hefty praise and even termed as the 'new normal' (Charles et al., 2018) in today's education. Some of the key advantages of blended learning instruction include reducing online transactional distance and increasing the interaction between teachers and their students (Jusoff & Khodabandelou, 2009); offering flexibility, pedagogical richness and increase in cost effectiveness (Graham, 2006); ensuring value interaction and learning engagement (Dziuban et al., 2005); and it is considered valuable for different sorts of learners (Heinze & Procter, 2004). The widespread and adoption of blended learning across various educational institutions have arguably led to the emergence of several other variants of blended learning such as flipped classroom which aims at fostering active learning.

Despite researchers and educationists foreseeing the significant rewards of blended learning instructional approach which affords the advantages of online and face-to-face instructional components, there are several factors to consider in order to build an effective blended learning instructional model. Researchers have studied several elements and aspects that play key role to the success of blended learning. For example, researchers have pondered on how to make the best blend (Boelens et al., 2017) of online and face-to-face components in terms of the proportion of online versus face-to-face. A series of studies by Graham et al. (2013), Wendy et al. (2016) and Porter et al. (2014) have investigated the institutional aspect of blended learning; studies such as (Brown, 2016; Ocak, 2011) have focused on blended learning from teachers' perspective which includes the challenges that teachers face in using technologies for instruction, teacher's

competency in using technology, preparation of lectures and learning materials prior to face-to-face classes etc.

From students' perspective, researchers have studied several aspects and elements of blended learning in relation to students such as performance and learning satisfaction (see (Cheng & Chau, 2016; Diep et al., 2017; Rahman, et al., 2015)), investigating the attributes, characteristics and latent profiles of students that supports blended learning design (see (Kintu et al., 2017; Van Laer & Elen, 2017, 2020; Vanslambrouck et al., 2019)) etc. However, one of the most eye-catching issues that persist and remain integral to the success of blended learning is students' self-regulation in the online component of blended learning (Broadbent, 2017; Broadbent & Poon, 2015). The elements of control granted to students over time, pace, and location has made it difficult for students to learn independently, stay connected and remain engaged with their studying independent of their instructor in their online component of blended learning. Students outside their face-to-face physical classrooms usually face enormous challenges such as seclusion, hunger for social interaction, and succumbing to adverse behaviors such as procrastination which deters them from properly utilizing their online component for studying. This has made self-regulation in both fully online and blended learning an interesting research area especially from the last decade (see (Broadbent, 2017; Broadbent & Poon, 2015)).

1.1.3 Definition of Self-regulated learning

Self-regulated learning is defined as "*an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate and control their cognition, intentions and behaviour, guided and constrained by their goals and the contextual features of the environment*" (Pintrich, 2000). Over the years, self-regulation researchers have come up with various self-regulated learning theoretical models (e.g. see (Boekaerts, 1996; Schunk, 1989; Zimmerman, 2000)). Pintrich (1991) classified self-

regulated learning strategies into motivation/affect, cognition context and behavior areas. Motivational regulation includes intrinsic and extrinsic goal orientation, self-efficacy, control belief, and text anxiety. Cognitive and metacognitive regulation involves elaboration, rehearsal, monitoring, organization, critical thinking and planning, goal setting and task analysis. Behavioural and contextual regulation involves time and study environment, peer learning, effort regulation, and help-seeking. In blended learning as well as its derivatives such as flipped classrooms, students are required to self-regulate their studying activities in their online component sessions. Particularly in flipped classrooms, students are expected to engage in active learning and preparedness before the face-to-face classes (Jovanovic et al., 2019)

The relationship between self-regulated learning and academic achievement has been theorised under the social cognitive view that self-regulated learning is acquired through a triadic interaction between three important characteristics: a) self-observation (monitoring one's actions) seen as the most important of these processes; b) self-judgement (evaluation of one's performance), and c) self-reactions (one's response to performance outcomes; (Zimmerman, 1989; Zimmerman & Schunk, 2001). More importantly, this view postulates that learning is not merely a fixed trait but can be influenced and improved with the aim of achieving successful academic outcomes (Zimmerman, 1989). Students may use a variety of cognitive, metacognitive, and resource management self-regulated learning strategies as part of their self-regulated learning behaviour (Puzziferro, 2008).

1.1.4 Definition of Scaffolding

The term ‘scaffolding’ has brought about numerous debates and arguments in academia. This is because the ‘scaffolding’ metaphor was originally used to describe the temporary supports assigned to buildings in construction sites to enable the builders to access the

building. In a broader educational context, 'scaffolding' was used as a metaphor for depicting the form and quality of the effective intervention by a 'learned' person in the learning of another person. Scaffolding was originally used to illustrate or describe the kind of step-by-step support or help that parents offer to their children or teachers offer to their students in order to accomplish a specific task (Burns & de Joyce, 2005; Maybin et al., 1992).

However, researchers from various research domains especially in the educational domains have gradually adopted and used the 'scaffolding' metaphor in describing the progressive supports teachers provide to their students for quality learning. In addition, the term has been used particularly in the educational technology domain to describe the kind of support that learning technologies offer to students in place of teachers. This is because learning technologies are arguably replacing teachers in online learning environments, and researchers have designed technologies to offer similar scaffolding support to that of the teachers in face-to-face classrooms.

There have been arguments and different opinions on the application and concept of scaffolding as many researchers believe it has been applied too broadly in educational and psychological research (Van de Pol et al., 2010). Pea (2004) even claimed that "*the concept of scaffolding has become so broad in its meanings in the field of educational research and the learning sciences that it has become unclear in its significance*". However, after a review of a decade on the concept of scaffolding, Van de Pol et al. (2010) concluded that there is no consensus with regard to the conceptualization of scaffolding. There have been several studies in the educational technology domain that used the scaffolding term in describing the support either from a teacher or the use of technology for learning (Azevedo & Hadwin, 2005; Jones, 2019; Panadero et al. (2016); Perry et al., 2008; Shamir & Lazerovitz, 2007). Therefore, scaffolding can literally be defined as the support that is designed to provide the assistance necessary to enable learners to

accomplish tasks and develop understandings that they would not be able to manage on their own. Scaffolding terminology has broadly been used for problem-solving (see (An & Cao, 2014; Kim & Hannafin, 2011a, 2011b; Raes et al., 2012) in technology-enhanced learning environments (Delen et al., 2014; Devolder et al., 2012; Panadero et al., 2016).

1.1.5 Definition of Peer Scaffolding

Peer scaffolding is a learning theory famously proposed by Vygotsky (see (Vygotsky & Cole, 1978)). Peer scaffolding is a form of collaborative learning that focuses on a student's ability to learn information through the help of a more informed individual. According to Vygotsky and Cole (1978), the best way of teaching and learning is direct instruction in which a more knowledgeable learner helps other learners in learning effectively by scaffolding them in their particular Zone of Proximal Development (Haider & Yasmin, 2015). The zone of proximal development is the distance between the actual level of learners' development and the potential level of development. The actual level of development is where a learner can solve a given task without requiring or needing any assistance, while a learner needs assistance and guidance to solve a task in the potential level of development (Haider & Yasmin, 2015; Vygotsky & Cole, 1978).

Over the years, researchers have used the term peer scaffolding interchangeably, referring to collaborative learning. Peer scaffolding insists on receiving and providing explanations and clarifications that help students or learners to engage in cognitive processing, such as correction of misconceptions, information reorganization, clarification of thinking and development of new understanding. Literature on peer scaffolding mostly tends to focus on scaffolding learners in writing or language learning fluency or towards improving the metacognitive skill of learners (see (Abune, 2019; Chairinkam & Yawiloeng, 2021; Pasand & Tahriri, 2017; Rezai & Shokrpour, 2011; Riazi & Rezaii, 2011; Sabet et al., 2013; Shooshtari & Mir, 2014).

1.1.6 Definition of Peer learning

Peer learning refers to the use of teaching and learning strategies in which students learn with and from each other without the immediate intervention of a teacher. Such an approach may be established and monitored by their teachers and may even occur in their presence, but teachers are not directly involved in teaching or controlling peer learning (Boud et al., 1999). Peer learning can be defined as the acquisition of knowledge and skill through active helping and supporting among status equals or matched companions. It involves people or students from similar social groupings who are not professional teachers helping each other to learn and learn themselves by so doing (Jackson & Bruegmann, 2009; O'donnell & King, 2014; Topping, 2005). In educational settings, the primary goal of peer learning is for students to work together in small groups to enhance one another's learning.

1.1.7 Definition of Affinity

The word affinity is mostly used in the domain of biological science to explain *the degree to which a substance tends to combine with another*". In boarder terms, Affinity can be defined as "*a natural liking for and understanding of someone or something*" (Rasheed et al., 2021). In small group formation involving human tasks accomplishment, group affinity involves the formation of small groups with the members having a natural inclination or fitting with one another which arguably determines how well group members collaborate and work together as a unit or team (Esfandiari et al., 2019).

1.2 Students' self-regulation in blended learning

Success in an online environment heavily relies on students ability to autonomously and actively engage in the learning process (Wang et al., 2013). Self-regulation has been highly praised as the key competence for initiating and maintaining learning in an online

environment (Broadbent & Poon, 2015; Rasheed et al., 2020; Rasheed et al., 2021; Zimmerman, 1989). As such, self-regulated learning becomes crucial in the online component of blended learning as the very nature of online settings necessitates self-directed learning (Serdyukov & Hill, 2013). It is therefore particularly important that students in these environments compared to those in traditional face-to-face components/settings have the self-generated ability to fully engage, control, manage, and plan their learning process effectively (Ally, 2004). Such a regulatory process is referred to as *self-regulated learning* (SRL) (Zimmerman, 2008). Therefore, research on the effectiveness of blended learning has led to a proliferation of studies that underline the importance of students' self-regulation in such environments (online component of blended learning) (e.g. (Broadbent, 2017; Jansen (2019)).

Research on self-regulation in blended learning has been on the rise and noticeable due to the definitive success of blended learning being dependent on the application of self-regulated learning in the online component of blended learning. Self-regulation is, therefore, a crucial competence for being a successful learner. Research on self-regulation in blended learning has only been found in the online component i.e. out of the face-to-face students' class sessions (Rasheed et al., 2020). This is because, in blended learning face-to-face settings, teachers are the motivators and usually facilitate learning activities among students and encourage in-class participation and engagement without necessarily needing technology for self-regulation scaffold. Teachers with the support of the educational institution could induce and encourage various learning strategies deemed as self-regulation strategies that scaffolds students learning in classrooms such as rehearsal, active learning that consequently averts students' disengagement *per se* etc. However, when students are out of their face-to-face classes, proper self-regulation, managing and engaging to learning becomes problematic. There have been numerous investigations into various aspects of students self-regulation that investigate and measure self-regulation

competency and other associated self-regulated learning behavior (e.g., (Barnard et al., 2009; Broadbent, 2017; Zhu et al., 2016)); investigating self-regulation by comparing students' self-regulation competency in fully online with blended learning (see (Barnard et al., 2009; Broadbent, 2017; Broadbent et al., 2020; Broadbent et al., 2021)) etc. While numerous published works have investigated self-regulation in blended learning, it becomes necessary to explore the studies that actually proposed approaches for scaffolding students' self-regulation.

1.3 Scaffolding students' self-regulation in blended learning

Students' self-regulation involves several scaffolding aspects that need prompting as self-regulated learning entails an active and constructive process in which an individual is cognitively, motivationally, and behaviorally engaged in his/her own learning. Teachers and educational institutions have encouraged and introduced several learning strategies deemed as self-regulation strategies that scaffold students learning in classrooms, such as collaborative or peer learning, and active learning to scaffold students learning and participation in physical face-to-face classrooms. There have been numerous influential studies that investigate and measure students' self-regulation competency and other associated self-regulation behavior or other self-regulation strategies in blended learning, typically by the use of the online self-regulation questionnaire tool (e.g., (Barnard et al., 2009; Broadbent, 2017; Zhu et al., 2016)). However, studies that actually proposed approaches for scaffolding students' self-regulation in blended learning are comparably less. Majority of these studies have proposed approaches or solutions for the flipped classroom type of blended learning. Moreover, these studies have mainly focused on scaffolding students' self-regulation behavior and have paid less attention to scaffolding self-regulation strategies such as metacognition, peer learning, rehearsal etc.

First, the existing blended learning literature that focused on scaffolding students' self-regulation involves the use of external scaffolds in the form of group awareness and peer assistance for online component studying (Lin et al., 2016); or the use or integration of a learning system component designed to function for self-regulation (Lai & Hwang, 2016; Shyr & Chen, 2018). Moreover, researchers have used learning analytics in order to track and identify learners' behavior in using their learning technologies for their online component assignments and related learning tasks (Silva et al., 2018). Other related studies for scaffolding self-regulated learning in the online component of blended learning involve the use of an instant response system (IRS)-facilitated collective issue-quest strategy for flipped classrooms (Chen & Hwang, 2019). The effectiveness of these proposed approaches in scaffolding student's self-regulation behavior generally measures the correlation between self-regulation and learning achievement or academic outcomes; measuring self-regulation behavior and the impact of self-regulation behavior on student's preparedness prior to the face-to-face class sessions in flipped classroom settings.

Online learning researchers from various research domains have defined and outlined certain strategies that support learners for proper self-regulated learning (Broadbent, 2017; Broadbent & Poon, 2015; Kizilcec et al., 2017). Both educational institutions and teachers are encouraged to promote the use of such strategies by their students as they have been proven to be effective and beneficial to learning in alleviating the challenges associated with online environments, and also enhancing learners learning activities which supports their overall self-regulated learning, learning achievements and overall academic performance, these strategies are called 'self-regulation strategies'. While self-regulation strategies adoption mainly centers around students, blended learning institutions and teachers are responsible for delivering and encouraging the use of these strategies by their students as a scaffold to their online component study activities.

Countless influential studies in various domains have shown the efficacy and benefits of adopting and using such self-regulation strategies in yielding significant positive academic outcomes and the effect on alleviating various challenges and worries typically faced by students in their online learning environments (Beishuizen & Steffens, 2011; Broadbent, 2017; Broadbent & Poon, 2015; Dignath & Büttner, 2008; Pintrich, 2004; Richardson, 2012; Wang et al., 2013; Zimmerman, 2008). That is, if learners are to succeed and realize the rewards and foreseen benefits associated with blended learning instruction, they need to adopt and properly implement the necessary online learning self-regulation strategies in their online components when necessary (Kuo et al., 2014).

The existing blended learning research for self-regulation strategy scaffold is limited by only focusing on the use of online discussion boards and text messaging to offer instant help as a form of feedback to their students (Fautch, 2015; Hardin & Koppenhaver, 2016); the use of intelligent tutoring systems (ITS) (see (Mohamed & Lamia, 2018)); and a web-based online help-seeking tool (Kopcha et al., 2015), tracking students procrastination behavior in the online component of blended learning (Akram et al., 2019). Researchers have not explored other key self-regulation strategy areas that could arguably offer a better self-regulation scaffold to students in their online components of blended learning.

1.4 Research Motivation

Existing literature has presented numerous approaches for scaffolding students self-regulation strategies. Students in learning communities are encouraged and motivated to adopt and use these self-regulation strategies especially in online environments that grants learners learning flexibility and autonomy. These defined self-regulation strategies such as metacognition, rehearsal, peer learning, help-seeking, effort management, time management, critical thinking etc. have shown their weighty impact on students learning achievement, academic outcomes and overall learning satisfaction (Broadbent, 2017;

Broadbent & Poon, 2015). In particular, several exiting studies have pointed to peer learning as an underused self-regulation strategy in various research domains (Broadbent, 2017; Broadbent & Poon, 2015; Kotturi et al., 2015). Research has shown the efficacy of online peer interaction on students learning achievements and is believed to be one of the most effective learning strategies that decide students' learning experiences in an online learning environment (Cho & Kim, 2013; Garner & Bol, 2011; McIsaac, 1999; Richardson & Swan, 2003). Scaffolding students to peer learning is a daunting task which necessitates several key phases to ensure effective peer learning scaffolding. Because peer learning does not just involve grouping learners in an arbitrary fashion to work together in small groups, effective peer learning must include sharing of knowledge and skills across members so that learners having a different set of skills or different skill levels of the same skill set can share among their peers; peer learning groups must be formed as a team to work together, and other related issues must be tackled such as students' reluctance to participate in peer discussions.

Due to the rapid advancement of modern technology and the continuous affordances of learning systems and software designs in todays' academic environment, this study was motivated by numerous literature that describes the formation of peer learning groups with learning potential, the suitable or ideal number of peer group discussion, etc. This study was also motivated from inspirational studies that describe and explain the importance of affinity in group learning. Affinity ensures that members in a group are fit to work together and have a natural inclination towards one another.

Another interesting aspect that motivated this study is the literature that explains the power of today's modern software technology, in which software designers especially learning system designers can leverage the capability of designing systems capable of shaping human behavior such as empathy, compassion, co-dependency etc. As such, learning systems could be designed and implemented from the inspirations of system design

literature that instigate and foster these encouraging behavioral responses from learners for positive collaboration and stickiness.

Before learners can reap the huge rewards associated with certain learning systems, incentivization is required. This is because a learning system is fruitless if its users are reluctant to use it or have a try on it in the first place (Kotturi et al., 2015). Peer learning also involves preventing or minimizing certain undesirable small group behavior such as social loafing (Kotturi et al., 2015). Although incentives are usually considered in the form of monetary or marks awards, recent literature from various research domains have shown how to leverage system designs to offer indirect form of incentives, for instance – co-dependency. As such learning systems could be designed to offer indirect form of incentives and could also be designed to minimize or possibly alleviate the risk of reluctance to the use of the learning system (Kotturi et al., 2015).

1.5 Problem Statement

One of the main challenges that students face in an online environment and more importantly online component of blended learning is proper self-regulation due to the flexibility and autonomy of learning granted to students. Students are hungry for social interaction (Kizilcec & Schneider, 2015; Kotturi et al., 2015) and often find it difficult to connect socially with the right peers to gain support for their online component studying. The lack of social ambience together with other challenges ranging from seclusion, and alienation that students face, has been found to negatively impact them in utilizing and realizing the rewards associated with their online components, as well as having a detrimental effect on their learning achievement, academic outcomes and overall satisfaction. Peer learning has long been identified as a learning strategy that is capable of alleviating the above-mentioned challenges and many more (see (Broadbent, 2017; Broadbent & Poon, 2015; Lim et al., 2020; Rasheed et al., 2020)). In addition to relieving

students of these challenges, peer learning offers students several benefits such as close interaction with one another, better engagement in their group discussion which is usually a challenge for them in the traditional teaching environment facilitated by a single instructor, enhancing their cognitive processing, boost students' confidence and make them believe in their skills and abilities by having partial control over their education (Keppel et al., 2011).

On the other hand, existing blended learning approaches for scaffolding self-regulation strategies have primarily focused on designing systems and techniques to scaffold online help-seeking self-regulation strategy, and have not proposed approaches to other types of self-regulation strategies more importantly peer-learning self-regulation strategies. The significant importance and foreseen benefits of peer learning in combating and alleviating the self-regulation challenges that students face as well as improvement in their overall learning achievement, have arguably led researchers in pleading and insisting on students' need for online peer-learning self-regulation strategy scaffold in blended learning instruction so as to deliver its promise of quality instructional excellence (Broadbent, 2017; Broadbent & Poon, 2015). This shows a clear need for research on peer learning self-regulation strategy in blended learning. As such, the next decisive step forward for research in blended learning is a framework for scaffolding students' self-regulation in the online component of blended learning. The framework would serve as a tool to aid higher educational blended learning institutions in scaffolding their students' self-regulation strategy in the online component of blended learning.

1.6 Research Aim

The aim of this research is to design a novel peer learning tool for scaffolding students' self-regulation in the online component of blended learning. To achieve this aim, the following objectives need to be reached.

1.7 Objectives and Research Questions

1. To investigate the challenges in the online component of blended learning from students, teachers and educational institutions perspectives.
    - *What are the challenges that students, teachers and educational institutions face in the online component of blended learning?*
2. To investigate the existing approaches for scaffolding students self-regulated learning in the online component of blended learning.
    - *What are the various techniques and approaches that researchers adopt to scaffold students' self-regulation in the online component of blended learning?*
    - *What are the limitations of these existing techniques and approaches?*
3. To design a scaffolding tool for the online component of blended learning.
    - *How could a scaffolding peer learning tool be designed for students self-regulation in the online component of blended learning?*
4. To evaluate the effectiveness of the proposed scaffolding tool for students' self-regulation in the online component of blended learning.
    - *How effective is the proposed tool in scaffolding students peer learning self-regulation in the online component of blended learning?*

1.8 Research Methodology

Phase 1 involves the literature review and problem extraction discussion. Phase 2 explains the research objectives. Phase 3 involves a deep understanding and thorough investigation of peer learning. Phase 4 deals with the system architecture and design, prototyping and expert evaluation, and phase 5 include results gathering, analyses and evaluation.

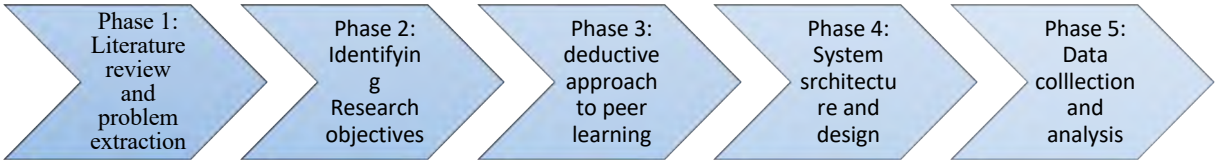


Figure 1.1: Research methodology phases

- **Phase 1: Literature Review and Problem Extraction**

The focus of this thesis is to propose a peer learning framework for scaffolding students' self-regulation in a blended learning mode of instruction. The systematic literature review undertaken is centered on the following:

I. First, blended learning literature is consulted to identify the existing challenges in the online component of blended learning from students, teachers and educational institution lenses.

II. By appraising and discussing these challenges categorically, a taxonomy of these challenges is presented.

III. Third, focusing on students' challenges, the research explored the existing blended learning literature that specifically proposes approaches for scaffolding self-regulation challenges in order to understand how researchers mitigate and solve the identified challenges in the online components of blended learning.

IV. Finally, limitations of the existing solutions are identified from the literature.

- **Phase 2: Research objectives**

By identifying the critical issue to be addressed from the literature review phase, the objectives for this research are then formulated. These objectives are systematically followed and achieved until the end.

- **Phase 3: Deductive approach to peer learning:**

Because this research adopts a deductive approach, this phase involves a deep understanding and thorough investigation on peer learning. This leads to understanding the phenomena, theories and existing works on how to successfully form effective peer learning groups, and any other related know-how of forming an effective peer learning scaffold. then relevant and suitable research methods are chosen and applied to test the hypothesis to prove them as either right or wrong.

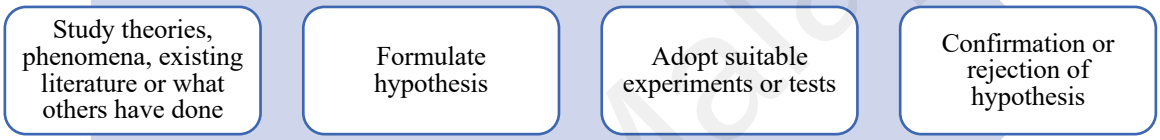


Figure 1.2: Deductive approach phases

- **Phase 4: System architecture and expert evaluation**

This phase involves the overall architectural design of the peer learning scaffolding framework which include forming groups with learning potential and affinity, implementation of group dynamics and incentivization. It also involves prototyping implementation to put forth the architecture into real world practice for expert evaluation.

- **Phase 5: Results gathering, analyses and evaluation**

This phase demonstrates the various modules incorporated to achieve the overall aim of this thesis. This phase involves conducting experiments using the developed prototype to finally achieve the aim of the study. The results obtained from the experiments conducted are collated and analysed to ascertain the performance of the proposed framework in scaffolding students peer learning self-regulation strategy.

1.9 Research Significance

The blended learning mode of instruction is customarily studied in educational and psychological domains, and have rarely been investigated in the information technology (IT) domain, despite information technology constituting and dominating one of its components (online component). The significance of this research lies mainly in the uniqueness of the focus of this research as it focuses on the technological aspect of blended learning (online component). Although this study mainly centers around the online component of blended learning, the face-to-face component is essentially impacted in a positive way since blended learning components are designed to complement each other (Rasheed et al., 2020). This research has a significant positive and exciting impact on today's modern education as it aims to improve the already proven and widely adopted blended learning instruction currently in practice in most parts of the world. This research attempts to offer better globalized online learning, as the world needs to move from a mass production delivery model to one where technology-enabled innovations are harnessed to democratize access to education and offer more personalized learning experiences to all students. As such, this research aligns with education for sustainable development (ESD) in offering a sustainable, more personalized and intuitive approach for today's 21st century online education (Owens, 2017; Sonetti et al., 2019).

This research could significantly impact the three dimensions of sustainable development (society, economy, environment). For instance, from the economic perspective, improving the already proven blended learning would consequently improve the quality of educational institutional products (students), in which skills and overall learning achievements would be significantly heightened. Therefore, blended learning institutions would potentially be saved from conducting workshops and training programs for their students which has been the common practice in motivating students to overcome the challenge of online studying and proper self-regulation.

From the societal dimension, students' psychological needs could be satisfied due to the presence of innovative and leveraging the use of software and redesigning of the blended approach to offer social ambience, social interaction, meeting the right peers to improve their learning etc. Psychological needs satisfaction has been studied over the years in relation to online learning (Fang et al., 2019; Howell & Hill, 2009; Wang, 2017; Wei, 2005). The three determinants of competence, relatedness and autonomy from the self-determination theory would be significantly improved for students. This would potentially and positively lead to a sustainable society by teaming and connecting students in small groups with affinity inclinations towards each other as well as ensuring group dynamic elements would contribute in promoting mutual understanding, harmony and togetherness in today's academia and society at large.

From the environmental dimension, this research addresses environmental dimension of sustainable development in ensuring that instructional environments are healthy and do not affect the well-being and peace of the general public. By redesigning blended learning to accommodate the rich form of peer learning scaffold, this research could practically engage and swiftly connect students with the right peers in the online environment without physically meeting one another. This becomes more important as this approach could be viewed as one of the remedies for combating the worries associated with today's learning, especially in addressing challenges of social distancing and other restrictions imposed due to global pandemics such as the covid 19 in ensuring healthy learning and the working environment globally.

1.10 Thesis scope

It is important to be clear of the scope of this thesis, highlighting the aspects that the thesis aims to focus on. Firstly, it is not the aim of this research to measure self-regulation, but rather to measure learning achievement with the use of the self-regulation scaffolding

approach. Although this thesis involves inducing and effecting self-regulation strategy to students, this research is focused on the impact of the induced self-regulation strategy on students' learning achievements since the aim is to improve students learning outcomes in blended learning instruction.

Secondly, this research does not measure the individual scaffolding elements that contributed to the peer learning self-regulation scaffold such as learning potential, group affinity, etc. This research adopts the scaffolding elements that contributed to forming the peer learning scaffold to form peer learning scaffolding approach for blended learning.

Finally, it is not the aim of this research to generalize its findings across different students' groups on different educational settings or to generalize findings across different instructional models such as MOOCs or fully online learning. This research is fully focused on blended learning in higher educational institutions. As such, the primary objective is building a richer theoretical understanding of peer learning self-regulation strategy scaffold for higher educational blended learning mode of instruction. This has made it easier for the author to recruit target participants who agreed to participate in the peer learning scaffolding experimental exercise. As such, it becomes easier by automatically disqualifying other participants from another level or domain to participate since peer learning involves learners of the same skill level or educational level working collaboratively as peers in small groups to achieve a common learning goal.

1.11 Research roadmap

Table 1.1 shows a roadmap for this research project summarising its underlying components (as explained previously) and the map between them.

Table 1.1: Research roadmap

Thesis title	Designing a peer learning scaffolding tool for the online component of blended learning				
Research Problem	Higher education students are hungry for social interaction and often find it difficult to socially connect with the right peers for learning Challenges ranging from lack of social ambience, seclusion, alienation that students face Peer learning scaffolding approach is the missing piece for blended learning instruction to realize its true potential.				
Aim/Motivation	Scaffolding blended learning students to engage in peer learning to proper self-regulate their learning				
Thesis Objectives	TO1: To investigate the challenges in the online component of blended learning from students, teachers and educational institutions perspectives	TO2: To investigate the existing approaches for scaffolding students self-regulated learning in the online component of blended learning.	TO3: To design a peer learning scaffolding framework for the online component of blended learning.	TO4: To evaluate the effectiveness of the proposed framework for scaffolding students' peer learning self-regulation strategy in the online component of blended learning.	
Research Questions	*RQ1: What are the challenges that students, teachers and educational institutions face in the online component of blended learning?*	*RQ2: What are the various, techniques and approaches that researchers adopt to scaffold students' self-regulation in the online component of blended learning?* *RQ3: What are the limitations of the existing self-regulation scaffolding approaches?*	*RQ4: How could a peer learning scaffolding framework be designed to scaffold students self-regulation in the online component of blended learning?*	*RQ5: How effective is the proposed framework in scaffolding students peer learning self-regulation in the online component of blended learning?*	
Thesis chapters	**Chapter 2**	**Chapter 3**	**Chapter 4**	**Chapter 5**	**Chapter 6**
Chapter objectives	Identifying the challenges in the online component of blended learning Investigating the approaches for mitigating these challenges and focusing on students	Understanding peer learning practice and its significance to learning. Existing works on peer learning scaffolds from various research domains Explaining the various schemes of forming groups in both educational and non-educational settings	Describes system architecture and its functionalities Discusses the development of the learning system prototyping incapsulating the system functionalities	Describes the experimental setup Presents the data and the corresponding statistical results obtained	Conclusion: The overall achievements of the research The limitations of the research and future research direction

	self-regulated learning challenges	The role of learning systems in shaping human (learners) behavior or attitude towards learning Incentivization	Presents the heuristic expert evaluation adopted and the results		
Thesis contribution	TC1: <u>Challenges in the online component of blended learning: from</u>: 1. Students. 2. Teachers. 3. Educational institutions. TC2: <u>Solutions to the identified challenges:</u> 1. Self-regulation challenges 2. Technological competency 3. Technological affordances by institutions 4. Strengths and limitations of these solutions	<u>TC3: Redesigning of blended learning instruction:</u> Higher educational institutions need to redesign and revise their learning systems and their whole blended learning structure to accommodate this rich form of learning strategy for the benefit of their students in alleviating the challenges that students face out of their online components, which also impacts teachers and the educational institution as these three entities have cross boundaries.	TC4: <u>Uncovered the affordances and capabilities of today's modern technology in shaping human behavior:</u> 1. Incentivization 2. Co-dependency and empathy 3. Humanization 4. Validation 5. Elements of group dynamics	TC5: <u>Relevance to global policies:</u> Nations believe that the world needs to move on from a mass production delivery model to one where technology-enabled innovations are harnessed to democratize access to education and offer more personalized learning experiences to all students.	

1.12 Thesis Outline

The remainder of this thesis is presented below, followed by table 2, which depicts the thesis structure:

Chapter 2: This chapter reintroduces blended learning with the two trendy types of blended learning (blended learning and flipped classrooms), and then explains the need for exploring the challenges in the online component of blended learning. Then, the chapter provides a comprehensive systematic literature review on the state-of-the-art challenges in the online component of blended learning from students, teachers and educational institutions lenses. The chapter also presents a taxonomy of these challenges by categorically grouping the related challenges into related themes. In addition, the chapter discusses the existing blended learning literature that specifically proposes solution approaches for scaffolding students' self-regulation in the online component of blended learning. Finally, the limitations of the existing solutions are identified which lays the foundation of this research.

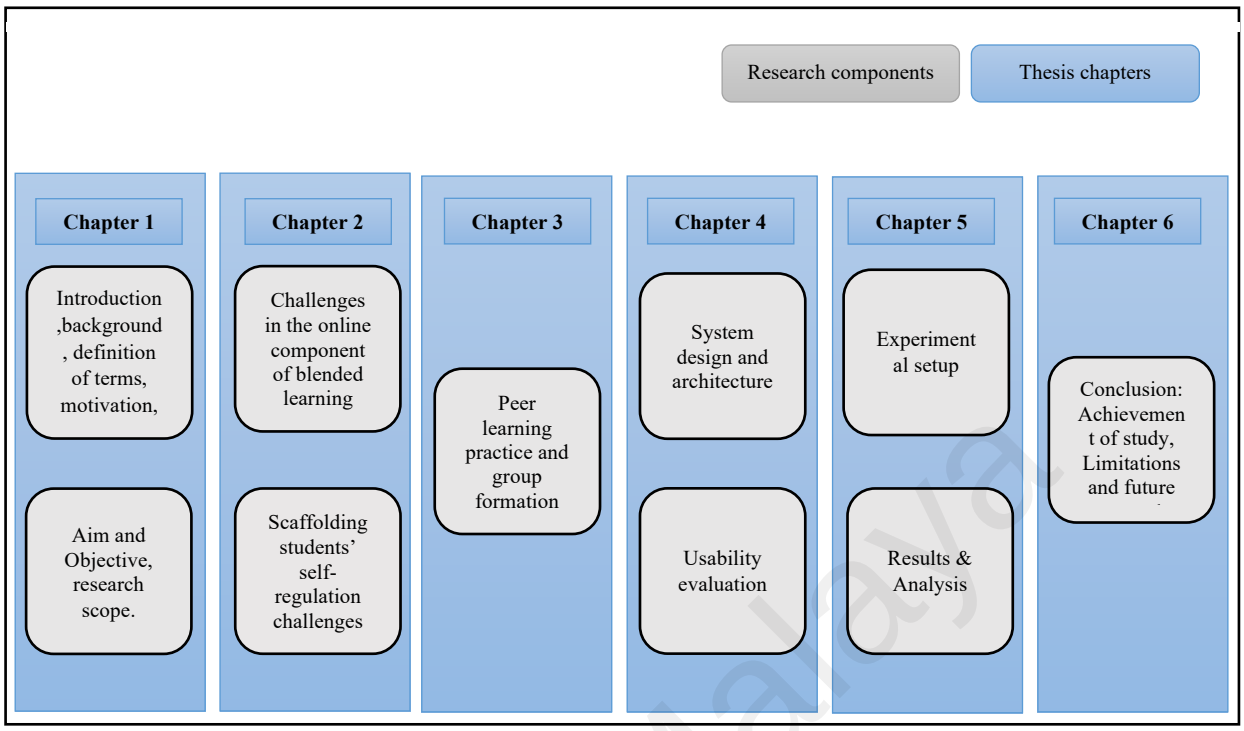
Chapter 3: This chapter is a sequel of chapter 2 which identifies peer learning as the missing piece for blended learning to realize its true potential. The chapter discusses peer learning practice in various educational settings thereby reviewing the literature from various online learning domain and other domains that investigated and proposed approaches for scaffolding peer learning. The chapter discussed the three types of collaborative learning from theoretical perspective. Since peer learning is done by forming small size learning groups, the chapter discusses on how to successfully form effective learning groups to accomplish tasks, and any other associated knowledge on how successful peer learning works in different application domains. The chapter also discusses how learning systems can be designed to motivate peer learning participation and learning achievement through indirect incentivization strategy, importance of humanization of learning systems, validation of learning systems.

Chapter 4: This chapter depicts the architecture and design of the peer learning system prototype, the design choices, the functionalities – functional and non-functional requirements of the system, the various software development tools employed and the justification and rational behind the design decisions and the tools used. The chapter also presents the expert evaluation exercise adopted and the corresponding results.

Chapter 5: This chapter presents the results of the experimental setup conducted to evaluate the peer learning scaffolding framework. The chapter discusses the results and provides charts and statistical analyses using the SPSS statistical analyses software. The results of the academic performance and learning achievement of students are presented that used the proposed learning system in scaffolding their self-regulation learning strategy.

Chapter 6: This is the conclusion chapter which discusses the achievements of the research, limitations as well as providing suggestions for future enhancements.

Table 1.2: Thesis structure



CHAPTER 2: STATE OF THE ART AND CHALLENGES IN THE ONLINE COMPONENT OF BLENDED LEARNING

2.1 Introduction

The blended learning instructional approach has received substantial interest from the academic community especially in the past two decades. As blended learning involves two instructional approaches – face to face and online amalgamated together, this chapter focuses solely on the online component by extracting the challenges that students, teachers and blended learning institutions face with their online component. These reported challenges identified and extracted from blended learning literature were discussed in relation to various research domains as well as other relevant and related literature from various technology-mediated domains to provide bases, arguments and justifications for the existence of these challenges. The obtained results are grouped into three categories of students, teachers and educational institutions. Each student, teacher and educational institution comprises a number of closely related challenges grouped as a theme which presents a taxonomy of these challenges.

This systematic review section provides an in-depth knowledge of the entire blended learning instruction particularly the online component. The review also discussed the relationships between the identified challenges and the complementary relationship between the face-to-face and online components, the interrelationship, cross-boundaries and the implication of these challenges to one another. The chapter ends by identifying the limitations of the existing studies for scaffolding students self-regulated learning which paves the way for the basis of this thesis.

This chapter is divided into six (6) main sections: The background section discusses the background and rational behind the review. The second section reviews and discusses the challenges that students face in the online component of blended learning, which comprises of five main subsections. The third section reviews and discusses the

challenges that teachers face with their online component of blended learning which mainly consists of four categorical sub-sections. The fourth section reviews and discusses the challenges that educational institutions face with their online component of blended learning. The fifth section provides a summary of findings and limitations with regard to the implication of the use of technology in blended learning from the previous three sections discussed; the limitations, the cross boundaries and relationships between the challenges as a whole. Because self-regulation challenges are this study's main focus, the sixth (last) section centers on students' challenges by reviewing and discussing the existing approaches for scaffolding self-regulation challenges in order to understand how researchers mitigate students' self-regulation challenges in the online components of blended learning. Finally, limitations of the existing approaches or solutions are presented from the literature which laid the foundation for this thesis.

2.2 Background

The idea of blending instructional materials with online interventions has proven to be an upgrade to both traditional face-to-face mode and the fully online mode of instructions. Because, if done well, the approach combines the benefits afforded by both face-to-face and online learning modes of instruction (Broadbent, 2017). While the merits and benefits of the blended learning approach in optimizing teaching and learning is apparent from countless influential studies and regarded by many scholars as 'the new normal' (Dziuban et al., 2018) in education due to its high rate of adoption, popularity and perceived benefits; the inclusion of technology into instruction thereby creating the online component has brought some level of unease to students, teachers and educational institutions. For example, it becomes necessary for students to have self-regulation skills and technological competence since they are required to manage and carry out their studies independent of their instructor, at their own pace, and also using online technology

out of their face-to-face sessions. Secondly, it becomes necessary for teachers to be technologically competent, to effectively use and manage technology for teaching, and also to create and upload learning materials to students (e.g., creating quality online videos). Thirdly, it is the responsibility of educational institutions to provide the necessary training and technological support to both teachers and students in order to ensure the effective utilization of the available technology and in addition, to efficiently utilize the online component.

Several studies have reported the problems that students (Broadbent, 2017; Prasad et al., 2018), teachers (Medina, 2018; Ocak, 2011) and educational institutions (Medina, 2018) encounter with online component of blended learning. However, these studies are limited in providing an overall and clearer picture of the challenges in managing teaching and studying out of face-to-face class sessions. Some studies are also characterized by reporting from a single type of blended learning. For example, the study of Akçayır & Akçayır (2018) reported the advantages and challenges of flipped classroom is only limited to flipped classroom type of blended learning, and it specifically reported the technological challenges found in flipped classrooms. Similarly, the study of Brown (2016) reported the challenges from teachers perspective only. Another related study to that of (Brown, 2016) is the study of Ocak (2011) which revealed the reasons for teachers not teaching blended courses.

Additionally, some of the recent and most pronounced studies in blended learning have focused on the design challenges as a whole, but not particularly focused on the online component. For example, the study of Boelens et al. (2017) identifies ‘incorporating flexibility’; ‘facilitating interaction’; ‘facilitating students' learning processes’; and ‘fostering an effective learning climate’ as the ‘four key challenges to the design of the blend’ in a blended learning environment. Similarly, the series of influential studies of ‘Graham’ and his team (Graham et al., 2013; Halverson et al., 2014; Porter &

Graham, 2016; Porter et al., 2016; Porter et al., 2014) filled a huge gap in blended learning literature by providing the framework, directions and guidelines for educational institutions in implementing an effective blended learning instruction, have also considered examining blended learning (face-to-face and online components) as a whole in offering such contributions. There is a clear need to understand the overall challenges of the online component of blended learning that the three main entities of students, teachers and educational institutions face.

This chapter explains the challenges in the online component of blended learning from students, teachers and educational institutions' perspectives. Furthermore, this chapter identifies and explains the areas in which knowledge is still inconclusive, thereby setting new directions for future research in blended learning. Keeping in mind that students, teachers and educational institutions as the three primary stakeholders or entities in blended learning. Furthermore, because educational institutions that employ a blended learning mode of instruction are responsible for providing the platform and support for the online component, this chapter describes the challenges that institutions face with regard to their online component support.

2.2.1 Literature search

This research involves querying the Web of Science (WoS) electronic database. This is because the WoS database is the gateway for all the Social Science Citation Indexed (SSCI) and Science Citation Indexed (SCI) journals. A search string was formed based on the understanding and knowledge of the blended learning domain and also, by referring to related blended learning search strings used in other studies such as (Boelens et al., 2017). The search string *(blend* learning OR hybrid learning OR flipped learning OR blend* course OR hybrid course OR flipped course OR flipped classroom*)* was keyed into the advanced search option of Web of Science electronic database. The range

of years was specified from 2014 to 2018, and the search was further refined by specifying (Social Science Citation Index SSCI); and research area (Educational Education Research, educational psychology research and educational scientific discipline) by adopting a similar method of refinement from. A total of 632 results were finally retrieved. Furthermore, three additional studies: (Brown, 2016), (Akçayır & Akçayır, 2018) and (Boelens et al., 2017) were added found from other sources (Google Scholar and Science Direct) to ensure that all the relevant studies for understanding the online component of blended learning state of the art.

Apparently, as a blended learning research area has been an active research area over the years and has yielded a large number of publications due to its popularity and termed as the most recognized mode of instruction globally, this research is therefore focused on considering studies from 2014 to 2018, and later updating the search to 2020. Secondly, keeping in mind that technology evolves and changes rapidly, and this research study intends to reveal the state-of-the-art challenges in the online component of blended learning; this has made the search process to only consider the most recent literature in order to avoid the risk of identifying irrelevant online or technological challenges that are obsolete. Nevertheless, this research has also referenced and cited numerous other influential studies related to the online component of blended learning to support and provide basis and evidence for this research.

Inclusion and exclusion criteria were set to further refine the 632 articles obtained. These articles were further refined by only considering articles that: (a) define blended learning as a combination of face-to-face and online interventions; blended learning must be the central topic of the article, or in synergy with a related instructional method e.g. fully online learning; (c) empirical studies; (d) articles must mainly investigate educational aspects of blended learning in educational settings. Exclusion criteria includes: (a) articles that solely focus on face-to-face aspects of blended learning; (b)

book chapter reviews; (c) non-English articles; and (d) articles in which the full text was not available. The obtained results were grouped into three categories of students, teachers and educational institutions challenges as discussed in the below sections;

2.3 Challenges that students face in the online component of blended learning

The challenges that students face with in the online component of blended learning are categorized into five related themes as follows:

2.3.1 Self-regulation Challenges

Students are basically required to self-regulate their learning activities out of their face-to-face sessions. Though, due to flexibility and autonomy offered in blended learning, students usually organize their learning activities by devoting a relatively small portion of their time to learning tasks (e.g., revision of learning materials) and assignments right before the due date/time. In this way, learners use most of the time intended for studying in the online environment for other activities.

From table 2.1, a large portion of the identified challenges that students face out of the face-to-face component are self-regulation challenges. Although self-regulation is not as crucial to blended students as it is to fully online students, but it appears to be imperative to the success of students in a blended learning mode of instruction. Freedom of learning at one's pace and flexibility that online modalities offer has always endangered or rendered students into poor self-regulation behavior. The results in table 2.1 highlight students' lack of self-regulation skills to organize and manage their studies independent of their instructor(s) as a key challenge faced by students. The studies of (Çakiroglu & Öztürk, 2017; Chuang et al., 2018; Lightner & Lightner-Laws, 2016) offered a more general description of self-regulation in describing 'self-regulation' as a challenge, while other studies were more specific in clearly defining the type of self-

regulation challenge in the form of procrastination (AlJarrah et al., 2018; Broadbent, 2017; Maycock et al., 2018; Sun et al., 2017), improper time management (Broadbent, 2017; Zacharis, 2015) and improper utilization of online peer learning and online help-seeking strategies (Broadbent, 2017).

Table 2.1: Students challenges in the online component of blended learning

S/N	Categorical challenges	Challenges	Reference articles
1	Self-regulation Challenges: This are challenges that are related to self-regulation which students face in their online component of blended learning	Procrastination	(AlJarrah et al., 2018), (Broadbent, 2017), (Maycock et al., 2018), (Chuang et al., 2018), (Sun et al., 2017)
		Online help-seeking challenge	(Broadbent, 2017), (Safford & Stinton, 2016), (Akçayır & Akçayır, 2018)
		Lack of self-regulation skills	(Sun et al., 2017), (Lightner & Lightner-Laws, 2016), (Chuang et al., 2018), (Çakiroglu & Öztürk, 2017)
		Limited preparation before class	(Long et al., 2017), (Xiao, et al., 2018),
		Poor time management skills	(Akçayır & Akçayır, 2018)
		Improper utilization of online peer learning strategies	(Broadbent, 2017), (Zacharis, 2015) (Broadbent, 2017)
2	Technological Literacy and Competency Challenges: This category of challenges is related to technological literacy and competency that students face in their online component of blended learning	Challenge in handling different user interfaces	(P. Prasad et al., 2018)
		Resistance to technology	(P. Prasad et al., 2018)
		Technological distraction from overly complex technology	(P. Prasad et al., 2018)
		Challenge of learning new technology by adult learners	(Salim et al., 2018), (Lightner & Lightner-Laws, 2016)
		Lack of technological competency	(G. Akçayır & Akçayır, 2018)
		Students' technological illiteracy	(Brown, 2016), (Kopcha et al., 2015),
		Adult learners' intimidation by learning technologies	(Zacharis, 2015)

		Resistance to/or confusion about seeking appropriate online help Poor understanding of directions and expectations in 'online learning' of blended learning. Students' perception of technology as a barrier to online help seeking	(Safford & Stinton, 2016) (Safford & Stinton, 2016) (Safford & Stinton, 2016) (Kopcha et al., 2015)
3	Students Isolation Challenges: This category of challenges that students face which are related to isolation and alienation	Students' alienation and isolation in online learning Students feeling of isolated and disinterested Students' problem with synchronous online communication with the use of video projection, the microphones and speakers Remote students uncomfortable being center of attention	(Chyr et al., 2017) (Lightner & Lightner-Laws, 2016) (Szeto & Cheng, 2016) (Bower, 2015)
4	Technological Sufficiency Challenges: This is the category of challenges that are related to how sufficient or limited the technologies for students are.	Insufficient access to technology Inequality of technological accessibility Outdated technology and lack of internet out of the class (in online component) Low bandwidth and slow processing speeds Experience of technical difficulties in completing assignments	(Gopalan et al., 2018) (G. Akçayır & Akçayır, 2018) (Safford & Stinton, 2016) (Safford & Stinton, 2016) (Henrie et al., 2015)
5	Technology Complexity Challenges: This category explains students challenges with complex technology for learning	Technological distraction from overly complex technologies Technological complexity Challenge with longer videos for learning	(P. Prasad et al., 2018) (P. Prasad et al., 2018) (Kim et al., 2014)

The concept of self-regulation has been in existence in various research domains. However, self-regulation in blended learning has received substantial attention through

evaluation and relationships with other online learning frameworks and models, notably the renowned community of inquiry (CoI) framework (Shea & Bidjerano, 2010; Szeto, 2015); and technological acceptance model (TAM) (Padilla-MeléNdez et al., 2013; Yeou, 2016). There are comparably few studies that actually proposed approaches for curating students' self-regulation behavior in the online component of blended learning. Previously, self-regulation behavior support systems have focused on providing a learner centered environment through repeating a training process to learners and guiding them iteratively. Recently, for example, the study of (Lin et al., 2016) considered using group awareness and peer assistance as external scaffolds in developing a system called 'self-regulated learning with group awareness and peer assistance' (SRL-GAPA) for stimulating students' self-regulation behavior in a blended learning environment. The approach has resulted in promoting students' self-regulation behavior outside their face-to-face sessions. Similarly, the study of Shyr & Chen (2018) in designing a flipped learning system to stimulate students self-regulation and overall performance has resulted in students not only better prepared before face-to-face meetings but also improved students' overall academic performances compared to the conventional flipped classrooms.

2.3.1.1 Procrastination

Procrastination, considered as a detrimental behavior has been peculiar and ever present in online learning settings due to the enormous flexibility and autonomy granted to online learners. Students' procrastination behavior in traditional face-to-face and blended courses differ because students in blended learning experience a greater sense of transactional distance compared to fully face-to-face students, due to reduced seat time in blended courses (Boelens et al., 2017). Because of some level of autonomy and freedom offered in blended courses, students are required to exert a higher level of self-

control in their online component in order to overcome learner isolation and the less spontaneous online interaction nature of blended learning which causes procrastination.

From the results in Table 2.1, (AlJarrah et al., 2018; Broadbent, 2017; Chuang et al., 2018; Sun et al., 2017) have identified self-regulation challenges in the form of procrastination, whereby students face difficulty in proper self-regulation, which results to poor time management and procrastination.

Procrastination is widely considered a psychological dysfunction behavior (van Eerde & Klingsieck, 2018), as such, majority of the research activities on procrastination were from the medical and psychological domain. The results from intervention studies have not only been heterogeneous in terms of designs but also in terms of research contents. For instance, Budney et al. (2015) provide a review of computerized therapies for substance addiction – having dire consequences than *per se* procrastination.

Researchers have categorized procrastination interventions in academia into three intervention groups: I) therapeutic treatment – intervention administered after students have demonstrated procrastination behavior; II) therapeutic intervention – aimed at preventing the negative effects of procrastination before it occurs; and III) teacher/instructor intervention. The limited number of effective interventions were proposed for the treatment of academic procrastination, and they are characterized as products of theories of academic procrastination (Zacks & Hen, 2018). Procrastination intervention studies are relatively less in academia, especially in technology-mediated domains like blended learning. This is because most procrastination intervention offers a generalized treatment approach and has not specifically targeted procrastination behavior in technology-mediated learning environments.

Recently, teacher intervention studies have adopted the use of smartphone based intervention, for example, the approach of using SMS reminder system as a stimulus alert to reduce procrastination (Davis & Abbitt, 2013); the use of mobile applications as an

intervention tool (Glomann et al., 2018); and the strategic teaching interventions studies by (Auvinen et al., 2015) that increase students' awareness of their behavior using achievement badges. Another teacher intervention approach was found to significantly reduce students' procrastination behavior when an online study material is only accessible contingently of completing the previous study exercise, resulting in reducing students' procrastination behavior (Perrin et al., 2011). A recent meta-analysis study on procrastination (van Eerde & Klingsieck, 2018) has revealed the current state of research on procrastination and highlighted the need for intervention approaches using online learning technologies used in technology-mediated environments (e.g. learning management systems) for treatment of students procrastination behavior.

2.3.1.2 Online Help-seeking

Findings notably in Table 2.1 from (Akçayır & Akçayır, 2018; Broadbent, 2017; Chen, 2015) reported that students were unable to get appropriate help while out of their face-to-face classes. The study of (Kopcha et al., 2015) highlighted students' challenge of perceiving technology in blended learning as a barrier to online help seeking. Similarly, (Safford & Stinton, 2016) reported that adult learners get confused and sometimes get intimidated by seeking online help. Possibly, this explains one of the reasons why students resort to seeking online help from other unreliable and informal sources such as 'how-to-do' manuals, search engines (e.g. Google), reading and studying online posts, reviewing conversations or chats on discussion forums, watching videos from YouTube etc. as asserted by (Broadbent, 2017).

Researchers have made considerable efforts in fostering online help seeking initiatives to students through different approaches, commonly through the use of intelligent tutoring systems e.g. see (Mohamed & Lamia, 2018; Mortali & Moutier, 2018; Roll et al., 2011; Vaessen et al., 2014); personalized information seeking systems and

adaptive learning systems (Lu & Hsiao, 2017) as scaffoldings and facilitators for students' help seeking initiatives. Research has shown that intelligent tutoring systems, which attempt to mimic the role of human tutors, are capable of offering intelligent, contextual and curating help through hints or direct feedback to students. Research has also shown that inputs, student mindsets, and attributes of help are the three factors influencing students help seeking behavior while programming with computer tutors (Price et al., 2017).

Another direction that researchers have taken in motivating students towards online help-seeking is through negotiation mechanisms. Chou et al. (2018) proposed a negotiation-based adaptive learning system for regulating students help seeking behavior due to many influential studies (Chen et al., 2019; Chou et al., 2015; Lan & Kinshuk, 2011) confirming that negotiation between students and the system improve students' metacognition. These approaches are basically designed to offer online help as a scaffolding for accomplishing in-class assignments, tutorials, quizzes or examinations. For example, the negotiation-based approach of (Chou et al., 2018) regulates students' help-seeking behavior by encouraging them to seek help from the system's suggested answer tips, and also, preventing them from seeking too much help or executive help. Furthermore, (Cummins et al., 2016; Fautch, 2015; Hardin & Koppenhaver, 2016) utilized discussion boards and text messages to offer instant help as a form of feedback while students are out of their face-to-face classes. Additionally, a web-based help seeking system 'EchoLu', was designed based on four design principles: Students' privacy needs in help seeking; students' awareness of teacher support; promotion of observability peers' help seeking activities; and promotion of social support has resulted in motivating students online help seeking initiatives in a flipped classroom (Kopcha et al., 2015).

Basically, students are known for seeking help through their institutions' online platforms by connecting and interacting with peers through discussion forums and online blogs. The study of Türel (2016) asserted that writing skills and detailed explanations on discussion forums affect online students in considering the usefulness of an online platform, thereby determining students' proper utilization of the platform for interaction and help-seeking. Higher order detailing of explanations in online and discussion forums would possibly be more beneficial to students that do not prefer face-to-face conversations and classroom interactions. For example, (Hsu & Hsieh, 2014) found that Taiwanese students are reluctant to engage in active classroom interactions and are traditionally less outspoken. This highlights the importance of taking cultural and geographical background factors into consideration for designing a blended course. It is clear that higher order writing and detailing explanations in online platforms play a key role in students' self-regulation and a motivating determinant for online help-seeking initiatives.

Another challenge faced by students in online environments when seeking help is that students perceive online discussion forums less private than for example an email. Students feel less comfortable sharing or inquiring every information or help, and are reluctant to detail such inquiries (Türel, 2016). Possibly, students in online environments would continue ignoring online help seeking due to the obvious reasons highlighted in the study of (Sun et al., 2018). Therefore, affecting a spontaneous learning environment in which every learner is respected, valued and cherished would possibly boost online peer learning and help seeking self-regulated learning strategies.

2.3.2 Technological Literacy and Competency Challenges

In addition to other skills required from a student, computer and technological literacy and competency have become necessary for students in pursuit of today's modern

education. Educational learning materials are being embedded in technologies, and gaining access and utilization of these materials depend on individual's literacy and competency level. The findings of Brown (2016) and Zacharis (2015) from Table 2.1 highlighted the lack of literacy from students concerning the use of technology for learning as a drawback of blended learning instruction. Zacharis (2015) mentioned that students' technological illiteracy and poor time management skills have led to delays in receiving immediate feedback from their teachers, thereby rendering students uninterested and procrastinating their study activities. Similarly, Chen et al. (2016) reported the challenges faced by students in the form of learning a new technology, especially by adult students (Lightner & Lightner-Laws, 2016; Safford & Stinton, 2016; Salim et al., 2018) (see Table 1). This finding possibly explains why students are intimidated by technology (Safford & Stinton, 2016).

Similarly, Akçayır & Akçayır (2018) and Jensen et al. (2015) from table 2.1 stressed the need for technological competency for blended learning students. Because blended learning students are presumably considered to be reasonably competent with technology; having no problem with online activities such as online peer learning, help seeking, problem solving and technical know-how; incompetency with learning technologies can be disastrous and possibly become an impediment to students in realizing the merits afforded by blended learning.

Another noticeable challenge faced by blended learning students is dealing with different technological user interfaces (P. Prasad et al., 2018). This becomes obvious with the evolvement of a wide range of operating systems, computer hardware and software technologies. Students lacking competence and proficiency with the use of various hardware and software technologies might not be able to handle the complexity of technological variations and interfaces successfully for studying. Although, Akçayır et al. (2016) argued that the current generation of students are presumed to experience fewer

difficulties in using technology than the former generations as they are considered 'technological born'.

2.3.3 Students Isolation Challenges

Students' study activities like reading, assignments and preparations before face-to-face classes are challenged due to the lack of motivation, alienation and isolation that students in their online component. From Table 2.1, Chyr et al. (2017) and Lightner & Lightner-Laws (2016) reported the level of discomfort and anxiety that students experience due to isolation in carrying out study activities. Two noticeable findings from the results have highlighted a similar problem with the blended synchronous learning mode that students feel unease and uncomfortable in using video projection, microphones and speakers (Szeto & Cheng, 2016) and also being the center of attention (Bower, 2015).

Students possibly fall into isolation and alienation due to their hesitance to participate/engage in online communities. This might be a result of a number of reasons such as personality, sense of transactional distance in online environments, lack of confidence and trust in the online community participants, lack of communication cues (facial expression, voice tone etc.), connection difficulties (e.g., low internet speed), poor writing skills or language barrier. Therefore, building online social presence - as part of the three elements of the community of inquiry framework, through identifying and participating in an online community and building sound relationships with the online participants have proven to be a key contributor in students' academic success (Garrison, 2011), especially in technology-mediated learning such as blended learning.

2.3.4 Technological Sufficiency Challenges

Since blended learning requires students to have access to technology for learning – both hardware and software, whether provided by themselves or by their educational

institution, the challenges of technological accessibility cannot be ignored. Akçayır & Akçayır (2018) and Chen et al. (2015) in Table 2.1 mentions students' worries about not having equal access and technological support with other peers. Similarly, the study of (Safford & Stinton, 2016) reported students experiencing difficulty with internet connection in their online component and also difficulty in dealing with outdated technology. Students may possibly feel the adoption of blended learning as a biased mode on instruction by rendering them unequal to their peers concerning the accessibility of the required online learning technologies. Moreover, Safford & Stinton (2016) also reported students complain concerning access to modern technologies for learning, and their online activities are troubled by low speed internet.

2.3.5 Technological Complexity Challenges

Findings from Prasad et al. (2018) in Table 1 reported students to complain about the complexity of technologies installed by their educational institutions for online studying, as such, students spend significantly more time on learning how to use these technologies. Interestingly, students become overly excited and distracted with the technology being employed, particularly the software aspect, which results in refocusing students' attention on the innovative features and complexities of the online learning environment than learning in the online environment. Technological distractions and complexity in particular can possibly be understood by educational institutions employing and installing state-of-the-art technologies in order to stay competent and update/upgrade the existing instructional technology. Nevertheless, students may possibly be one step behind technological innovation and, therefore may find these technologies complex and become incompetent in effectively using them for learning purposes.

Another possible explanation for students being distracted by technology is the provision of technologies and services that students do not have access to or are lacking in their homes. For example, a high broadband Wi-Fi, which students can use for other non-educational purposes like faster video streaming on YouTube, downloads and other non-educational purposes. Although, the studies of Wang et al. (2015) highlighted the necessity of educational institutions in constantly replacing older technology with newer ones as a theme across the blended learning literature. Nevertheless, educational institutions should constantly moderate between students' technological needs and sufficiency; and technological gold plating as this would possibly lessen the misuse or abuse of technological resources.

Despite the benefits associated with online learning videos such as the authenticity of teachers' emotions, and demeanor (Borup et al., 2014), results from Kim et al. (2014) reported students complain of longer videos for learning. Kim et al. (2014) mentioned students' verdict on online content being "bulky, cumbersome and too much to digest". Research carried out on videos for learning has characteristically shown online video lectures of having poor or limited pedagogical and technical features which limit student learning experience in a flipped classroom (He et al., 2016). Another example is the study of Giuliano & Moser (2016) which found that the length of an online video is inversely correlated with the percentage of videos viewed by students. This shows that the lengthy a video is, the less likely students would fully engage and be interested in it. As such, pedagogical and online learning researchers have highlighted some of the ways to engage students with videos for lectures, for example recommending that the length of an online video should not exceed 20 minutes considering most students' attention span (Kaya, 2015; Mason et al., 2013).

2.3.6 Discussion

Arguably, the five categories of students' challenges highlighted in Table 2.1 are related to one another. For instance, technological illiteracy and incompetency undoubtedly contribute to students' isolation, as well as students' poor self-regulation skills out of their face-to-face sessions. Although, it is agreed that technology support students learning, researchers have stressed the importance of placing students at the center of learning experience, not the technology. Recent research has shown that traditional learning management systems fall short of providing a collaborative and interactive online community, which essentially offers students a sense of ownership. The approach of improving students' online social presence by integrating social network sites with traditional learning management systems has proven to significantly impact students learning outcomes, and has brought a higher level of students' satisfaction and engagement by intervening in some of the challenges that students face with technology in their online components. Furthermore, a greater sense of online closeness would surely nurture students' behavior and possibly reduce isolation and seclusion outside face-to-face sessions. The studies of Özmen & Atıcı (2014a), (2014b) and Thoms & Eryilmaz (2014) show the merits of integrating social networking sites with learning management systems in positively affecting the quality of communication between students and also between students and their instructor(s), thereby improving and sustaining the level of social interaction and ensuring an overall engaging learning experience. Therefore, students enrolled in institutions where social networking sites are employed for online activities would possibly experience a reduced level of the identified challenges in Table 2.1.

While the goal of blended learning for students is to provide them with a richer learning experience through careful structuring of face-to-face and online components, research has proclaimed how these two components support each other in reducing the

worries associated with each component. The face-to-face introductory meeting sessions, which usually take place at the beginning of a blended course, typically provide students with information about the institution, study expectations, introducing the institution's technologies (e.g., the learning management system) and so on. This human touch experience in a face-to-face introductory meeting initiates social activities of the online component by stimulating social interaction and communication between students and their teacher(s) and also among the students (Boelens et al., 2017; Graham, 2006). As such, students would have a sense of feeling of who their peers and even their teacher(s) actually are. Introductory face-to-face meetings have shown to be a promising approach in promoting students' understanding with their peers, thereby lessening the level of unfavourable challenges highlighted in Table 2.1. On the other hand, the excellence of online social interaction and optimization of the online component enriches and supports the face-to-face component, whereby students feel increasingly comfortable with their peers when they meet in face-to-face sessions. From the students' point of view, careful structuring of the face-to-face and online components would lessen the challenges highlighted in Table 2.1.

2.4 Challenges that teachers face in the online component of blended learning

The challenges that teachers face with the online component of blended learning are categorized into four related themes as follows:

2.4.1 Teachers' Technological Literacy and Competency Challenges

Teachers' technological literacy and competency challenges are the first category of related reported challenges that teachers face in the online component of blended learning. From table 2.2, the studies of Lightner & Lightner-Laws (2016) in particular, reported that teachers lack confidence, time and willingness to learn new technology for teaching a blended course. Another reported challenge is teachers' lack of experience with

creating instructional content on their learning management systems (Maycock et al., 2018). Furthermore, some of the studies reported teachers' technological illiteracy (Brown, 2016) and resistance to use new technology for teaching (Bower, 2015; Hung & Chou, 2015). Other literacy and competency challenges reported include the difficulty of learning new technology for creating and managing online courses (Lightner & Lightner-Laws, 2016); teachers' resistance to technology (Brown, 2016; Wanner & Palmer, 2015); technological illiteracy and technological anxiety (Brown, 2016); technological incompetency (Pilgrim et al., 2018); and unwillingness to learn and use technology for teaching (Hung & Chou, 2015).

In a blended asynchronous learning setting (see table 2.2), overly focused on remote students; time wasting in troubleshooting technical problems; challenge of managing students in both modes were the key challenges that teachers face in steering an effective blended asynchronous class (Bower, 2015).

2.4.2 Online video challenges

The task of creating quality online video has been a top challenge for teachers especially in flipped classrooms. From table 2.2, Akçayır and Akçayır (2018) mentioned that teachers should pay more attention to the quality of instructional videos (interesting and short) and also, the provision of interaction or communication tools for easing students to obtain feedback. In addition, Akçayır & Akçayır (2018) reported that teachers face difficulty in making quality online videos. Similarly, Brown (2016) and Long et al. (2017) reported a similar challenge that blended learning teachers spend too much time and effort in creating online teaching content especially videos. Leo and Puzio (2016) revealed that blended learning teachers find it weighty to create and share online video due to slow internet connectivity.

2.4.3 Technological Operation Challenges

The third set of challenges that teachers face in the online component of blended learning is technological operation challenges. Teachers find it challenging to seamlessly operate and use instructional technologies proficiently. From table 2.2, teachers are worried with regard to troubleshooting technical problems (Leo & Puzio, 2016); time consuming resolving technical difficulties (Bower, 2015); and time consuming and difficulty in designing and managing online courses (Lightner & Lightner-Laws, 2016).

2.4.4 Teachers' Belief Challenges

The last category consists of the set of teachers' reported beliefs about using technology for teaching and technology as a barrier to competency (Pilgrim et al., 2018). It was also reported that flipped classrooms create a barrier between technology and teachers (Zengin, 2017), and teachers' scepticism about the effectiveness of online instruction in improving learning (Lightner & Lightner-Laws, 2016) were the reported negative perceptions and beliefs from blended learning teachers with regard to using technology for teaching.

Table 2.2: Teachers' challenges in the online component of blended learning

S/N	Categorical challenges	Challenges	Reference articles
1	Teachers Technological Literacy and Competency Challenges: This category involves the related technological literacy and competency challenges that teachers face.	Challenge in making students aware of the online materials that are available as part of their learning program	(Cuesta Medina, 2018)
		Challenge of training students in the use of online materials and effective approaches to autonomous learning	(Cuesta Medina, 2018)
		Lack of technological competency	(Akçayır & Akçayır, 2018)
		Lack of experience with creating instruction content on LMS platforms	(Maycock et al., 2018)
		Challenge in fostering an affective online learning climate	(Boelens et al., 2017)
		Challenge in learning a new technology to manage online courses	(Cheng & Chau, 2016)
		Technological Illiteracy	(Brown, 2016)
		Resistance to technology	(Hung & Chou, 2015), (Bower, 2015)

		Teachers lack of confidence, the time, and willingness to learn the use of technologies for teaching Technological anxiety	(Lightner & Lightner-Laws, 2016) (Brown, 2016)
2	Online Video Challenges: This is the category of challenges that are related to dealing with lecture videos from teachers.	Challenge in making quality online videos Spending too much time and effort in creating online teaching contents (videos) Time consuming and difficulty in creating and editing an online video content Sharing of online videos is weighty with slow internet connections	(Akçayır & Akçayır, 2018) (Long et al., 2017) (Brown, 2016) (Leo & Puzio, 2016)
3	Technological Operational Challenges: This category involves the challenges that teachers face with operating technology for teaching.	Challenge in making students aware of online materials that are available as part of their learning program Challenge of training students in the use of online materials and effective approaches to autonomous learning Resolving technical difficulties is time consuming Time consuming in designing and managing online course Time wasting in troubleshooting technical problems Managing students in both modes (online-synchronous & online students) is challenging to teachers. Overly focused on remote students	(Cuesta Medina, 2018) (Cuesta Medina, 2018) (Leo & Puzio, 2016) (Lightner & Lightner-Laws, 2016) (Bower, 2015) (Bower, 2015) (Bower, 2015)
4	Teachers Belief Challenges: this category involves the negative beliefs teachers have on the use of technology for teaching	Technology as a barrier to competency Flipped classroom regarded as one of the barriers between technology and teachers Skepticism about the effectiveness of online activities in improving learning	(Pilgrim et al., 2018) (Zengin, 2017) (Lightner & Lightner-Laws, 2016)

2.4.5 Discussion

Teaching in blended learning requires teachers to possess a certain level of technological skills and competence. Because of the role of technology in blended as well

as students' interest in technology, teachers must have the necessary technological and pedagogical support from their institutions to motivate them in fully integrating technology into traditional face-to-face teaching proportionally.

From table 2.2, it is clear that blended learning teachers are characterized with illiteracy and incompetency in using technology for teaching. The manifestation of illiteracy and incompetency with technology for teaching has certainly led to the other four categories of teacher challenges in table 2.2. Thus, technological beliefs, online video challenges and technological operation challenges are certainly altogether part of the wider scope of technological illiteracy and incompetency challenges from teachers in their online component of blended learning. Similarly, technological resistance and illiteracy are possibly connected in a way that teachers who are below-par in technological literacy or competency are likely to resist the use of technology for teaching, they would prefer resorting to the fully face-to-face teaching method.

The struggles in fully adopting technology for teaching as reported by (Brown, 2016; Hung & Chou, 2015) might be viewed as a distraction and disruption to instruction. Teachers might view blended learning as an instruction having two teaching components to deal with. Teachers' repulsiveness and unwillingness to learn and use online technology can possibly be linked to the studies that highlighted teachers' complains on lack of proper training and motivational support from their institutions in using technology for teaching (Medina, 2018). Although, teachers are themed with reluctance to technological use for teaching, institutional culture and practices contribute to teachers' negative perception and repulsiveness towards proper adoption and use of technology for teaching. For example, blended learning teachers revealed in an interview that their University has not particularly specified the type of blended learning to implement (e.g. either blended or flipped) and the type of blended learning suitable for a particular course or set of students (Jobst, 2016).

Another explanation for teachers' struggles in the online component of blended learning is that teachers might have to deal with the creation of online learning communities. These online communities would potentially foster and enable online discussions, help seeking, experience sharing etc., so as to establish and sustain a sense of closeness and socialization in the online component. Teachers might feel the necessity of an online community in order to reduce online transactional distance; the foreseen harms of isolation and alienation; and the lack of motivation for students to study (Chyr et al., 2017; Lightner & Lightner-Laws, 2016) in the online component. Secondly, because of the reduced seat time in blended learning - as the face-to-face meetings or class sessions are replaced with a significant portion of online activities, teachers might be worried about passive and inactive students in the online component and might, therefore, constantly need to keep in touch and monitor their activities possibly via email, text messaging, direct phone calls or even traces of their online group discussions. Thirdly, teachers might feel the need to guide their students especially novice students, in organizing their online activities, making them aware of the online learning materials available to them as highlighted in Table 2.2. The task of making students aware of online materials that are available as part of their learning program, guiding students in using the online material on their e-learning systems, and guidance to effective strategies to autonomous learning are challenging tasks to teachers (Medina, 2018). These perceived responsibilities and tasks might render blended learning teachers in having less time to master and learn the technology for teaching, thereby developing negative beliefs and scepticism of adopting technology for teaching. This possibly explains the identified challenges in the study (Akçayır & Akçayır, 2018) from teachers perspective as time consuming (Wanner & Palmer, 2015), higher workload (Sage & Sele, 2015), difficult managing tasks (Chen et al., 2015) and difficulty in planning the sequence of activities (Schneider & Blikstein, 2016).

Another possible explanation of blended teachers' resistance, incompetence and illiteracy in using online technology for teaching might be a result of their longevity and age-wise of teaching in the traditional face-to-face method. Teachers' satisfactory routine method, loyalty and proficiency of traditional face-to-face is challenged and disrupted by the ever emerging and innovating technology, as Akçayır et al. (2016) argued that the current generation of students is assumed to experience fewer problems in using technologies. This conversely means that older generation cohorts of teachers are likely to be less competent in using technology for teaching.

Another possibility that comes into the mix is that blended learning teachers might require need to constantly enrol in training sessions for every new technology installed in their educational institution or required to be used for instruction, which is also another burden or considered a 'course' by itself. Again, teachers are constantly under pressure to deal with technical issues and online interactions for their blended learning courses (Ocak, 2011). Teachers are likely to be confused about how to structure and manage the course materials through the integration of the face-to-face and online components. Arguably, by referring to the technological acceptance model, students' and teachers' perceptions of ease of use and perception of usefulness can be reasoned as the two major predictors of acceptance and use of online technology for educational purposes.

Lastly, the task of creating quality online videos has been a top challenge to teachers especially in flipped classroom (see Table 2.2). Definitely, teachers spend too much time and exert a lot of effort in creating quality videos for their students; reviewing, uploading and sharing a lengthy video might be time consuming, difficult and frustrating with slow internet connections. This is the reason why there is a growing concern that blended learning teachers might spend a significant amount of time in learning technologies for teaching than delivering the instructions to their students (Hung & Chou, 2015). As such, the challenges of creating quality online videos for students are self-

explanatory from the obvious results of teachers' technological incompetency, illiteracy and negative perceptions about the use of technology for instruction.

2.5 Challenges that educational institutions face in the online component of blended learning

The rapid nature of technological innovations and inventions means that educational institutions must always assess the provision of required technological support in meeting their teachers' and students' requirements. Educational institutions are liable for having a clear picture of their teacher's and students' technological literacy, competency and proficiency level in order to mount dependable and vigorous technological infrastructural support and diversified learning management systems as a prerequisites for implementing successful blended learning (Chen et al., 2014; Wang et al., 2015).

Over the years, the blended learning research community has provided guidelines and directions for institutional adoption and implementation of blended learning (see (Graham et al., 2013; Porter & Graham, 2016; Porter et al., 2016; Porter et al., 2014)). However, a substantial amount of understanding of the key challenges that institutions face in mounting suitable technologies for instruction is lacking in the blended learning research community. Blended learning literature focused on students' and teachers' struggle with the online component, whereas, little is said about institutions struggles in effecting a sustainable online component to blended learning.

Table 2.3: Educational institution challenges in the online component of blended learning

S/N	Categorical challenges	Challenges	Reference Articles
1	Technological Provision Challenges: This category involves the challenges that blended learning institutions face in providing the suitable and required technology for their teachers and students.	High cost of producing electronic content Cost of online learning technologies Overly complex technology – distractions to students Creation of tools that are flexible and compatible with other systems Complexity of technology Implementation of LMSs to suit students learning styles	(Dehghanzadeh & Jafaraghaee, 2018) (Akçayır & Akçayır, 2018) (Prasad et al., 2018) (Brown, 2016) (Brown, 2016) (Cheng & Chau, 2016)
2	Teachers Training Challenges: This category involves the challenges that blended learning institutions face in giving adequate training for blending technology into face-to-face teaching	Challenge in training teachers in the use of online materials and effective approaches to autonomous use of online technologies for instruction	(Cuesta Medina, 2018)
3	Other Challenges: This category involves other challenges that don't fall into the above-mentioned category	Lack of electronic technicians	(Dehghanzadeh & Jafaraghaee, 2018)

The challenges that teachers face with the online component of blended learning are categorized into three related themes as follows

2.5.1 Technological Provision Challenges

From Table 2.3 (Akçayır & Akçayır, 2018; Dehghanzadeh & Jafaraghaee, 2018) highlighted educational institutions' challenges on the cost of online technologies, maintenance cost, training costs and obtaining suitable 'state of the art' technologies to foster an effective blended learning environment. Secondly, the studies of Prasad et al. (2018) in table 2.3 highlighted that one of the challenges that educational institutions face is determining the level of technological innovations, robustness and complexity that is suitable for their teachers and students' online component activities. Institutions are challenged with regulating the level of technological complexity for instruction. This complexity can possibly be in the form of the learning management systems or the physical hardware installed in the institution; and also, the seamlessness of integrating

both the hardware and software in providing an effective online learning experience. Moreover, Brown (2016) mentioned that blended learning institutions face challenge of seamless integration of new technologies that are flexible and compatible with the existing or new technologies.

2.5.2 Teachers Training Challenges

The results in Table 2.3 can be understood that teachers in the blended learning mode of instruction suffer from a lack of institutional training in using technology for teaching. From table 2.3, Medina (2018) pointed out that one of the key challenges to educational institutions is providing effective training to teachers and students in attaining the benefits of the online component of blended learning. One possible explanation of institutions' reluctance to provide effective training support to teachers and students for online component activities in blended learning might be that educational institutions possibly feel relatively less training is required for both teachers and students due to face-to-face interventions, and teaching blended courses does not require extensive technological and online instructional training and support compared to fully online learning. Therefore, any difficulty or challenge encountered in the online component can be clarified and addressed during the face-to-face sessions.

Another possible explanation for institutions reluctance to provide effective training support to teachers is cost. For instance, not all institutions can pay for the cost of ‘quality matters’(QM) professional development to their teachers. Blended learning teachers that are not sponsored by their institutions on such professional training might fall short in delivering the promise of blended learning to their students. Institutional reluctance or perceiving the issue of technological training to teachers as less important is arguably one of the reasons that contributed to teachers' lack of motivation, teachers being less passionate in learning and embracing modern technology into their teaching.

2.5.3 Other Challenges

Lastly, the study of Dehghanzadeh & Jafaraghaee (2018) in Table 2.3 reported a lack of electronic technicians to fix and repair the institutions' online technologies. Similarly, some studies also highlighted the lack of immediate support for fixing technical problems of instructional technologies are frequent challenges that blended teachers experience while teaching with technology (Ocak, 2011).

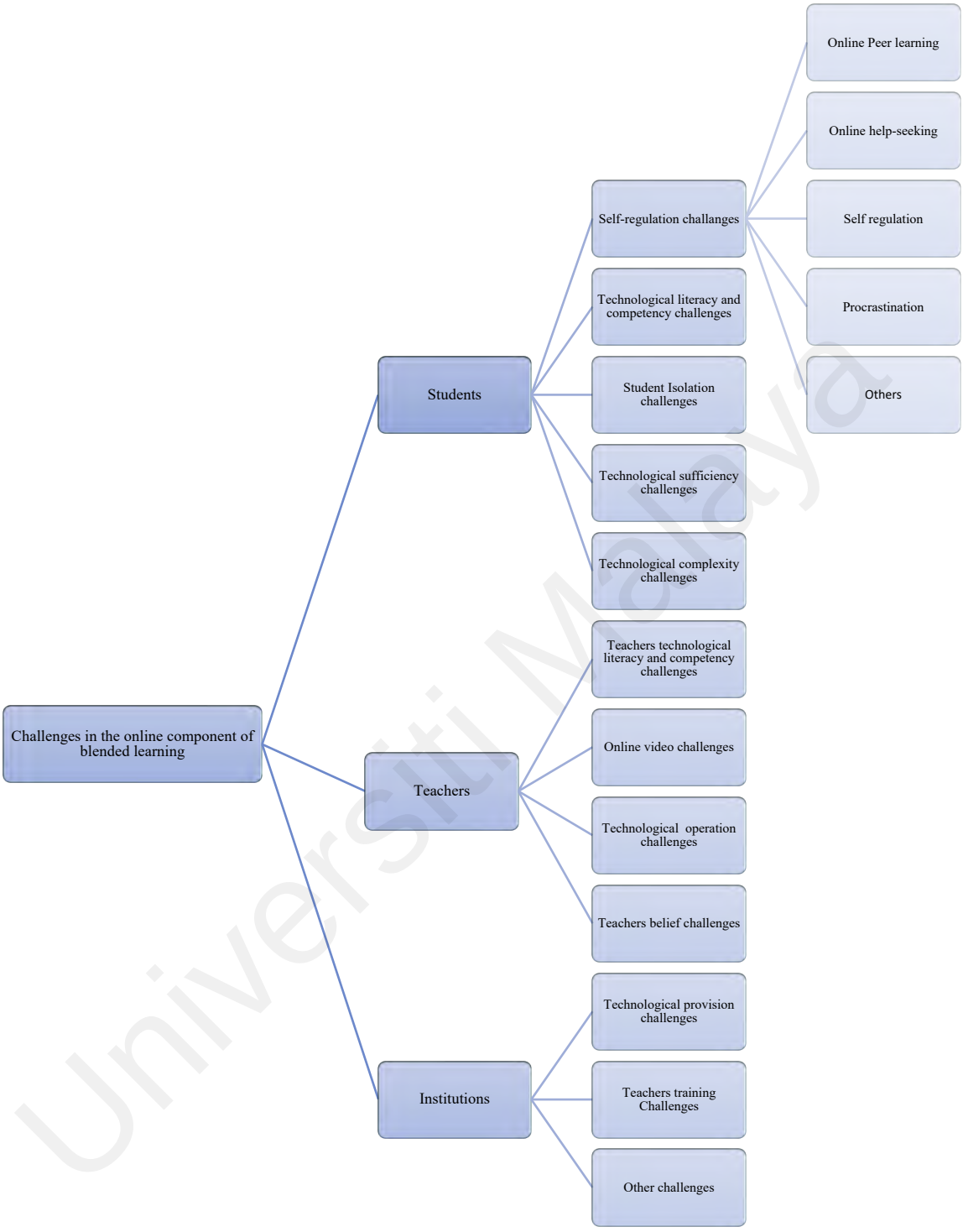


Figure 2.1: A taxonomy of challenges in the online component of blended learning

2.6 Discussion of findings on the challenges and implications of using technology in blended learning

As technology advances every day, new requirements in blended learning evolve, accompanied with a new set of challenges. Stakeholders therefore find it difficult to address these challenges. The skills required for students and teachers to access online educational materials change on a regular basis, as stated by (Maycock et al., 2018) and the speed at which technology is used for educational purposes is overwhelming for both digital and non-digital born users. The findings of this review have resurfaced several challenges that hinder the true realization of blended learning mode of instruction from the perspectives of students, teachers and educational institutions.

This review has uncovered a number of related challenges with the use of technology from both students and teachers. From our findings, it is understood that students are willing and positive about using technology for studying. Most of the technological challenges that students encounter in their online components point to their inability to make proper use of the available technology for studying; and the prospects of the level of support the technology would offer to them. This is in line with various studies that labelled students of nowadays as technological born. Thus, blended learning students have accepted the use of technology for studying, but they cannot effectively use and maximize the benefits afforded by such technologies for their online component studying. Blended learning institutions should support students to effective use technology for their online component studying. Although, researchers in various online learning disciplines have proposed varied approaches for addressing technological complexity, literacy and competency (Klašnja-Milićević et al., 2011; Rahman & Abdullah, 2018); these initiatives have proven to ease learning systems complexity and also improve students' overall learning performance. As such, these approaches should be tested specifically in blended learning environments.

On the other hand, the challenges of using technology for teaching have been the title of teachers challenges in this review. Largely, these challenges originated from teachers' negative perceptions and skepticism about the effectiveness of technology for instruction, which resulted to their reluctance, illiteracy and incompetency; and consequently, their inability to proficiently operate and use technologies for teaching. This review shows that the technological challenges that teachers encounter point to their unwillingness and reluctance to use technology for teaching.

It is quite clear that blended teaching involves the combination of varied sets of technological tools and teaching methods that require careful consideration to improve students learning experience. This review has shown that the challenges associated with blended learning as a whole have greater impact on blended teachers because educational institutions are more concerned about their students compared to their teachers; and also, students are more proficient and technologically competent in using technology for studying than teachers using technology for teaching. Furthermore, it is still unclear whether teachers' reluctance to use technology for teaching is largely due to their longevity in face-to-face teaching, as some studies (Ocak, 2011) suggested that teachers need to overcome their own fears by themselves to excel in effecting successful blended learning; or it is largely due to their institution's slackness in investing and provision of effective intervention training and development programs.

In general, the blended learning research community have focused more on students' challenges; on the other hand, relatively less attention was given to teachers' struggles. Thus, there is a need for additional investigations on correcting teachers' negative perceptions of using technology for instruction. Likewise, blended learning institutions should contribute by easing these negative perceptions through the development and training programs for their teachers. Interestingly, it is important to discuss that this review has not found any complain about teachers' self-regulation challenges. In addition,

this review has found few studies highlighting a generalized training exercises/programs those educational institutions offer to pre-service and in-service teachers. These training programs were generalized workshops/programs for blended learning as a whole.

Supposedly, the concept of technological affordances can be adopted to lessen the level of the identified challenges in using technology for teaching and learning. Because many of the available technologies deployed in educational institutions, as well as technologies that students use in their homes, are not explicitly designed for instructional purposes. The success of technologies depends on educators' capability to analyze the educational merit, affordances and constrains in them so as to strategically repurpose them for educational context (Bower & Sturman, 2015; Mishra & Koehler, 2006). Alternatively, educational institutions and blended learning practitioners could suggest and recommend certain types of technologies deemed as a better fit and suitable for scaffolding both students' and teachers' technological competency and affordances for a better online component of the blended learning experience.

Thirdly, the review has shown that educational institutions' challenge with the online component of blended learning is mainly with the provision of effective training support to teachers and the provision of suitable hardware and software technology. This literature review section also highlights 'cost' as an impediment for educational institutions in providing the optimum platform for blended learning instruction. Educational institutions should periodically assess how their students' and teachers' technological competency levels and requirements have changed over time in order to mount and made available the needed technology for instruction. Educational institutions should periodically evaluate their blended learning by reviewing and evaluating their standards, for instance, using quality matters (QM) rubric.

Arguably, the challenges identified from students, teachers and educational institutions' perspectives are not mutually exclusive, they cross boundaries. For example,

the lack of sufficient technological competency and literacy in using technology for instruction from teachers is related to the lack of effective training support from their institutions. Similarly, students' ability to self-regulate their behavior as well as the motivation and zeal to learn and use online technologies for studying largely depends on the technological infrastructure and services provided by their institutions. Likewise, when institutions do not support teachers' professional development, teachers are bound to fall short in the effective use of technology for teaching, fostering their students to optimize their online activities as such, rendering students to poor self-regulation behavior (reluctance to help seeking, procrastination, etc.) and seclusion.

2.7 Related works on scaffolding student's self-regulation in blended learning

Self-regulated learning (SRL) has received increasing attention from researchers from various computer-based learning environments in multiple disciplines such as psychology, education, computer science etc. (Bellhäuser et al., 2016; Broadbent, 2017; Broadbent & Poon, 2015; Loeffler et al., 2019; Sitzmann & Ely, 2011). In today's educational settings, particularly Universities which adopts technology for online courses, relatively higher self-regulated learning competency is required from every student. Over the years, this competency has been fostered through various training interventions in face-to-face environments or components. For the online components, researchers have incorporated various self-regulated learning strategies into their online environments through learning systems intuitive designs to support their students online component studying (e.g. see (Su, 2020)). In order to understand how blended learning researchers, scaffold their students self-regulated learning, electronic databases (Science direct, Web of Science (WoS), Springerlink, ACM digital library, IEEE Xplore, Wiley) were searched to carefully elicit and extract the empirical studies that proposed a self-regulation scaffolding approach for supporting blended learning students in their online

component. Keywords from influential studies in synergy with other influential blended learning studies (see (Akçayır & Akçayır, 2018; Boelens et al., 2017)) were adopted, and then keyed into the electronic databases search interfaces. In addition, Google scholar database is searched using 'snowballing search technique' to deeply uproot every relevant study. It is important to clearly mention that most of these studies have not explicitly used the '*online component of blended learning*' phrase, but rather used instances such as homework, home assignments, out of the classrooms to refer to the online component of blended learning.

The results of the search show that majority of these studies have proposed solution approaches or examined self-regulated learning in the flipped classroom type of blended learning. From the existing studies obtained from the databases, the methodological approaches that researchers have adopted for scaffolding self-regulated learning is categorized into two: 1) scaffolding self-regulation through external scaffolds or learning systems designed to facilitate and support students' self-regulated learning; 2) scaffolding self-regulation strategies - online help-seeking self-regulation strategy has been the most prominent.

From Table 2.4, Lin et al. (2016) proposed an approach to improve student's self-regulation in the online component of blended learning by developing a self-regulated learning system through utilization of group awareness and peer assistance as external scaffolds in developing a system called 'self-regulated learning with group awareness and peer assistance' – (SLR GAPA). The study measured students' participation, help seeking initiation and responses in relation to the scaffolding system. Then the impact of the self-regulation scaffolding approach was measured through self-regulated learning behaviour and overall learning achievement of the students in their online component of blended learning. The approach resulted in benefiting students with relatively low self-regulation competence more than those with relatively higher skill or competence. The study also

shows that external stimuli can motivate learners to better self-regulate and persist in learning activities in their online components. The major drawback of the study is that it focused on improving the generalised students self-regulated learning without focusing on any of the self-regulated learning strategies.

Another study from Shyr & Chen (2018) involves the design of a learning system to foster students' self-regulation and overall academic satisfaction and performance. The study examines the use of a learning system as a metacognitive tool for improving students learning competencies. The aim was to combat some common challenges that students face in a flipped classroom setting which include inadequate pre-class preparation, self-regulation as a whole and the disorientation nature of flipped learning. Results of the study show that learning with hypermedia through external scaffolds improves learning performances and students' preparedness prior to their face-to-face class component which in turn positively impacts students face-to-face flipped sessions for interacting and engaging more with their instructors and peers. However, the experimental approach was limited to scaffolding students' generalized self-regulation of language learning pedagogy in the flipped classroom.

The study of Lai & Hwang (2016) designed a learning system consisting of four sub-modules for scaffolding students' self-regulation. The system consists of 'out of class learning component', 'a self-regulated monitoring system component', 'a teacher management system component', and 'a database component'. The out-of-class learning system module consists of the e-books and quizzes provided by the teachers in which students are expected to read those learning materials and took the quizzes before commencement of the in-class activities. The self-regulation monitoring system module is a self-evaluation module that enables students to set their learning goals and evaluate their learning performance before and after their face-to-face classes. The teacher system component allows teachers to upload learning materials such as e-books for students and

to give students comments and feedback based on their learning progress. The database component not only records the students' learning logs and their profiles but also provides them with diagnoses based on the teacher's set of criteria of self-regulated learning. Experimenting with the system has shown to significantly improve students overall learning achievement and self-regulated learning behaviour.

The study by Silva et al. (2018) investigates the use of learning analytics for scaffolding students' self-regulated learning in a flipped classroom which helps students identify strategies that can increase their academic performance, which results in positively scaffolding students' self-regulated in their online component of blended learning. However, the study does not involve the use of learning system design features to precisely scaffold students' self-regulation in their online component of blended learning. Also, the study uses students' self-regulated learning for the purpose of understanding their self-regulation needs.

Another study by Chen & Hwang (2019) uses an instant response system (IRS) which integrates an online course with a collective issue-quest flipped classroom as a learning approach to support flipped learning activities specifically on students' learning performance, self-regulation, collective efficacy and satisfaction for scaffolding students self-regulation in flipped learning. The use of interactive technologies was able to determine the three dimensions of self-regulation, namely environment, task strategies and help seeking, and also enhance students' interactivity and collaboration during a flipped learning process.

On the other hand, the study of Van Laer & Elen (2018) proposed an unfamiliar type of scaffolding approach by proposing a framework that can be used to characterize support for learners' self-regulation in blended learning environments. The study proposed an instrumentalized framework for characterizing supports for learners' self-regulation in blended learning instruction, which can serve as a basis for empirical trials

and investigations to uncover blended learning redesigns and guidelines. The instrumentalized framework elaborates on seven attributes of learning environments that may be expected to support self-regulation. However, the study does not involve the use of technologies or learning systems for scaffolding self-regulation

Table 2.4: Existing approaches for scaffolding students' self-regulation in the online component of blended learning

S/N	Articles	Blended learning type	Technique/Approach
1	(Chen & Hwang, 2019)	Flipped classroom	The use of instant response system (IRS)-facilitated collective issue-quest strategy to engage students in self-regulated flipped learning.
2	(Shyr & Chen, 2018)	Flipped classroom	The use of technology that employs planned instructional strategies with sustainable support of self-regulation.
3	(Van Laer & Elen, 2018)	Blended learning	A framework to characterize support for learners' self-regulation.
4	(Silva et al., 2018)	Flipped classroom	The use of learning analytics to improve self-regulated learning in flipped classrooms which helps students in identifying strategies that can increase their academic performance.
5	(Lai & Hwang, 2016)	Flipped classroom	System consisting of: out of class learning system; a self-regulated monitoring system; a teacher management system; and a database
6	(Lin et al., 2016)	Blended learning	Group awareness and peer assistance as external scaffolds to foster Self-regulation
7	(Akram et al., 2019)	Blended learning	An approach for intervention of procrastination behavior through monitoring and tracking procrastinating student's homework submission
8	(Hardin & Koppenhaver, 2016)	Flipped classroom	The use of discussion board for instant help
9	(Kopcha et al., 2015)	Flipped classroom	Web-based help-seeking tool called (EchoLu) designed based on four (4) design principles: Student's privacy needs in help seeking; student's awareness of teacher support; promotion of observability peers' help seeking activities, promote social support.
10	(Fautch, 2015)	Flipped classroom	The use of discussion board to offer instant help in form of feedback

Another common approach for scaffolding students' self-regulation by blended learning researchers is by encouraging students to adopt the defined self-regulation strategies. As mentioned earlier, most of these studies have focused on students' online help seeking self-regulation strategy. From Table 2.4, the studies of (Fautch, 2015; Hardin & Koppenhaver, 2016) used online discussion boards and text messaging to offer instant

help as a form of feedback to their students. Students post or seek help out of their face-to-face classrooms by posting question in the form of texts on online help discussion boards in which fellow students or peers could answer. The approach was found to increase the level of scaffolding online help-seeking self-regulation initiatives for their studying. However, the approach is arguably not different from discussion boards without any structure or embedded scaffolding functionality.

Another interesting study was carried out by (Kopcha et al., 2015) that designed a web-based online help-seeking tool called EchoLu for scaffolding online help seeking self-regulation in flipped classrooms based on certain design principles. The design principles of the learning system was built based on addressing the privacy needs of students in help-seeking by '*posting questions anonymously';* the increase of students' awareness to teacher support for help-seeking through '*notification system that informs students of teacher activities automatically'*; promoting observability of peers' help-seeking activities through '*enabling posts to be visible to all class members, following others, subscribing to a specific activity (i.e., bookmarking), notification system'*; and promoting social interaction support through *personal walls, public profiles, likes/comments*.

The study of (Akram et al., 2019) thus, set a new research direction in blended learning by presenting the first intervention for procrastination behavior in the online component of blended learning through monitoring and tracking procrastinating students homework submission behavior. The study leverages the use of algorithms that predicts student's procrastination behaviors through computer-supported learning environments. This would enable teachers to be aware of their students' online component behavior and more importantly the procrastination behavioral trend. Thus, teachers in turn could directly contact and in a way intervene for high procrastinating students. One of the main shortcomings of this study or approach is that it does not combat the procrastination

behavior or support students in overcoming procrastination dysfunctional behavior but rather supports teachers in identifying the students with high procrastination behavior and who are struggling and in need of immediate intervention from their teachers.

2.8 Discussion on self-regulation strategies

Over the years, researchers have identified and pinned several self-regulated learning strategies. Self-regulation learning strategies are categorised into cognitive, metacognitive and resource management strategies. Cognitive strategies such as rehearsal aim to help learners in acquiring knowledge at a surface level by aiding students in retaining knowledge. Metacognitive strategies refer to the awareness to monitor, plan, and regulate learning (Broadbent & Poon, 2015; Yukselturk & Bulut, 2007), while resource management strategies require students to use resources around them such as their peers (Puzziferro, 2008). Self-regulated learning strategies affect learning outcomes by assisting learners to acquire and retain knowledge in a structured and methodological way. The application of these self-regulated learning strategies is theorized to predict high academic achievement in the traditional learning environment (Broadbent & Poon, 2015). Findings from the study of (Broadbent & Poon, 2015) show that the strategies of time management, metacognition, effort regulation, critical thinking, and peer learning were positively correlated with academic outcomes, whereas rehearsal, elaboration, and organisation had the least empirical support.

From Table 2.4, it can be seen that blended learning researchers and practitioners have focused more on resource management strategies such as help-seeking. Although this research study has found only one metacognitive learning strategy, which is procrastination. However, a key resource management self-regulation strategy which is peer learning, is missing. This clearly shows the need for more research on all three cognitive, metacognitive and resource management self-regulation learning strategies.

2.9 Limitations of student's self-regulation scaffolding approaches in the online component of blended learning

It is obvious that the existing blended learning approaches for scaffolding self-regulation in the online component of blended learning are limited in primarily focusing on designing learning systems and tools to scaffold self-regulation and have not considered scaffolding solutions to other types of self-regulation strategies more importantly peer-learning self-regulation strategy of the resource management category. Although, approaches for scaffolding online help seeking have considerably been researched, students are still in need of a cohesive and solid learning support that encompasses several key aspects of self-regulated learning for the online component of blended learning. As discussed earlier, the pivotal challenge identified from the above literature review is students' self-regulation which needs careful addressing. Students' lack of social ambience, hunger for social interaction, difficulty in connecting with the right learners in order to gain support for the online component studying, and various other detrimental setbacks that students face have negatively affected their online studying and consequently deprived them from reaping the promised rewards of blended learning instructional model. The significant importance and foreseen benefits of peer learning in combating and alleviating these self-regulation worry that students face as well as improvement in their overall learning achievement, have arguably led researchers in pleading and insisting on the need for online peer-learning self-regulation strategy scaffold in blended learning instruction so as to deliver its promise of quality instructional excellence. Undoubtedly, the next decisive step forward for research in blended learning is engaging students to peer discussions in a structured and effective manner.

2.10 Summary

This chapter presents and explains the current challenges in the online component of blended learning from students, teachers and institutional perspectives. Although, it is very difficult to identify all the challenges due to the rapid advancements of technological innovations and the complex nature of human behavior. This research discussed the concept of blended learning, the advantages of blended learning instructional approach over other related instructional approaches. It is obvious that researchers and blended learning practitioners have paid more attention on addressing the overall blended learning design challenges, comparing the types of blend and other blended learning dimensions. Secondly, researchers and blended learning practitioners have focused more on students' challenges in the online component of blended learning, thus teachers and education institutions challenges receiving relatively less consideration. This chapter also shows that students suffer mainly from self-regulation challenges and inability to effectively use technology for studying; teachers main challenge is their unwillingness and negative perception of using technology for instruction; while educational institutions find it difficult in providing the correct and sufficient technological infrastructure, as well as providing effective training support to their teachers. This chapter also discussed the various approaches proposed for scaffolding students' self-regulation challenges in the online component of blended learning. Keeping in mind that the goal of blended learning to students is to provide them with richer learning experience through careful structuring of face-to-face and online components, it is proclaimed that these two components are meant to complement each other and be mutually beneficial thereby reducing the worries associated with each component. The pivotal finding from this chapter in relation to students' self-regulation existing blended learning approaches for scaffolding self-regulation in the online component of blended learning are limited in primarily focusing on designing systems and techniques to scaffold self-regulation and have not considered

scaffolding solutions to other types of self-regulation strategies more importantly peer-learning self-regulation strategy. Thus, this chapter has clearly identified the recommended research in need for blended learning instruction and more importantly, the chapter has identified the research in precedence which is scaffolding students peer learning self-regulation strategy in the online component of blended learning.

CHAPTER 3: PEER LEARNING PRACTICE AND GROUP FORMATION

This chapter is a sequel and the result of the key finding of the previous chapter (chapter 2). With students' peer learning self-regulation strategy identified in the previous chapter as the missing piece in todays blended learning instruction, this chapter aims to explore and understand the related research, elements, evidences and entities that constitutes the formation of an effective peer learning. The chapter begins by defining peer learning and briefly discussing its significance to overall learning achievements. Then, the subsequent sections discuss the common peer learning practice in a typical face-to-face classroom, and the related studies carried out on scaffolding online peer learning from various research domains. Subsequently, the chapter explains the various schemes of forming groups in both educational and non-educational settings, the significance and impact of forming groups for learning, and the different criteria considered in forming groups for learning purposes in various educational settings.

3.1 Peer Learning and its significance

Lotan (1994) define peer learning as a student-centered teaching and learning method that facilitates the exchange of knowledge among learners. It departs from traditional approaches which emphasize the superiority of the teacher over students and instead, builds on the concept that learning is more effective when knowledge is constructed and shared among peers. The term 'peer learning' refers to a situation where peers support each other in a learning process. Peer learning occurs among mates from similar social groupings or educational level, who are not professional teachers, but helping each other to learn and in doing so, learning themselves (Topping & Ehly, 1998). This is because research has shown that teaching others increases one's ability or knowledge of the related subject matter (Agrawal et al., 2014). From the studies

of (Jacobs et al., 2008; McGuire, 2006; Parr & Townsend, 2002), peer learning can be categorized into three types, as described below:

I. Peer tutoring: This involves a single member appointed as a guide or mentor and shares his/her knowledge with other fellow peers or students through formal tutorials.

II. Cooperative learning: This involves forming small groups of learners working together in small groups in which they are individually accountable for the assigned task or work, yet also evaluated as a group. Cooperative learning groups usually work face-to-face.

III. Collaborative learning: A clear example of collaborative learning from the categorical works of (Jacobs et al., 2008; McGuire, 2006; Parr & Townsend, 2002) involve individuals from different geographical area working together on an assignment online via the internet. These individuals team up in a less structured way to explore and share skills together.

The advantages of peer learning in higher education can be explained by (Bandura & Walters, 1977) social learning theory which suggests that students' behavioral and cognitive learning processes become integrated in an environment which encourages social interactions and self-directed learning (Fernández et al., 2001; Idris et al., 2019). This theory views knowledge as socially constructed, resulting from dialogic and interactions between teachers and learners, and amongst learners themselves. From a constructivism point of view (Evans, 2015), peer learning articulates mechanisms in which learners internalize knowledge through the accommodation and assimilation processes and construct new knowledge from their experiences. Most peer learning models are based on the concept of collaborative learning guided by behavioral, cognitive and constructive theories (Idris et al., 2019; Jacobs et al., 2008).

In educational settings, the primary goal of peer learning is for students to work together in small groups to enhance one another's learning. A group is a set of individuals who will work together to accomplish a given task. There are several benefits of learning in a small group: By forming groups for learning, peers tend to concentrate and focus attentively on their group members without veering to other unreliable sources of information/knowledge (Burke, 2011); groups typically have more information than a single individual because groups have pool of resources and information available due to the variety of backgrounds and experiences among them (Burke, 2011). Other benefits of learning in a small group is that group members who are engaged in problem solving are more committed to the solution and are better satisfied with their participation in the group than those who are not involved (Burke, 2011). The study of (Smith et al., 2009) showed that peer discussion enhances understanding even when none of the students in the discussion group originally knows the correct answer. Peer learning combines individual accountability to ensure that students work on their own with positive interdependence to ensure that all students in a learning group participate in group work (Johnson et al., 1991; Rhem, 2012). Effective peer learning also leads to resolution of socio-cognitive conflict among group members (Fischer et al., 2002).

Peer learning in non-educational settings is mostly termed as 'collaborative learning' (Effeney et al., 2013) which has been a common learning strategy particularly for crowd workers, but in educational settings, peer learning is considered a self-regulated learning strategy. In particular, online peer-learning self-regulation strategy has been widely regarded as an underutilized self-regulation strategy (Broadbent, 2017; Broadbent & Poon, 2015; Rasheed et al., 2019) despite several influential studies telling its significant pedagogical benefits on learning achievements (Chase & Okie, 2000; Coetzee et al., 2015; Millis & Cottell Jr, 1997; Smith et al., 2009; Springer et al., 1999). The study of (Broadbent, 2017) stated that online peer learning self-regulation strategy is an

'underused' learning strategy in blended learning. Similarly, the study of (Kotturi et al., 2015) labeled online peer learning as 'valuable yet underutilized'.

3.2 Peer learning practice in educational settings

Today's modern technology has made it possible for students to interact with other learners located in geographically distant areas across the globe. These technological advances have led to the emergence of new research fields such as Computer-Supported Collaborative Learning (CSCL) and Computer-Supported Cooperative Work, where the goal is to use technology to support collaboration (Jeong & Hmelo-Silver, 2016). This resulted in a large body of work on CSCL and other forms of technology to enhance the learning environment/virtual environment (Ainsworth & Chounta, 2021; Fischer et al., 2013; Jeong & Hmelo-Silver, 2016; Maqtary et al., 2019; Muñoz-Carril et al., 2021; O'Malley, 2012).

Over the years, peer learning has been practiced in educational settings mostly in physical face-to-face classroom settings. It is believed that educationists have understood the importance and value associated with learning in peers despite the existence of diminutive research evidence on students' peer learning in academic environments. Teachers in a face-to-face classroom setting arrange and engage their students for peer learning by grouping them to work together in dyads or other small groups, typically consisting of three to five members. These peer learning arrangements typically happen in the face-to-face classrooms because most educational institutions of nowadays are blended (face-to-face and online components) in which students are expected to autonomously manage their study outside of their face-to-face classrooms by using technology. Teachers/tutors have been adopting this learning strategy in motivating their students to learn and it has shown that their students learning achievements increases more than if they did active learning. Researchers have reported that even trying very

simple peer learning methods in physical classroom settings has shown to be effective in scaffolding students' cognition and learning outcomes in general (Ruhl et al., 1987). These classroom peer learning initiations are mostly formed by the tutor or by the students themselves. However, these groups enable students to discuss and learn from one another in an arbitrary fashion without any defined structure for forming effective peer learning groups.

In online learning environments, engaging peer students in learning has generally been devised via asynchronous discussion, typically using discussion forums (Chen & Looi, 2011) on the learning systems discussion platforms. Other related peer discussions have focused on a pair of students or a student and a teacher rather than grouping students to work together as a team (Gweon et al., 2006). The asynchronous peer discussion taking place on the students learning systems discussion boards was found to have minimal impact in scaffolding peer learning self-regulation strategy. Teachers and their students in universities and other higher educational institutions have used these discussion forums available in their learning systems such as Moodle, Blackboard or even created informal discussion groups on social media platforms such as Facebook for asynchronous chat between students. However, these asynchronous peer discussion groups for educational settings are found to be ineffective in properly scaffolding peer learning as well as scaffolding students' cognition, skills and motivation in learning.

3.3 Related works on peer learning scaffolds from various research domains

This section explains the various peer learning scaffolding approaches from various research domains.

Table 3.1: Related works on peer learning scaffolds from various research domains

S/N	Articles	Research domain	Focus	Limitations
1	(Esfandiari et al., 2019)	Crowd workers	Forming peer learning groups based on learning potential and Affinity structures	Focused only on forming groups based on learning potential and affinity in non-academic setting
2	(Coetzee et al., 2015)	Crowd workers	Focused on Incentivizing students for peer learning	Focuses only on providing incentives to motivate crowd workers and MOOC students peer learning activities
3	(Kotturi et al., 2015)	Philosophical paper	Incentivization and fostering social ambience	Lack of group formation e.g., based on (learning potential and affinity). Discussions on peer learning incentivization and fostering social ambience
4	(Chen et al., 2020)	K-12	Uses reciprocal peer learning with a social robot to scaffold children learning and engagement.	Peer learning between kindergarten kids and a social robot

The study of (Esfandiari et al., 2019) investigates the formation of online peer learning through group formation to optimize learning potential and affinity structures by the formation of learning models with an algorithmic solution. The study is limited by only focusing on group learning potential and affinity formation without other key components that are critically required for effective peer learning. Furthermore, the study has focused on scaffolding peer learning for Amazon Mechanical Turk (AMT) crowd workers. The study of (Coetzee et al., 2015) investigated the design of a synchronous online peer learning system for an online for scaffolding crowd workers in learning new tasks at work

and students in learning MOOCs course material. One of the interesting findings of the study was incentivizing the Amazon Mechanical Turk crowd workers to help one another in achieving better learning results. Although the study investigates designing synchronous peer interaction for MOOCs student as well as crowd workers, it is limited by only focusing on providing incentives to motivate crowd workers and MOOC students peer learning activities.

The study of Kotturi et al. (2015) articulates and addresses three adoption challenges for global-scale peer learning and offers three corresponding socio-technical remedies. I) Incentivization to combat reluctance to the use of the system and social loafing; addressing the wrong perception of system designers in assuming that learning systems are merely social sites; II) Addressing the absence of ambient social encouragement that traditional settings provide; III) Scaffolding peer learning from behind students learning systems in which teachers need to for example leverage students demographic and behavioural information in carefully structuring their peer instruction. However, the study is limited by solely focusing on providing incentives for peer learning as well as designing systems to combat social loafing and interaction. The study has not considered the formation of an effective peer learning group structure such as the number of peers in a peer group, grouping high and low-skilled students to disseminate skills and knowledge across peers, etc. Social loafing can be defined '*as the tendency of a person to put forth less effort when they are part of a group*'. Because all members of the group are pooling their effort to achieve a common goal, each member of the group contributes less than they would if they were individually responsible.

It is clear that the adoption of peer learning strategy in supporting learning and instruction is steadily on the rise with studies such as (Chen et al., 2020) that used reciprocal peer learning with a social robot to scaffold children's learning and engagement. Another related effort concerning peer learning scaffolds is the recent

exploratory study that analyses the nature of peer feedback during a collaborative writing assignment in blended learning (López-Pellisa et al., 2020) which does not propose a scaffold for peer learning. The study by Cheng & Chen (2018) proposed a scoring mechanism to encourage students to learn from their peers. However, the study shows that students are left to form peer groups by themselves without any guidelines or structure to participate in face-to-face classrooms.

In summary, most of the proposed approaches for scaffolding online peer learning have aimed at the crowd workers of amazon mechanical turk (AMT). These studies have diverse focuses and each of these study focused on a certain dimension and aspect that contributes to peer learning participation. One of the noticeable themes across these studies or aspects is offering incentives to motivate peer learning participation and engagement or motivation to participate and concentrate on peer learning. Peer learning requires stimulation and willingness to work in a group and necessitates interacting with peers.

3.4 Formation of learning groups

The study of Fischer et al. (2002) show that effective collaborative learning is rarely achieved simply by putting learners together without some supportive instruction and defined structure to serve as the recipe for sustaining the knowledge construction and dissemination across the learners. While the focus of this study is on peer learning rather than collaborative learning, it is clear that peer learning group formation necessitates definitive structure and pedagogical support from both the teachers as well as the technology (learning system) in use.

Small group work is a strategy commonly used in learning situations (Cohen, 1992, 1994; Davidson et al., 2014). Educationists and researchers in education have long identified learning in small groups as a motivator and effective learning strategy in

scaffolding students learning initiative. Learning in small groups is a learning strategy commonly used in various educational settings (Forsyth, 2018). A group of five (5) to eight (8) persons is considered a small group (Forsyth, 2006; Lohman & Finkelstein, 2000; Merlin et al., 2020; Mucchielli, 2017). However, the literature that explains and addresses peer learning shows that peer learning typically takes place by forming smaller-sized groups involving three (3) to five (5) members (see (Agrawal et al., 2014; Esfandiari et al., 2019; Kotturi et al., 2015; Zher et al., 2016)). Although, any group consisting of three (3) to eight (8) members is considered a small group (Merlin et al., 2020).

There are numerous studies in various research domains that contributed to how to form successful teams/group to accomplish a given task (Agrawal et al., 2014; Agrawal et al., 2017; Anagnostopoulos et al., 2010; Basu et al., 2015; Esfandiari et al., 2019; Lappas et al., 2009; Rahman et al., 2019). Similarly, group formation in online learning settings has been studied primarily in the context of task assignments (Anagnostopoulos et al., 2010; Roy et al., 2015; Lappas et al., 2009; Rahman et al., 2015).

3.5 Peer-Learning group formation

3.5.1 Forming groups with learning potential

One of the primary goals of peer learning involves sharing ideas and skills among members of a small group so that each group member benefits from the skills of the other members. Research have shown that for effective peer learning to take place, peers having different skill set or different skill level of a particular skill must be grouped together to perform tasks (Agrawal et al., 2014; Anagnostopoulos et al., 2010; Esfandiari et al., 2019). A peer can only learn from another peer if the skill of the latter is strictly higher than the skill of the former; or one of the pair has a different skill set that the other does not have (Agrawal et al., 2017; Esfandiari et al., 2019). Learners are able to increase their skills or abilities through interactions and collaborations with more capable peers

(Agrawal et al., 2014; Hertz-Lazarowitz & Miller, 1995). In addition, research has shown that higher ability/skilled members also increase their skills as teaching others has been shown to be positively correlated to an increase in ability (Agrawal et al., 2014; Bargh & Schul, 1980; Webb, 1989). The learning potential of a least skilled member from a highest skilled member of a peer learning group is defined as the difference in skills between the two of them (Agrawal et al., 2014; Agrawal et al., 2017; Esfandiari et al., 2019). The learning potential of a peer learning group is the sum of learning potentials of all its members.

In order to form small groups for peer learning, one of the promising approaches that researchers adopt is grouping peers from the two ends of the spectrum in terms of skills and talent/ability (both highest skilled (Hs) and lowest skilled (Ls)), and ensuring that each group is having a highest and a lowest skilled member. This notion implies that the lowest or less capable peer would benefit and learn from a higher-skilled member of the same group.

3.5.2 Forming groups with affinity

In group formation involving human tasks accomplishment, group affinity involves the formation of small groups with the members having a natural inclination or fitting with one another which arguably determines how well group members collaborate and work together as a unit or team (Esfandiari et al., 2019). Successful teams have members with greater affinity with each other (Evans et al., 2017; Rahman et al., 2015). Groups with low affinity often suffer from low productivity and take longer to complete given task (Esfandiari et al., 2019; Lappas et al., 2009; Rahman et al., 2015).

Although, research on forming task completion groups with affinity inclination and stickiness structures has been primarily studied in non-educational settings, these studies have not clearly defined the most applicable defining elements or attributes for

structuring groups to foster affinity as well as measuring group affinity (e.g. see (Esfandiari et al., 2019; Rahman et al., 2015)). These studies have typically measured or formed groups for fostering affinity inclination by explicitly eliciting common socio-demographic or personality information commonly using questionnaire tools (see (Esfandiari et al., 2019; Rahman et al., 2015; Yan et al., 2014)). Arguably, different researchers in various research domains could use various scales in determining the suitable, easiest or convenient way of coupling peers to form an effective team based on their natural inclination such as the use of personality traits 'the Big 5 personality traits', commonly found in computer based learning systems (see (Normadhi et al., 2019; Tlili et al., 2016)) etc.

Recently, online learning researchers (see (Kotturi et al., 2015; Kulkarni et al., 2015)) have articulated that the formation of learning groups with peers from diverse geographical locations and culture or heterogeneous background increases stickiness and therefore have a positive impact on both group dynamics and affinity inclination (see (Kotturi et al., 2015; Kulkarni et al., 2015)). Moreover, a recent study by (Bilgin et al., 2015; Eid & Nuhu, 2011; Merlin et al., 2020) mentioned that the inclusion of different experiences, cultures, and knowledge has a positive effect on learning in small groups while improving interaction. In peer learning literature specifically, studies such as (Idris et al., 2019) have reiterated that interactions among peers of different nationalities benefit them from gaining cultural experiences and related global issues of the subject matter. Diversity contributes to the learning contexts and adds fresh viewpoints during a classroom discourse (Charles-Toussaint & Crowson, 2010).

As such, the literature on group affinity for small group learning and task accomplishment has shown the application and the possibility of adopting various human factors that could be scaled in forming groups with relatively stronger and effective affinity inclinations to ensure stickiness and togetherness for small group peer learning.

3.6 Group dynamics

There have been numerous studies that investigate the determinants of a successful group, how to form a successful group to work as a team, the influences and forces that give rise to a successful team, and these are referred to as group dynamics. Group dynamics consists of elements that ensure stickiness and togetherness in an already formed group. The presence of group dynamics ensures smooth and coherent functioning of a group to accomplish a given task or goal. In a social context, group dynamics have been a complex phenomenon which is defined by the interpersonal relationships that develop in a small group set to accomplish a task (Forsyth, 2018).

Researchers have been investigating the elements of group dynamics and the influence of these elements on small group learning in various educational settings. A recent study of (Merlin et al., 2020) reviews and summarises the literature on group dynamics in various undergraduate educational settings, and consequently identifies five (5) key group dynamic elements that support effective small group learning. These five key group dynamic elements are: *support*, *openness*, *engagement*, *style of dominant behaviour*, and *quality of communication*. Although (Merlin et al., 2020) argued that group dynamic elements could be categorised into two: openness, engagement and style of dominant behaviour are more of a personal nature, since the learner has more control over these behavioural elements; while 'support' and 'quality of communication' are determined by interactions between learners in a small group learning. The elements of group dynamics have cross boundaries and are interrelated, that is why the absence or presence of a single element can affect the presence of the other four elements (Merlin et al., 2020).

Although there are studies such as (Anwar, 2016; Hommes et al., 2014; Iqbal et al., 2016; Willis et al., 2002) that identified other group dynamic elements such as respect

and trust, these studies have stressed the importance of respect being a key factor in group discussion. Being open and trusting the strength of others helps the functioning of a small group and promotes mutual respect in that group (Anwar, 2016; Hommes et al., 2014; Iqbal et al., 2016; Willis et al., 2002). However, the study of (Merlin et al., 2020) asserted and clearly defined respect and trust as subsets of openness. Therefore, openness leads to respect and trust the strengths of others in small group learning (Merlin et al., 2020).

3.7 Forming groups that promote pro-social behaviours and incentivization

Earlier studies show that researchers have been making mistakes in believing that learning systems are merely like social sites, with the notion of "build the system and learners would use it or engage in it", and it happens that is not the case (Kotturi et al., 2015). Even if peer learning groups are successfully formed based on learning potential and strong affinity structures, there is no guarantee that students would participate and reap the benefits associated with these systems. Students might be reluctant to participate in the peer learning discussion due to the lack of ambient social motivation that face-to-face components offer (Kotturi et al., 2015). Arguably, even the best-designed peer learning activities have little or no value unless students overcome their initial reluctance to use them. Therefore, peer learning platforms necessitate incentivizing their users.

Existing literature in various online learning domains has shown different incentivization strategies formulated by educational institutions and teachers to their students such as crediting or giving additional marks to peers who use their learning system effectively; or additional credit if all the members in a peer group participate (Coetzee et al., 2015; Kotturi et al., 2015). Similarly, researchers have deployed various incentive strategies depending on the context and learners (e.g. see (Coetzee et al., 2015; Trytten, 2001)); incentivization from a reputation system in MOOC discussion forums (Coetzee et al., 2014), and help seeking (Howley et al., 2017). Participation in educational

settings has a different incentive structure than in a socialization setting. Therefore, incentive in online learning environments and in particular for online peer learning has their own logic different from that of a social setting.

Researchers have devised indirect forms of offering incentives to their students in motivating them to use learning platforms by leveraging the design of learning systems to support and encourage pro-social behaviours and norms (Kotturi et al., 2015). Norms have an enormous impact on people's behavior (Kotturi et al., 2015). While online components lack the prospect of face-to-face in which teachers easily promote and encourage pro-social behavior due to limited social visibility through social norms, the opportunity of shaping and promote social behavior arise through learning system design. Learning system designers and software developers have the opportunity to shape and encourage pro-social behaviors and norms through system design. Influential studies have recently shown the tremendous impact of designing learning systems that promote and encourage social norms and empathy towards the success of learning systems (Cialdini & Goldstein, 2004). In peer learning context, peer empathy is *"the ability to emotionally understand what other people feel, see things from their point of view, essentially, putting yourself in someone else's position and feeling what they must be feeling"*.

Studies have also highlighted the use of incentives in the form of co-dependency in which members of a group can feel valued and important (Coetzee et al., 2015; Kotturi et al., 2015; Trytten, 2001). For example, sending emails to group members suggesting the importance and value of each members' contribution during peer learning for task accomplishment which drives and motivates the users in using and committing to the group members. Studies have shown that students are highly motivated when they feel that their contribution matters (Bransford et al., 2000; Ling et al., 2005). Co-dependency is a circular relationship in which one person needs the other person, who in turn, needs to be needed. Systems that highlight co-dependence are more successful at encouraging

pro-social behavior (Cialdini & Goldstein, 2004). Humanization of learning systems, norm setting, validation of system strategies are all indirect form of incentives and reward offered to students in educational settings (Coetzee et al., 2015; Trytten, 2001).

Humanization in education has long been identified to support learning. In classroom settings, humanized pedagogy that incorporates students' culture, values and language into the learning context tends to support students' metacognition and increases learning satisfaction. Humanization of technology and specifically learning systems are highly beneficial for learning. As humans naturally have empathy and tend to show compassion and love, humanized designed learning systems are obliged to foster naturalness, transparency and encourages engagement with the other peers using the system. In particular, validated systems such as a system that displays students' experiences and reviews about a system or product helps validate the system and encourage others to use the system especially with positive reviews and encouraging word-of-mouth experiences. This tends to improve the overall system efficiency and efficacy in achieving the system's ultimate goal. Arguably, humanization could further enhance and strengthen affinity, resolution of socio-cognitive conflicts, greater learning achievement – knowledge transfers across peers as well as group dynamics. Humanized learning systems helps in significantly improving the quality and transforming classroom (online peer discussions), and overall a more humanized learning atmosphere.

3.8 Summary

This chapter explores peer learning literature as well as other related facts that entails the formation of an effective peer learning scaffolding approach. First, the chapter discussed the theories and the three types of peer learning. The chapter also explained the peer learning practised by face-to-face classroom teachers. This discussion becomes integral because it is vital to recap and understand peer learning practice and how it was

perceived and implemented or practised in traditional classroom settings. Furthermore, the related works on peer learning scaffolding approaches were presented which were primarily from the crowd-workers domain. These related works have shown that scaffolding peer learning practices were mostly targeted at crowd-workers and have been sparsely researched in the educational domain and, in particular, students in blended learning institutions. In addition, this chapter also discussed group sizes such as small, smaller and large groups, the forces that exist is these small groups and the implications of forming these groups based on certain criteria, and how various group formations shape learners' behaviour. Similarly, as peer learning involves grouping students to work together as a team in order to share their skills and intellect with the other members of the group in order to accomplish a specific task, researchers have studied various group formations in various educational and non-educational settings and contexts which involves grouping based on learning potential, affinity, group dynamics and their impact on students learning achievements. This chapter has also shown the power of today's modern technology in which system designers and software engineers could leverage their learning systems designs in shaping human behaviour such as designing systems to offer incentives, peer-empathy, promoting pro-social behaviour such as co-dependency.

CHAPTER 4: SYSTEM DESIGN AND EXPERT EVALUATION

This chapter presents the detailed architectural design of the proposed system for scaffolding students' peer learning self-regulation strategy in the online component of blended learning. To achieve the goal of implementing a system capable of such scaffolding task, the system is designed to effectively provide the key functional and non-functional requirements thus, these requirements and the overall system architecture are explained. This chapter explains how the framework components are selected and verified. The chapter then describes the learning potential modelling, the choice of the number of peers for small group peer learning used in this research and the affinity structure. Furthermore, the chapter describes the instigation of the group dynamics aforementioned in chapter 3, and the implementation of learning system features to support the peer learning initiatives. The last section of the chapter explains prototyping and the expert evaluation exercise for the learning system prototype.

4.1 Components selection, verification and development of the framework

The development of the framework involves understanding the concept of peer learning and any associated or related component or entity that contributes to an effective peer learning self-regulation strategy. This involves how to form peer learning groups, how to propel peers of each learning group to work and function as a team and share knowledge among themselves, and more importantly to encourage participation so as to consequently avoid social loafing. The development of the framework, selection and verification of the various components can be categorized into three:

- Logistics in small group formation: This involves understanding and determining the number of peers for small group peer leaning. Secondly, since peer learning is a learning strategy that involves sharing of knowledge within a small group of

learners, literature from various disciplines have shown the requisite of every peer learning group to have members with a different set of skill or knowledge or different degree of knowledge of a particular skill or knowledge that could be shared among the peer group members. Therefore, this research resorted to grouping peers into small groups having varied skill level of the same set of skill.

- Small group influences. Being in a small group produces different behaviours, feelings, challenges and resolutions in the learning process. This research involves studying different types of groups and different influences or forces that shape or influence small learning groups. This research explored literature on different types of groups such as group dynamics, group affinity, group polarization etc. Thus, this research have identified group affinity and group dynamics as key elements of peer learning self-regulation strategy.
- Students' participation and prevention of social loafing. Since learners are required to willingly participate and engage to the peer learning discussions, they have to be given incentives to attract them and draw their attention to participate in the first place. This research involves studying the concept of incentivization in its various forms which led to understanding direct (e.g., monetary) and indirect (e.g., co-dependency, peer empathy). Thus, identifying incentivization as a key component of peer learning framework.

4.2 Modelling learning potential

One of the keys and fundamental features of this research is establishing learning potential for every peer learning group. Because, by carefully structuring peers of different sets of skills or different skill levels of the same skill set, knowledge is transferred and shared among the small group members. Moreover, the higher skilled students are expected to increase their skills due to teaching others have shown to increase

a person's skill or knowledge of a subject matter. In this research, the goal is to form models such that the overall gain for all the peers in a group is significantly increased and maximized as possible. This can be achieved by grouping peers from the two ends of the spectrum in terms of skills and talent/ability (both highest skilled (*Hs*) and lowest skilled (*Ls*)), and ensuring that each group is having a *Hs* and a *Ls* member. The first step in achieving the learning potential (*Lp*) goal of this study is to form groups of students into k-equisized groups such that the totaled *Lp* of the groups are significantly improved. Secondly, this research ensures that the least skilled peer benefit from the higher skilled, or every peer can benefit from a higher skilled peer of the small peer group. The *Lp* of a least skilled member from a highest skilled member of a peer learning small group is defined as the difference in skills between the two of them (Agrawal et al., 2014; Agrawal et al., 2017; Esfandiari et al., 2019), which we defined it as learning potential width (*LpW*) as illustrated in figure 4.1

$$LpW(g) = \max_{l_i \in g}(L_i^s) - \min_{l_j \in g}(L_j^s)$$

Where L_i represents a learner (student), s is the skill of a learner L, and g is the peer group.

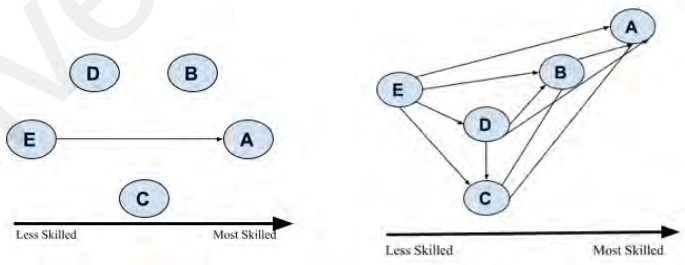


Figure 4.1: Illustration of learning potential width

Figure 4.1 is designed to illustrate and better explain the learning potential width (LpW) from two dimensions. Since the proposed system uses five learners for peer grouping, A, B…. E from figure 4.1 are used as annotations to illustrate the most skilled students (seemingly having an 'A' grade and therefore annotated as A), to the least skilled student (seemingly having an 'E' grade, therefore annotated as E) are depicted as A and E

respectively. The diagram on the left depicts the students or peers arranged according to their skills in an ascending linear graph with the *Ls* and *Hs* at the two ends. The diagram on the right illustrates that each of the least skilled student is capable of learning from a higher skilled student. Thus:

- E student → Gains from D, C, B and A
- D student → Gains from C, B and A
- C student → Gains from B and A
- Grade B students → Gains from A

However, grade A peer could potentially gain extra skill or ability by teaching or disseminating the knowledge to the less capable peers in the group.

Learning potential width (LpW): This study defines learning potential width (LpW) of a group as a single pair of students consisting of a highest skilled and lowest skilled. As such, every single peer learning group is formed consisting of at least a *Hs* and a *Ls* student. The remaining students in the group could be of any skilled value as that does not decrease or increase the *LpW* value. This logical technique is the first step in the formation of k-equisized groups. Therefore, two pots with a total of 2k students was created, the *Ls* pot containing the k Ls students while the *Hs* pot containing the k *Hs* students. Therefore, k pairs can be formed by grouping or pairing a *Hs* student and *Ls* student into a single group.

Algorithm 1: Learning Potential Width LpW

1. **input**: Set of Students L, k
2. **output**: a grouping G, OPTLpW
3. **begin** LpW (L, k)
4. OPTLpW ← 0
5. Create highest and lowest skill pots with k learners for each
6. G ← a set of *k* **null** groups
7. **for** *i* in (1, …, k) **do**
8. **select** $L_a \in$ most_skilled and $L_b \in$ least_skilled;
9. $g_i \leftarrow \{l_a, l_b\}$
10. L ← L\ $\{l_b, l_a\}$
11. OPTLpW ← OPTLpW + (l_a^j - l_b^j)
12. **end for**
13. **While** L is not **null do**
14. Assign $l_i \in L$ in g_i, s.t $g_i \leq$ n\k
15. **end while**
16. **end**.

Figure 4.2: LpW Algorithm

The remaining (n − 2k) students can be randomly assigned across the k peer learning groups, while keeping the group size the same (see pseudo-code in Algorithm 1) in Figure 4.2.

Consider the set of k highest skilled students and k lowest skilled students. It is easy to see that changing the assignment of the least skilled members would not change the overall sum of the skill difference. *LpW* of the groupings is: OPTLpW = $(S_1^{s.high} + S_1^{s.low}) + (S_2^{s.high} + S_2^{s.low}) + (S_3^{s.high} + S_3^{s.low}) \ldots\ldots\ldots (S_n^{s.high} + S_n^{s.low})$

4.3 Affinity Grouping

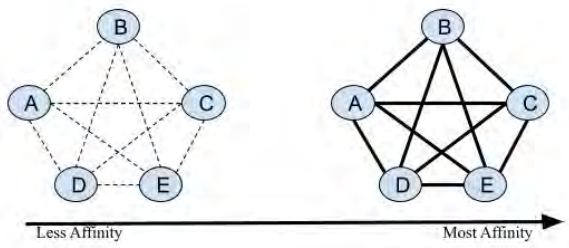


Figure 4.3: Illustration of affinity between peers

Figure 4.3 illustrates affinity on a linear graph with the connection between the peer group {A, B, C, D and E} having a weak affinity and thus is illustrated by dotted lines, while the strong affinity is illustrated by thick bold lines.

As discussed in the previous chapter, affinity deals with human behavior and in this research, it specifically deals with how students could be grouped to form an effective team to effectively accomplish a peer learning task. Research on affinity inclination has involved diverse sets of assumptions and human scales that postulate the best way to group humans to ensure togetherness for accomplishing tasks. As such, this research postulates instigating peer learning group affinity by ensuring that members from diverse regions and cultures are grouped together, with the notion that a peer learning group having members from either different ethnic, geographical backgrounds or experiences would incline towards one another and form stronger group affinity to work together as a team. Therefore, this research aims to mix different cultural backgrounds with geographical locations or experiences in each small peer learning group asserted by the evident literature aforementioned for fostering affinity in small group learning.

This research used the C4.5 classification algorithm typically used in data mining as a decision tree classifier which can be employed to generate a decision. This would enable every student to be profiled based on their geographical information data, such as place of birth, residential address, ethnic background etc. Decision trees can be utilized for inducing classification models, usually alluded to as a statistical classifiers. The C4.5 algorithm is also a popular algorithm that has appeared in the top 10 Algorithms for Data

Mining and that the C4.5 algorithm is the most preferred and most powerful method in use, and have been used in technology-mediated systems (see (Rahman & Abdullah, 2018)) as illustrated in figure 4.5.

4.4 Categorization process of Affinity with Lp as a constrain

To instigate and foster a stronger affinity between members of a peer group, this research leverages the use of background or registration data culled from students' database to categories them into the three main ethnic or cultural groups of the blended learning class. Because the foreseen evaluation experiment to be carried out involves students' data from three main ethnic or cultural groups, each of these cultural backgrounds could be themed based on three distinct, closely related geographical locations. Therefore, this research learning system design is constrained for categorization into three main groups denoted as (background) and a further three sub-groups on each main group as (GL) illustrated in figure 4.4 due to the foreseen experimental data and target students' participants aimed for evaluating the peer learning framework.

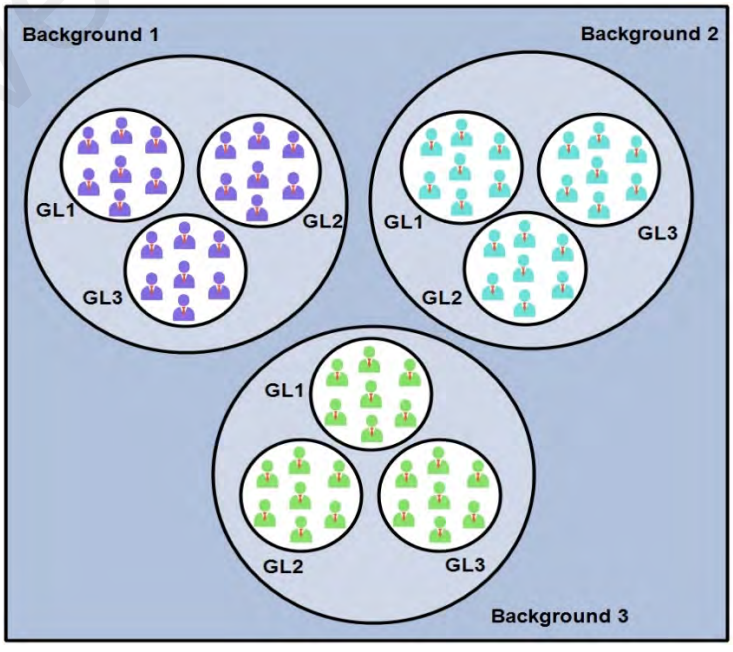


Figure 4.4: Categorization based on ethnic background and geographical location

The categorization process first involves grouping based on learning potential. Then affinity categorization involves swapping the members between groups, ensuring that students of the same geographical location and ethnic backgrounds are not put in the same peer group with learning potential as a constrain. The Lp width value does not change. A *Hs* member of a group must only be swapped with a *Hs* member in another group as long as it increases the affinity of a particular group. A *Ls* in a group could be swapped with a *Ls* of another group as well to increase affinity. This becomes easier since a *Hs* and *Ls* members of a group would not have exactly the same affinity attribute as defined by the categorization in figure 4.4. Peers are greedily swapped across groups to ensure geographical or cultural differences and experiences while maintaining the two ends of the learning potential spectrum (*LpW*) of a peer learning group (*Hs* and *Ls*).

This procedure was repeated until the overall group learning potential and affinity among peers of each group was deemed satisfied. This research defined and measures 'satisfaction' by considering the aggregate of learning potential of each group - having satisfied the *Hs* and *Ls* of each group, the aggregated scores of the groups should be somewhat neighboring in terms of aggregate skills of the members of each group.

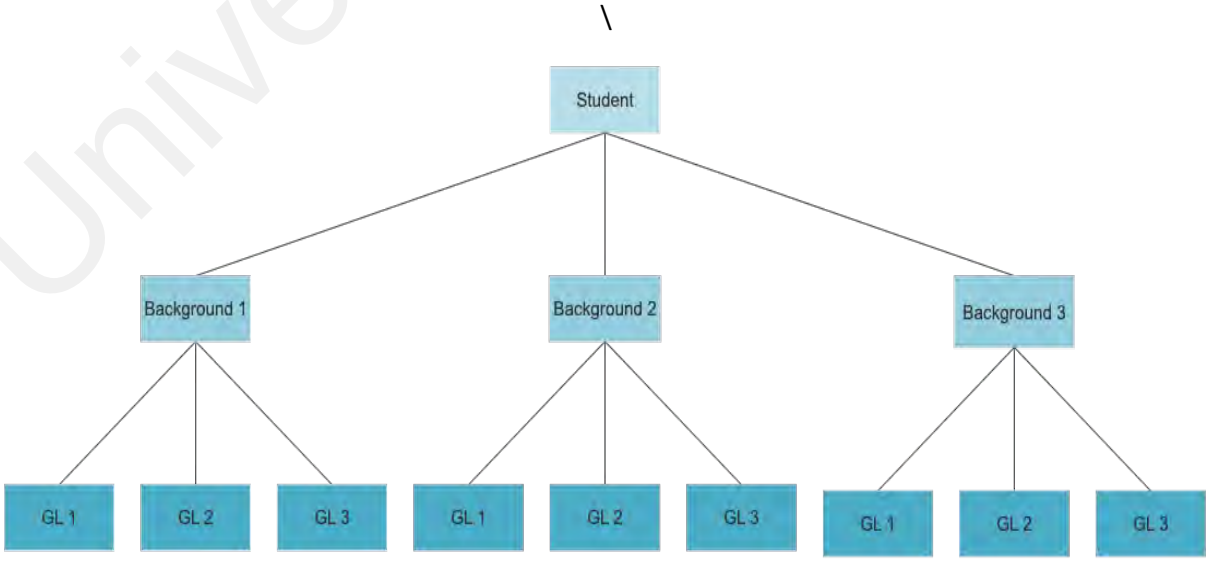


Figure 4.5: Decision tree for peer learning affinity grouping

Students are categorized into three main ethnic background as background 1, background 2, background 3; Geographical location as GL1, GL2, in each of the backgrounds GL3. For example:

Assuming each of the GL1 = {a, b, …., f}, GL2 = {a, b, …., f}; and GL3 = {a, b, …., f}; A group could be formed with *i* in GL1 Background 1 assigned to (→) *i* in GL2 Background 1→ *i* in GL1 Background 2 → *i* in GL3 Background 3 → *i* in GL1 Background 3; but NOT → *j* in (n-*i*) in GL1 background 1.

4.5 Fostering pro-social behavior, Incentivization and Implementing Group dynamics.

Small group learning requires the presence of the five (5) group dynamic elements. As such, the learning system for this research is designed to offer indirect incentives to students in terms of 'co-dependency' and 'peer-empathy' among other peers. This is in form of a humanized and personalized email repeatedly sent to each peer clearly stating that other peers are counting or relying on them to show up for the discussion. This approach would significantly encourage 'support' and 'engagement' to the peer learning activity, therefore encouraging mutual 'support' and 'engagement' needed in a small group peer learning - group dynamic elements. This also serves to initiate the need for support among the group members even before the peer discussion commences. This approach is motivated by the studies of (Kotturi et al., 2015; Kraut & Resnick, 2012) that shows that students feel highly motivated and engaged to peer discussions when they feel that their contribution matters. This approach also fosters 'openness' through system design by requesting students to provide a short biography about themselves, their academic skills, as well as displaying a brief bio information which pops up for every group member in the peer learning discussion board. During peer

discussions, peers can quickly access a brief information about their other peers withing their group to have an idea on each of their peer learning group member.

To ensure excellence in communication, this research adopts a text-based chat rather than video chat for higher 'quality of communication'. Several online learning literatures especially in MOOCs have shown that text-based interaction from students is far more reliable than video interaction (see (Chiu & Hew, 2018; Coetzee et al., 2015; Setlock et al., 2004; Wang et al., 2009)). Although text-based communication is not optimum in itself, many online instructors are capable to effectively reaching and communicate with their students who do not have for example high speed internet, and has proven to be a superior choice for ensuring a significant level of quality of communication especially among diverse set of students. Literature has also supported the use of text-based interaction having a significant advantage among participants from varying backgrounds and language disparities. For example, non-native English speakers might feel more comfortable expressing themselves and communication using text than video conferencing. Furthermore, by referring to the theory of (Walther, 1992; Walther et al., 2005), people express affect and interpersonal affinity as effectively as using an online chat system using text-based interactive systems as in a face-to-face chatting, and can effectively use verbal cues more efficiently that other means of online communication. As this research involves students from the dissimilar geographical backgrounds and obviously varying in native languages, text-based chatting becomes the best suitable approach than video chat or conferencing in ensuring the quality of communication.

Lastly, the number of characters to be posted at once by a peer is limited to 250 to reduce dominating the discussion by a single peer – 'style of dominant behavior' (a group dynamic element). The students list panel is designed in such a way that peers in a group can sneak peek or view the other participants' profile displaying some background

information, a profile picture and a short biography 'about me' which ensures openness (a group dynamic element) and eases any uncertainty about the members in a group.

Table 4.1: Implemented functions

S/N	Component	Function	Description
1	Learning Potential	The use of learning potential width algorithm	Highest skilled (Hs) and lowest skilled (Ls) students are grouped together such that each sub-group is having a *Hs* and a *Ls* member.
2	Affinity	The use of Decision tree algorithm C4.5 to categorise students.	Using existing data from the university database, students from different cultural, geographical background and experiences are grouped together to work as a team with learning potential width value as a constrain
3	Group dynamics	The use of indirect incentivization strategy by sending humanized emails to registered participants	'Support' and 'Engagement': (1) Support and (2) engagement are implemented by repeatedly sending humanized emails to registered participants of the experimental group. These emails incentivised peers towards co-dependency and peer empathy among themselves in their peer groups. This approach would significantly encourage 'support' and 'engagement' to the peer learning activity, therefore encouraging mutual 'support' and 'engagement' needed in a small group peer learning. This research adopted an incentivization technique to promote and foster *support* and *engagement* group dynamics elements.
		A display function button	Openness: A students list panel displaying background information in

			the form of a profile picture and a short biography 'about me' of each student, which ensures 'openness' and eased potential uncertainty among the peer group members.
		The use of text-based discussion in itself ensures better quality of communication.	Quality of communication is ensured by enabling peers to communicate via text based.
		The use of maxlenght (maximum and minimum) length attribute/function in Java.	Style of dominant behavior: peers are restricted to dominate the text-based conversation with their fellow peers by limiting the number of characters in a single post from a peer group member.
4	Incentivization	Enabling posting review function by peers. Displaying reviews function on the lead page of the peer learning system	Indirect incentivization: Another indirect incentivization involves fostering pro-social behaviour through humanization of learning systems, validation of system, word of mouth impact. Enabling posting review from peers

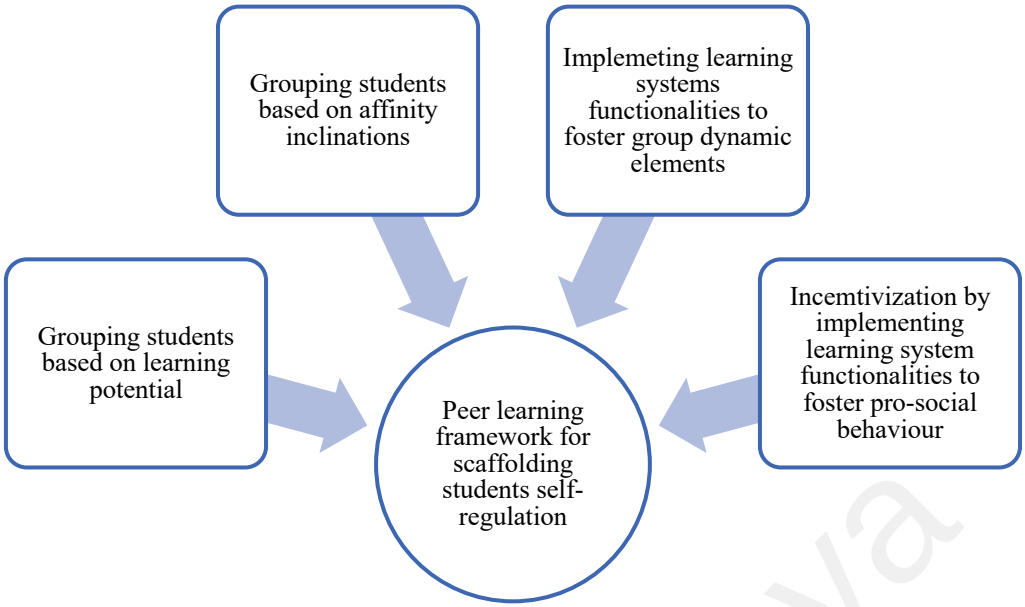


Figure 4.6: Peer learning framework components for scaffolding students' self-regulation

4.6 Peer learning system architecture

Figure 4.7 explains the system architecture. The diagram illustrates that when students register for the peer-learning exercise on the prototype system, which mimics their learning management system for their online component activities, the system fetches their background information which includes their previous academic score of the course module,

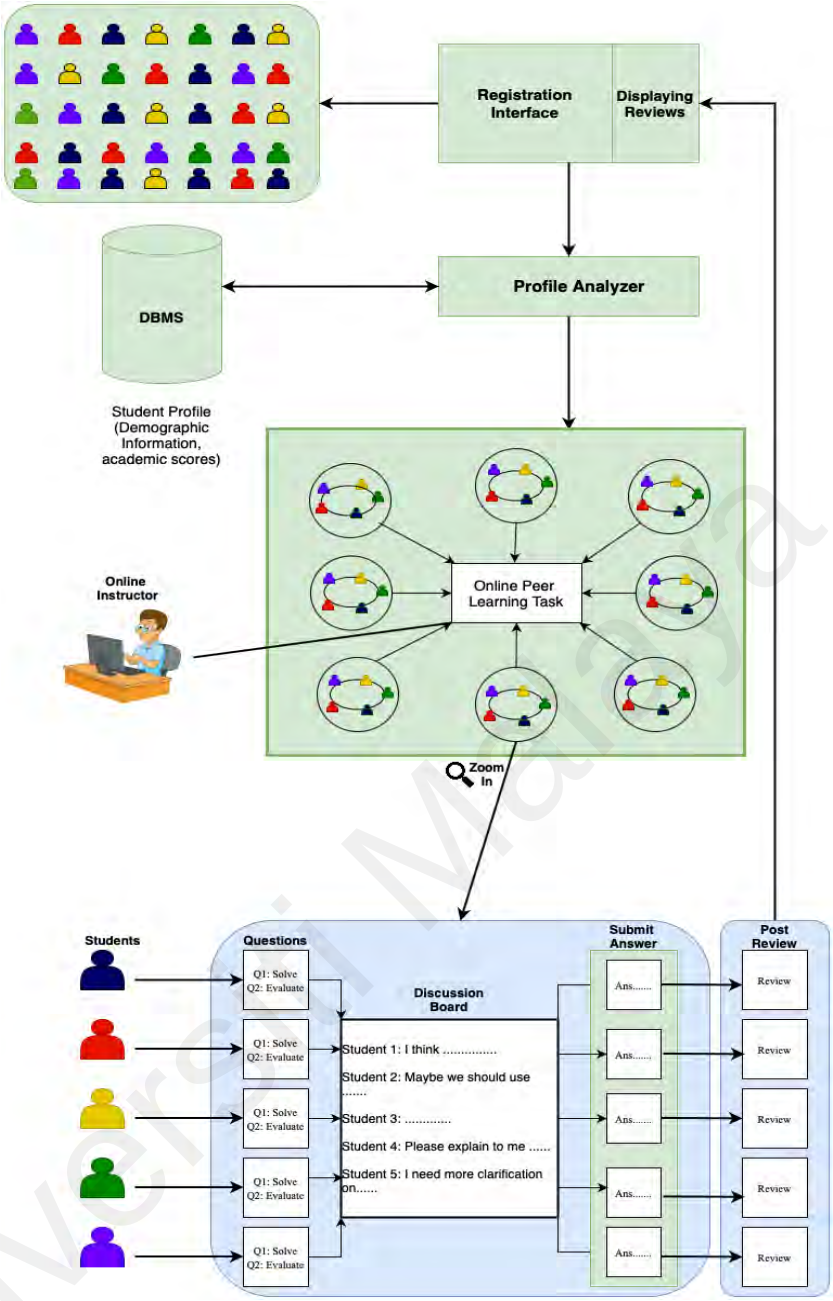


Figure 4.7: Architectural design of the peer learning self-regulation scaffolding system

then the system automatically assigns a student to a group that can accommodate a maximum number of five (5) peers for their online peer learning group discussions based on learning potential and affinity. Every group member uses the same learning material. In addition, figure 4.7 provides an illustration of the system design and grouping flow for online peer learning self-regulation strategy. It also provides an illustration of the sneak peeks of a peer discussion group. The use of different colors illuminates an exclusive

student skill set and background, which demonstrate learning potential and affinity presence. Students are required to log in during the online component and discuss their assignments or homework/online component task in a synchronous fashion with their assigned peers, after which they submit the assignment and then post a review on their perceived efficacy of the system in scaffolding their peer discussion before finally logging out. The reviews posted are displayed on the lead page of the learning system to validate the system and encourage others to give it a try.

Furthermore, this study involves forming smaller groups of five (5) by default. As such, the maximum number of remaining peers without a group would be 4, since any number of peers can only have n % 5, and the remainder R < 5, and each of the remainder would be assigned to a group equaling 4 sub-groups with 6 members, which is also considered a smaller group since any group consisting of 3 to 8 members is considered a small group.

4.7 Prototyping

The main idea of implementing a prototype for this research is to ascertain the performance of the proposed approach when deployed in an online environment. The use of prototyping is a useful approach in demonstrating the key components of the proposed scaffolding functionalities to show the applicability in real life scenarios using web based interfaces. The use of prototyping in evaluating and conducting experiments in several online learning domains has been a common and well-known practice over the years (see (Chou et al., 2018; Lin et al., 2016; Rahman & Abdullah, 2018)). The prototyping designed in modules present graphical user-friendly interfaces, which enable users to interact with the system. Prototyping enables a flexible and convenient way for the learning potential and group affinity models proposed in this research work to be carefully embedded under the system. However, for the purpose of evaluation, this research

designed two identical peer-learning system prototypes named PL-LPAD, and PL-N. The basic difference between the two prototypes is that PL-LPAD has the embedded peer learning scaffolding functionalities while the PL-N system does not have these embedded functionalities, merely a (a placebo/dummy system). The naming of the prototypes was inspired by influential online help seeking self-regulation strategies (Kopcha et al., 2015; Lin et al., 2016) in blended learning studies.

The prototypes were developed using a document object model (DOM) comprising PHP, HTML, JavaScript and CSS. The decision to consider and use these categories of software development tools was as a result of their reputable benefits and unlimited advantages in several prototyping instances. For example, PHP is a cross-platform application, easy to use, open source, having powerful library support, easy integration and compatibility, is extremely flexible. Also, these software tools are widely used in today's modern software designs to fulfil the necessary non-functional requirements of software such as portability, compatibility, security, etc., which is arguably required for a system in a higher educational environment and in particular, a learning system which necessitates security and user friendly features to enable its users (students) to reap the supposed benefit of the system. The prototypes were carefully developed by adopting the best practices of programming to ensure optimum user friendliness across all the various aspects of the prototyped system.

Prototyping has numerous advantages, especially in an educational environment in which a prototype system can be designed to mimic its target users (students) learning system. Prototyping a learning system enables errors to be detected and thorough usability evaluation by experts by involving user feedback for multiple tests until the desired output is achieved. The prototyping of this research was inspired by influential studies in scaffolding students learning in higher education, such as the study of (Rahman &

Abdullah, 2018) that built a prototype to evaluate the effectiveness of a personalised web search recommendation for students.

4.8 System Requirements

Use cases are requirements discovery techniques that were first introduced in the objectory method (Sommerville, 2011). The use case diagram of the Unified Modelling Language (UML) is typically used to visualize the design of a prototype. Basically, a use case identifies the actors involved in an interaction and names the type of interaction. Use cases identify the individual interactions between the system and its users or other systems. Use case diagram has been widely used to portray a graphical representation of a functional description of interaction among external entities and systems, as well as their collaborations. In relation to this research, UML use case diagrams identifies the actors (student, teacher and admin) involved in an interaction and named the type of interaction (Sommerville, 2011) as depicted in figure 4.8.

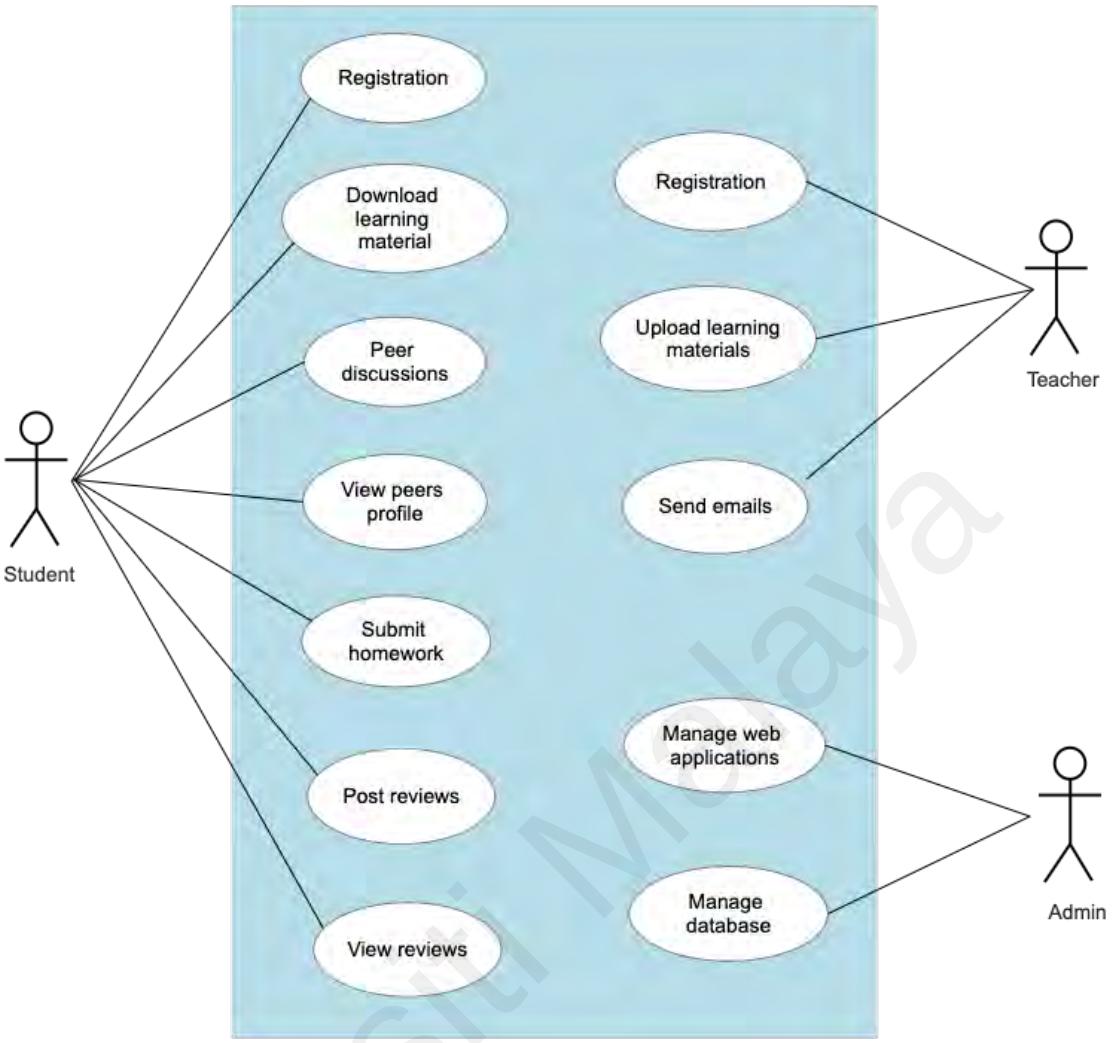


Figure 4.8: UML Use case diagram of the peer learning prototype system

- A User shall be able to register to the system, log-in to the system, be able to use the discussion board for peer discussion, be able to access other users' bio profiles, submit homework after the peer discussion, be able to download learning materials, be able to post reviews after submission of peer learning task, be able to see reviews posted after logging out.
- A teacher is responsible for facilitating the peer learning exercise. Teacher registers to the system to be able to upload learning materials. Teacher also is responsible for announcing and motivating students to register to the system in order to participate in the peer group discussion. This is done by teacher

scheduling the date and time of the peer learning exercise, teacher is responsible for sending emails to instigate the peer discussion as explained earlier.

- The administrator: The function of an administrator (admin) is to maintain the hosted prototype web applications as well as the database of the proposed system. The administrator maintains the system and consults the teacher in case of any technical difficulty. He/she must ensure that the system is always available.

4.9 Usability evaluation of the prototype

Usability is a key issue in human-computer interaction (HCI) since it is the aspect that commonly refers to the quality of the user interface (Parlangeli et al., 1999). The International Standards Organisation (ISO) defines usability as "*the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context*" (Bevan et al., 2015). Usability evaluation is typically done in order to assess, evaluate, and suggest improvements as well as identify problems of a system's interface and functionalities (Shneiderman & Plaisant, 2010). There have been numerous usability evaluation methods (UEM) in existence such as survey, analytical, expert heuristic evaluation, and observational (Brinck et al., 2001; Shneiderman & Plaisant, 2010). In order to evaluate the usability of a system, it is very important to identify the most suitable UEM (Ssemugabi & De Villiers, 2007) by considering key factors such as time, ease of evaluation, availability of experts, cost effectiveness (Parlangeli et al., 1999; Ssemugabi & De Villiers, 2007).

Expert usability evaluation techniques offer a discount way for assessing the usability of systems in a quick way using a few experts. This allows expert evaluators to quickly evaluate the system functionalities and identify potential usability problems using a set of predefined questions or heuristics. This method is usually quick but affords quality feedback at minimal cost in terms of resources and time spent on the usability evaluation.

The most commonly used expert usability evaluation techniques include a cognitive walkthrough, heuristic evaluation, guideline review, and consistency inspection (Maguire, 2001; Molich & Nielsen, 1990).

This research uses heuristic evaluation, which has been a classic and very popular evaluation method in human computer interaction typically used for assessing web-based systems and in particular web-based learning systems (Nielsen & Molich, 1990). This involves the use of a few experts to evaluate a system based on a set of predefined heuristics. The objective is to quickly evaluate the usability attributes of a system in terms of its strengths and weaknesses, and to identify the usability problems (Nielsen, 1992). HCI researchers believed heuristic evaluation to be sufficient for the assessment of computer system interfaces, a cheaper alternative to full-scale usability assessment which require minimal investment. It is described as straight-forward, fast, inexpensive, and consequently resulting in significant improvements to the usability of a system. Heuristic evaluation is effective when carried out during development as well as when a system is completed – on real operating systems (Kientz et al., 2010; Nielsen, 2005). Figures 4.9 and 4.10 are the interfaces of the developed prototype. However, these interfaces were not the final versions of the interfaces because the prototype has undergone several improvements and modifications based on the expert's feedback.

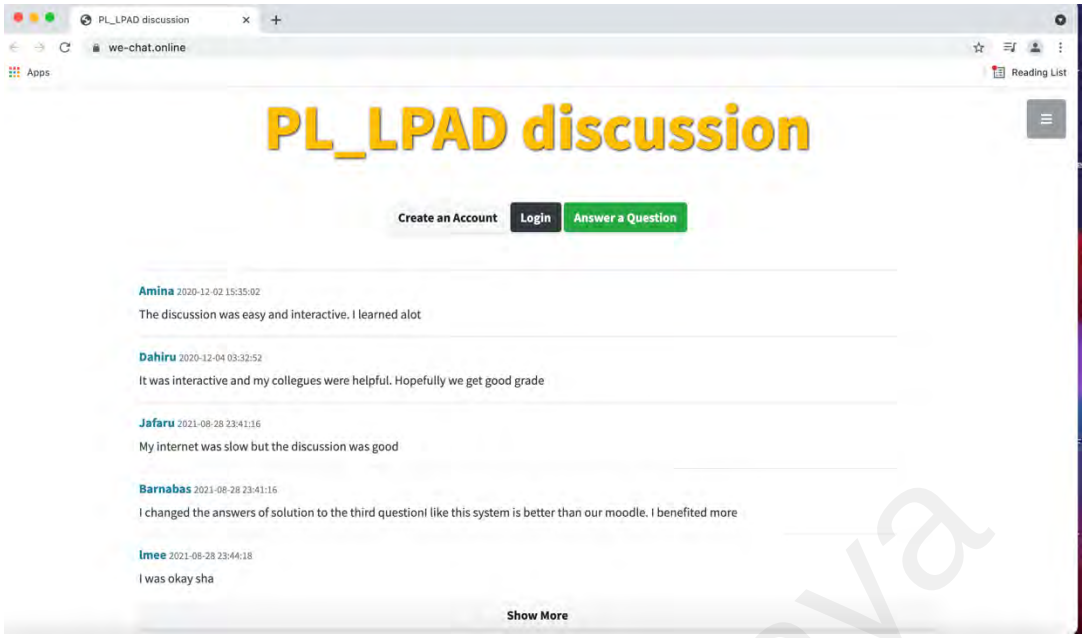


Figure 4.9: Prototype Lead page

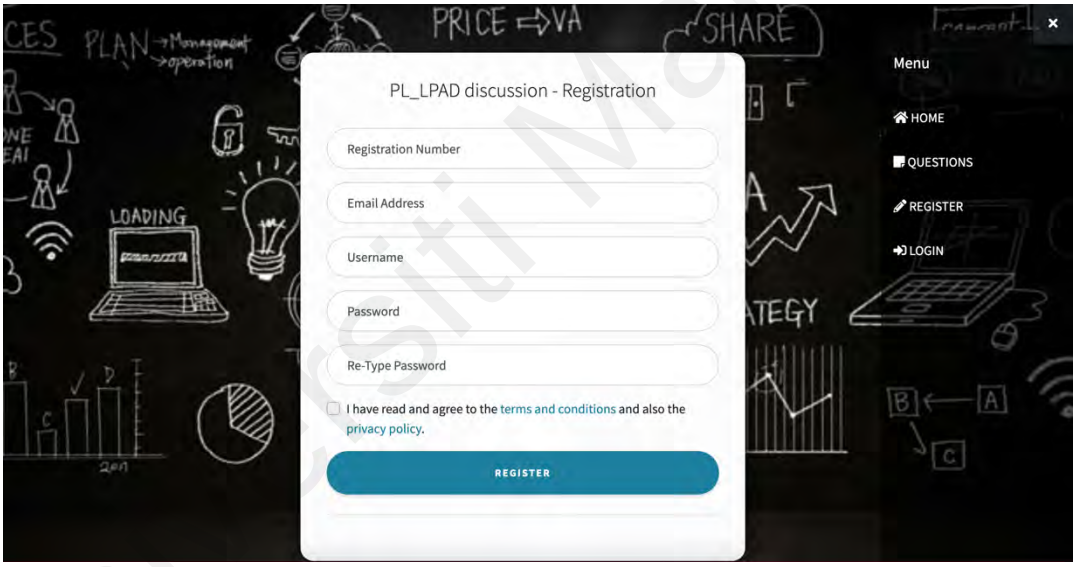


Figure 4.10: Registration interface

4.9.1 Heuristics evaluation

In the context of usability evaluations, heuristics are a rule of thumb or human-computer interaction-based guidelines that are used for user interface evaluation of systems. This evaluation process is usually done by evaluators independently assessing the user interfaces. The heuristics used in this research involves exploring various set of heuristics and arriving at a product of three sets of evaluation heuristics: i) Web 2.0 heuristics adopts the traditional Nielsen's heuristics with some considerations of the web 2.0 paradigm; 2)

learning heuristics – which are drawn from a set of educational and learning heuristics from the existing UEM literature; and 3) Tool heuristics that considers other usability heuristics deemed as essential for evaluating of web-based and e-learning systems in educational domains (Granić, 2008; Munaiseche & Liando, 2016; Ssemugabi & De Villiers, 2007). Therefore, this research formed an evaluation framework of heuristics aimed to address interface, usability and interaction of web-based peer learning self-regulation scaffolding system from human computer interactions, as well as pedagogy and learning (see Table 4.2). These sets of heuristics include Nielsen's Heuristics (Nielsen & Molich, 1990), heuristics on instructional design (Benson et al., 2002), Mehlenbacher et al. heuristics (Mehlenbacher et al., 2005), educational design heuristics (Albion, 1999), principles for effective online learning (Vrasidas, 2004), and Web 2.0 extended framework for heuristic evaluation (Thompson & Kemp, 2009). In addition, other heuristics are considered from various relevant expert evaluation studies on web-based learning and e-learning systems in educational domains (see (Jones et al., 1999; Karoulis & Pombortsis, 2003; Levi & Conrad, 1996; Storey, Phillips, Maczewski, & Wang, 2002) particularly the study of (Levi & Conrad, 1996) that which involves evaluation of a web-based prototype forming a total of twelve (12) pre-defined heuristics. Figure 4.11 illustrates a flowchart of the activities of the prototype.

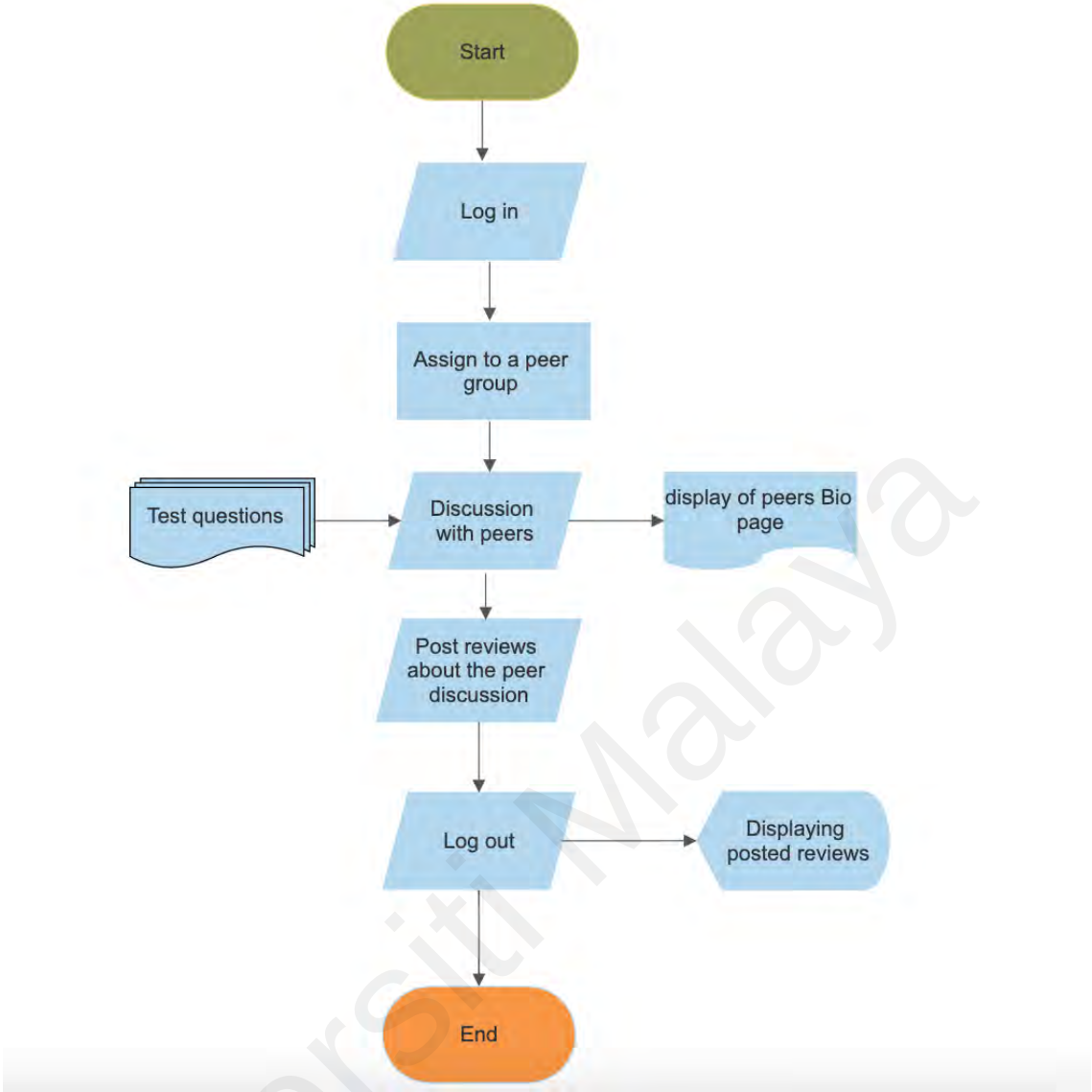


Figure 4.11: A flow chart illustrating the flow of the activities of the prototype

4.9.2 Experts' selection and evaluation

As suggested by (Nielsen & Molich, 1990), expert evaluation could consist of typically three (3) to five (5) experts conducting their evaluation independently. As such, this research adopted a similar heuristic evaluation approach (Albion, 1999) with four (4) heuristic evaluation experts. Two of the experts are lecturers teaching software engineering courses for undergraduates and are regarded as 'double experts', taught in undergraduate and postgraduate typical blended learning mode of instructional university courses and are familiar with e-learning system designs and regularly use Moodle or Blackboard for their students' online component teaching. The other two experts are

students' experts. Both the identified lecturers and students' participants are reasonable experts in Moodle, web-technology, software design, courseware technology, and e-learning in general. Their task is to thoroughly check, and evaluate the system and identify any problems or issues with the interface, navigation, functionalities and best practices in web-based e-learning system design based on the defined framework of heuristics formed (see table 4.2). Although, the prototype system of this research is considered a simple one, therefore the aim is to assess the built-in functionalities that support the peer learning self-regulation scaffolds, the navigation and other key interface functionalities.

The experts used the 11 selected criteria framework (see table 4.2) to evaluate the PL-LPAD peer learning prototype to rate the functionalities from a scale of 1 to 5. The experts are also tasked to identify any or potential problems with the learning system interface and functionalities. Table 4.2 below shows the mean score of the four experts based on this research heuristics framework.

Table 4.2: Peer learning system heuristics framework

General interface usability based on Nielsen's heuristics modified for web-based e-learning context		**Mean**
1	Visibility of system status: Measures the degree to which a user is duly informed about ongoing processes and events taking place in the system.	3.5
2	Match between the system and the real world: Measures the level of familiarity between the language, objects and annotations used in the peer learning system to describe actions, function, and activities and that of the user.	3.5
3	Consistency and adherence to standards: Measures clarity and consistency in the way actions, situations, different words on the peer learning system are presented.	4
4	Flexibility and efficiency of use: Measures how simple and suitable is the design of the peer learning system for all categories of users.	4.5
5	Interactive interface: Measures how well the peer learning system supports active interaction among the peers using the discussion interface.	4
Learning heuristics designed from the educational design heuristics, and other learning heuristics		

6	Quality of learning content: Measures the quality of instructional content that is available on the peer learning system compared to the curriculum.	4.5
7	Motivation to Learn: Measures innovative features that stimulate learning and varied learning activities that increase the rate, and quality of learning.	3.5
8	Support for group interaction and collaborative learning: Measures the support that is provided for learners to be able to interact with each other through discussion and other collaborative activities. It assesses whether tools are provided for peer interaction	4
9	Support for problem-based learning, knowledge exploration and self-learning: Measure how well the peer learning system supports transfer of skills beyond the learning environment and facilitates self-improvement of the learner.	4
Tool heuristics to support effective online learning		
10	Accessibility: Measure how well users can readily access the resources and features of the peer learning system. This could be in terms of being free from technical errors, and being able to engage with the peer learning system through different types of devices.	5
11	Privacy and Security: Measure of the degree to which the peer learning system ensures the privacy and security of learning resources that are available.	5

Table 4.2 depicts the mean score of the experts with regard to the peer learning self-regulation strategy system. The evaluation shows that the proposed peer learning system got an acceptable rating in most aspects covered by *Web heuristics, leaning heuristics* and *tool heuristics*. In addition, figure 4.12 shows the overall assessment rating of each of the components by the four experts as 'student usability expert' (student UE) and 'teacher usability expert' (teacher UE).

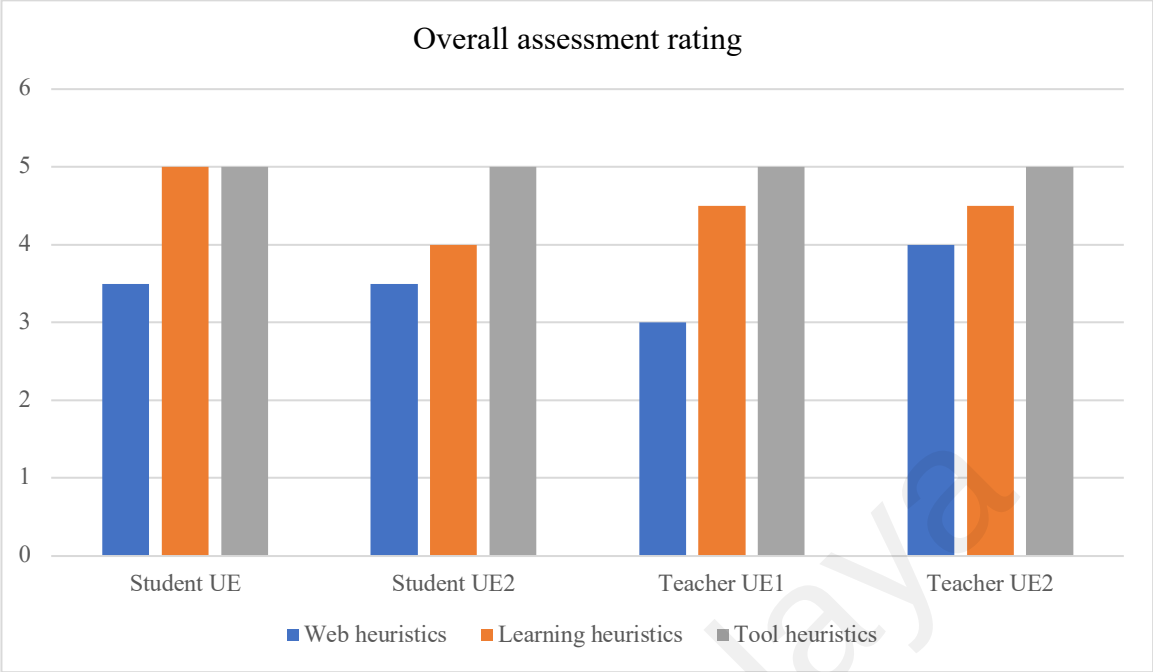


Figure 4.12: Overall assessment rating of each of the component

The result of the heuristic evaluation by the experts revealed the strengths and weaknesses of the peer learning self-regulation scaffolding system. Some of the identified problems and concerns deal with learner control and freedom such as the undo and redo buttons for swift navigation between interfaces, and the need for help or frequently asked questions (FAQs) module to aid users by providing quick answers about the peer learning system. These noticeable issues raised were then carefully and meticulously addressed for a smooth usability experience.

4.10 Summary

This chapter explains the system designed for students' peer learning self-regulation strategy scaffold. The chapter explains the design choices for adopting a smaller group of three to five peers, and the use of background and geographical information for affinity grouping. The chapter also explained how five group dynamic elements are instigated by leveraging learning system designs as well as offering indirect incentivization to students. The chapter also discussed the prototype implementation, and the UML use case to depict

the functional requirements and finally discussed the heuristic expert evaluation adopted that best suit the usability evaluation of the learning system prototype. This includes the constructed heuristics usability framework, the results and concerns raised by the experts, and the overall assessment ratings of each component by the experts.

CHAPTER 5: EXPERIMENTAL SETUP AND RESULTS

This section discusses the experimental set-up and processes carried out to evaluate the effectiveness of this research proposed peer learning self-regulation strategy scaffold in the online component of blended learning. This involves testing and presenting the results of the hypothesis. By referring to studies that evaluate self-regulation strategies such as (see (Chou et al., 2018; Mohamed & Lamia, 2018)), the key determinant of the success and efficacy of the approaches that scaffold the proposed self-regulation strategies, as well as the use of learning systems or technology that supports students learning process is measuring the students learning achievement with the use of the system. As such, this research adopts a similar evaluation approach in determining the level of increased academic performance, participation and overall satisfying learning experience using the approach.

5.1 Experimental aim

The main aim of this research experimental evaluation is to test the hypothetical assertions. This chapter aims to confirm or reject the effect of grouping students based on learning potential and affinity structures, the effect of instigating group dynamics among the peer learning groups, and the effect of incentivizing students through pro-social behavior system implementation. Therefore, the experimental group is expected to perform better in academic scores than the control group in these hypotheses.

5.2 Research Hypothesis

H1: *Grouping students based on learning potential and strong affinity inclination would ensure knowledge transfer and improved learning outcome.*

The first hypothesis states that by grouping students based on learning potential and strong affinity inclination would ensure knowledge transfer and improved learning

outcomes: This hypothetical assertion means that students in the online component of blended learning grouped in small peer learning groups based on learning potential and affinity inclinations would share knowledge/skill among themselves and have significantly better scores compared to peer groups without this structure.

H2: *Designing peer learning systems with pro-social behaviour functionalities would incentivise students towards peer learning participation*

The second hypothesis states that by designing peer learning systems with pro-social behaviour functionalities would incentivise students towards peer learning participation: This hypothetical assertion means that peer learning system designed with indirect pro-social behaviour functionalities would incentivize students in the online component of blended to take part and participate in the peer learning discussions with their peers. This means that students would not be reluctant to participate in the first place thereby reducing or preventing social loafing from occurring.

H3: *Designing learning systems that foster the presence of group dynamics would ensure the coherent functioning of a peer learning group in accomplish a given learning task.*

Designing learning systems that foster the presence of group dynamics would ensure the coherent functioning of a peer learning group in accomplishing a given learning task: This hypothetical assertion means that the presence of group dynamic elements in small peer groups ensures the coherent functioning of a peer learning group.

5.3 Experimental Setup

5.3.1 Participants

The experiment involves 120 third (3^{rd}) year students from the department of software engineering in a public university who are willingly to participate in the experiment. The

bachelor of software engineering is a 4-year undergraduate degree program taught using the typical blended learning instructional model. The experiment took place in the first semester of 2019/2020 academic session. The Bachelor's of Software Engineering comprises modules such as Java Programming, Research Methods, and Software Engineering 1. In particular, the module 'Software Engineering 1' involves a 2-hour weekly face-to-face class session, with an online component for a typical blended learning module. The face-to-face classes are conducted in a so-called 'software engineering lab' which is divided into two sections, each having the capacity to accommodate a maximum of 70 students equipped with desktop computers running various programming and software programs. Each of the lab is taught/assigned by a single lecturer.

Participants' recruitment strategy is very important in every experiment involving humans. That is why this experiment targeted third-year students because they are deemed reasonably competent with computers and are already familiar with the use of Moodle – a free open-source learning management system, in accessing their online assignments or learning materials for online component studying. Also, peer grouping must involve members of the same educational level. Therefore, the identified set of students best fits the criteria for conducting such experiments as it makes it easier to form small groups for peer learning experiments.

5.3.2 Ethical and professional concerns

In every valid experiment that involves human subjects, the timing, location, and overall setup was carefully and diligently planned to enable all the necessary ethical and professional practices to be observed which involves the sensitivity and confidentiality of data collection, beneficence, participants' consent and other guidelines; and more importantly dealing with human subjects. Approval from the head of the department was

obtained regarding the experiment detailing the purpose of participants, and data,to be involved in the experiment.

5.3.3 Preparation phase

Engaging sizeable peers into peer learning self-regulation scaffolding activity in their online component discussions does not only involve designing learning systems, it also requires teachers' intervention for engaging the students to participate in the peer learning discussion with the help of the designed scaffolding learning systems. Students must be mentally prepared and feel motivated to participate and be part of the peer learning process. As such, the teachers play a key role in facilitating such preparation phase. The preparation stage involves making students aware and prepared for peer learning participation which involves encouraging them to register and consequently view or have a glance at the past reviews of the users, which motivates them to have a try, and sending humanized email. This was achieved through a general announcement during the face-to-face class sessions by the teachers.

- Registration module

The registration is a key step in the peer learning which introduces the participants to the learning system. Participants were informed to register first in order to use the prototype system for peer learning discussion regarding their online assessment usually termed as continuous assessment (CA). The registered students were categorized into the experimental and control groups.

- Experimental groupings:

There must be at least two groups in a valid experiment: the experimental/intervention group and the control group. The experimental group are the group of research participants that receives the experimental treatment or variable being tested in an experiment, while the control group is a group of research participants that resemble the

experimental group but do not receive the experimental treatment. The control group provides a reliable baseline data for comparing the experimental results. Control groups remain essential in any true experiment because it allows for the elimination and isolation of variables or experimental treatment. In this research, the experimental group are designed to use the hosted prototype having the built-in peer learning scaffolding functionalities named PL_LPAD, while the control group uses the PL_N that eliminates/isolate the peer learning self-regulation scaffolding functionalities aforementioned. For experimental purposes, the differences in these two prototyping functionalities are kept anonymous from the participants such that none of the participants in both groups knows the differences of the functionalities of the system they used. Figure 5.1 is a snapshot of the registration prototype sub modules. Participants key in their detail and then register to the system.

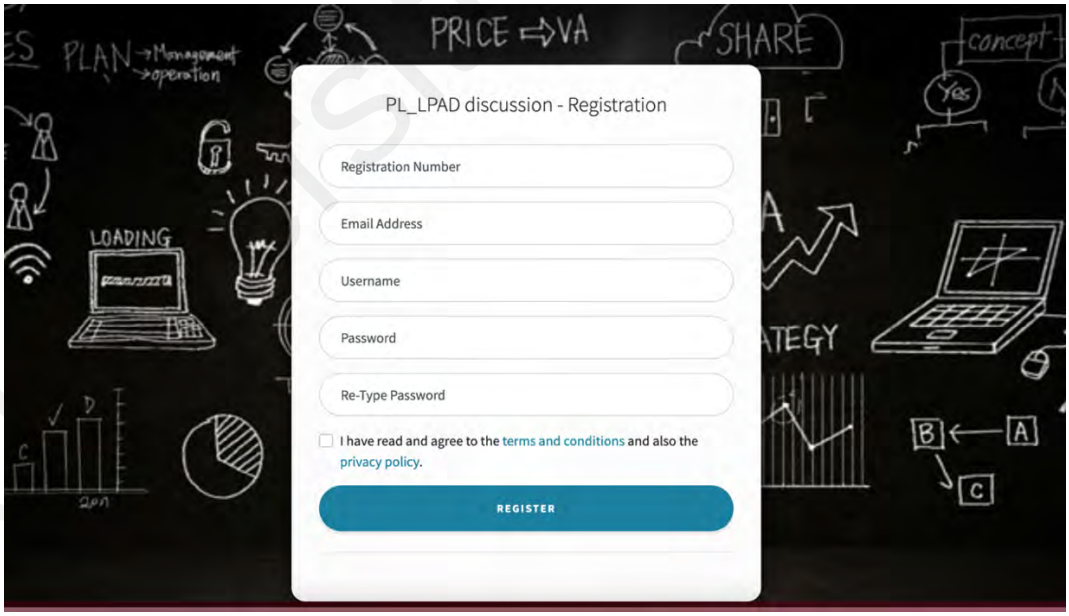


Figure 5.1: Registration sub module of the experimental group prototype.

- Humanized email

The second important preparation step involves sending personalized emails to each registered participant. The lecturers composed and designed a personalized email which

the system would send. The system sends the customized email automatically to every registered student of the experimental group in a humanized form encouraging co-dependency, engagement and support as well as the importance of their participation for a successful peer learning self-regulation strategy. The participants were informed about the time that the online peer learning material would be uploaded, the system availability for log-in and the time duration for the online peer learning exercise. This approached is motivated by the study of (see (Kotturi et al., 2015)).

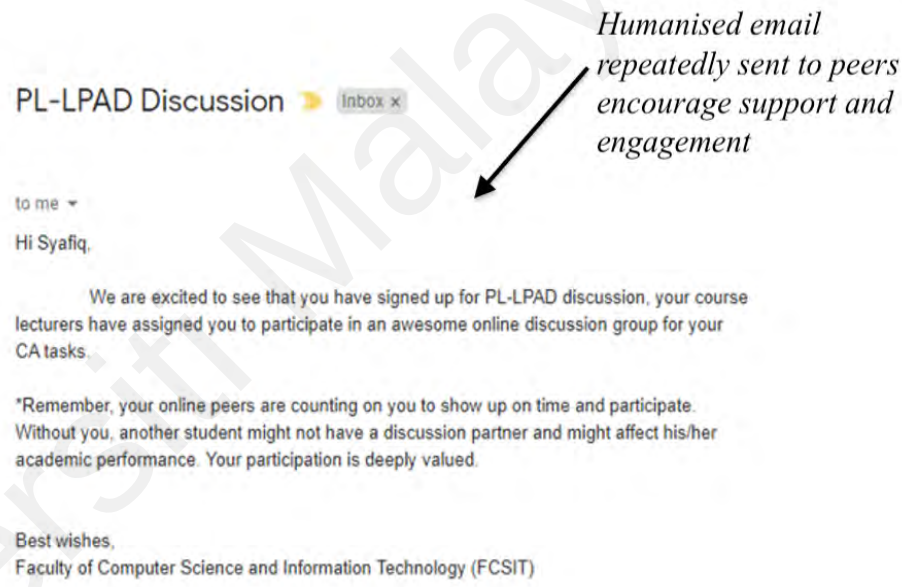


Figure 5.2: A sample email sent to students prior to their peer learning discussion, reminding them of the importance of their attendance and that their peers are counting on them

A similar email was repeatedly sent to all the registered participants of the experimental group a few hours before the peer learning discussion. This is an important and significant step in combating social loafing and apathy of the registered students towards the peer learning discussion. The preparation step is a significant milestone in ensuring that registered students are connected with the system and keen to participate and experience the peer discussion exercise.

5.3.4 Peer discussion phase

Log in module: In the experiment, the participants were requested to use the prototyped peer learning system hosted on the web using the web link made available to all the registered students. Student log-in module is a friendly user interface with a colorful and appealing background. Students are required to log-in with their student ID and a password. The log-in module is designed to display the first part of the student id of the students as place holder, a student participant just needs to fill up the latter part of the student id.

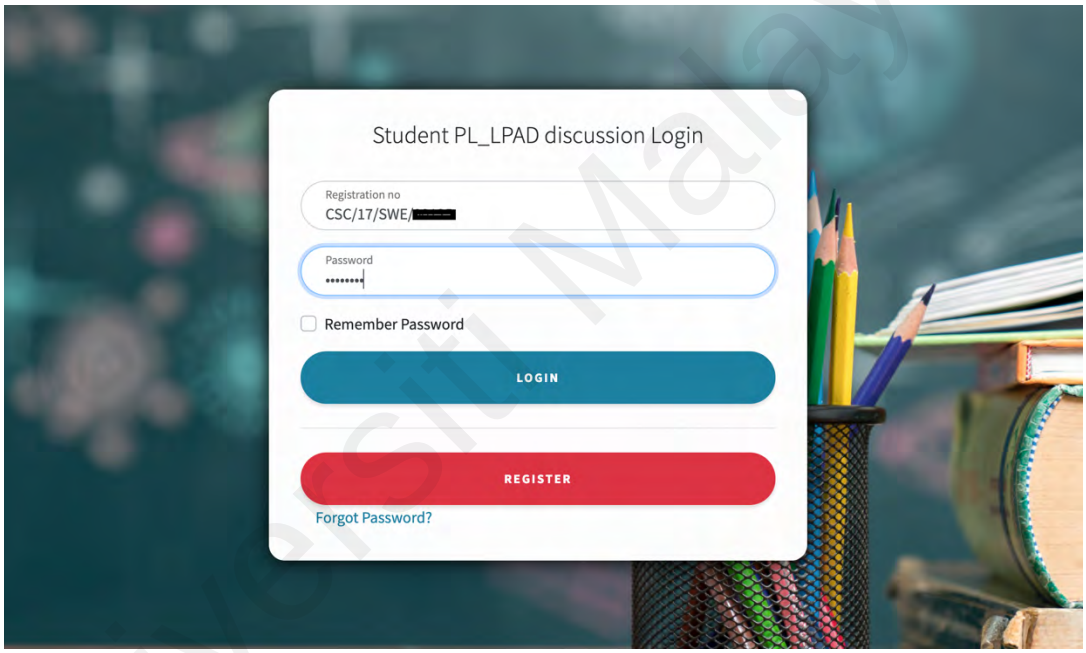


Figure 5.3: A screenshot of the log-in interface for the peer-learning group discussion

Once a student logs in, he/she can first view the questions which comprise of five questions. One (1) question is a Java programming question and the remaining four (4) questions deal with Introduction To Software Engineering. The course 'Software Engineering 1' (SWE3301) was taught based on 'Software Engineering 9th edition' by *Ian Sommerville*. The four questions are from the first part of the textbook taught to them which consist of one question for each of the book chapters – introduction, system modelling (unified modelling language (UML), mainly the relationship between actor and

the system), requirements engineering (functional and non-functional requirements) and software testing. Although 'java programming' and 'software engineering 1' modules were taught separately, this experiment adopts the use of both of them for creating the test material.

The assessment structure of the course involves two (2) distinct assignments or quiz that usually takes place between the 4th and 8th week of each semester calendar, with each of the assessment weighting 30%. The final exam is a written exam that weighs 40%. This research experiment uses the students first assessment CA score of the course as the pre-test score.

A pre-test post-test design is an experimental approach in which measurements are taken both before and after an intervention. The design means that the effect of the intervention of a group is realized at the post test assessment. A pre-test post-tests experimental design have been a common practice in educational settings to determine the effect of an intervention, typically the use of a learning system. In particular, pre-test and post-test assessment strategy have been used in determining the self-regulation scaffolding effect of self-regulation learning systems (see (Lin et al., 2016; Shyr & Chen, 2018)). The skill category scores in this research are based on the typical 100% marking and grading system of the University and most higher institutions. Both pre-test and post test scores weigh 30% (30 marks) each as depicted in Table 5.1

Table 1.1: Marks, grade and skill category

S/N	Marks/30	Grade	Skill Category
1	>= 21 (70%)	A	Highest skilled (Hs)
2	>= 18 (60%)	B	Medium-high skilled (Mhs)
3	>= 15 (50%)	C	Medium skilled (Ms)
4	>= 12 (40%)	D	low skilled (Ls)
5	< 12 (40%)	E	Lowest skilled (Ls)

Once a student logs in, he/she can download and access the learning material designed for the peer discussions with the other peers in their small group discussion. The peer discussion panel displays the names highlighted in students list panel.

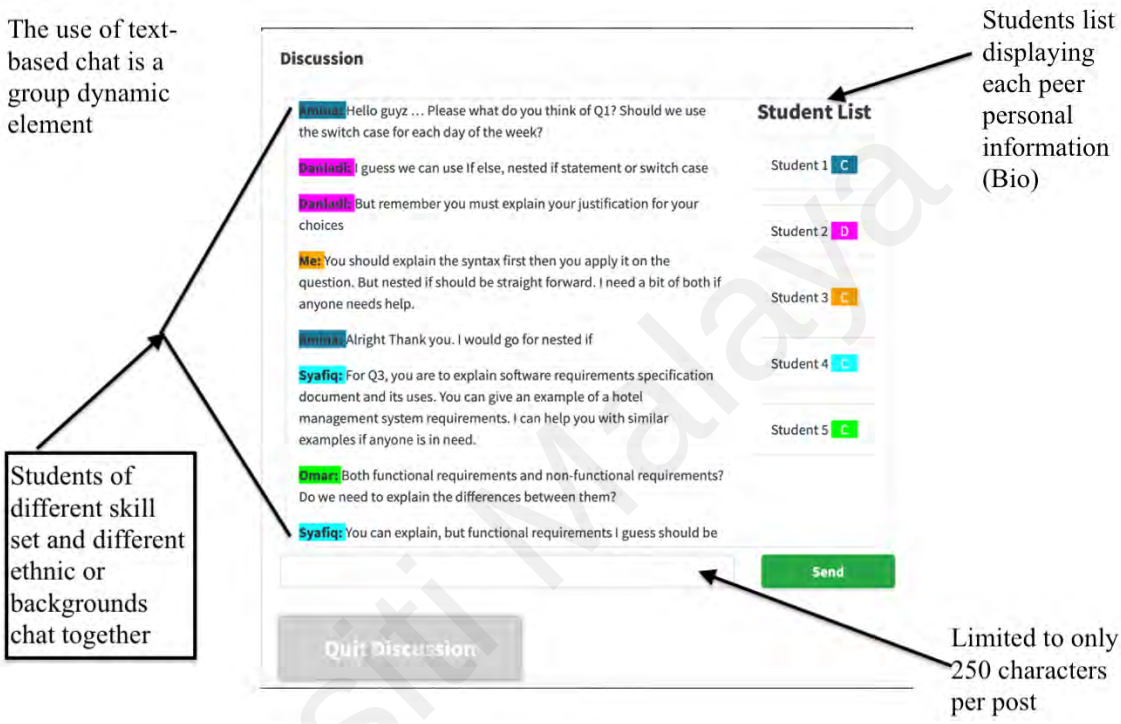


Figure 5.4: A screenshot sample of an active peer-learning group discussion during evaluation

From figure 5.4, the student list panel provides a link to every peer's bio displaying his/her brief background information. Every member in the peer group discussion could click and access or view other members or peer's bio from the displayed 'student list' above. Peers are able to discuss and converse with one another by capping the number of characters to be posted at once by a peer at 250 to reduce dominating the discussion by a peer - aforementioned style of dominant behaviour group dynamic element.

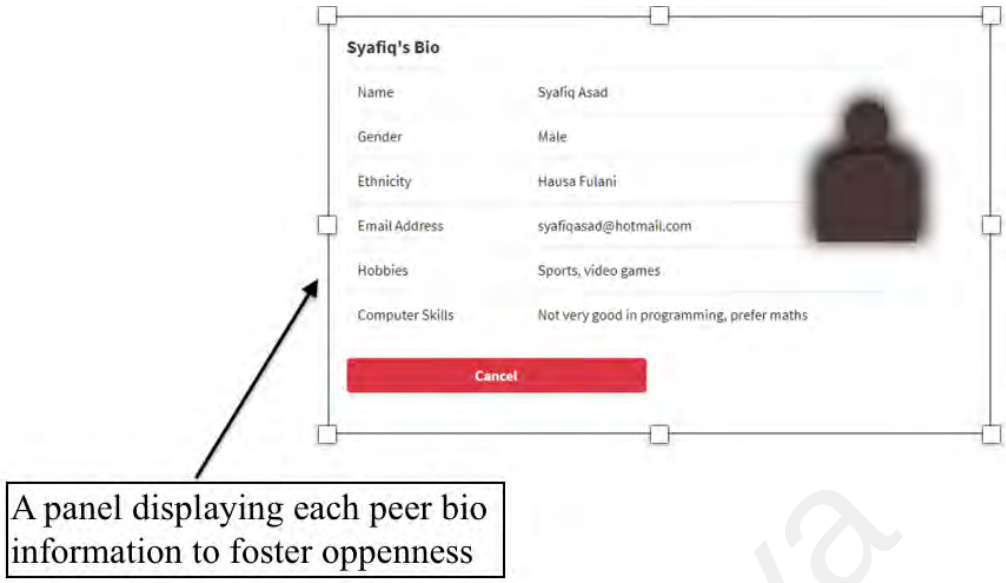


Figure 5.5: A screenshot of a peer's bio information

Figure 5.5 shows the peer's bio information which displays a passport photograph of the peer, short bio containing full name, gender, ethnic background, email address, self-declared hobbies and so on. The passport photograph in figure 5.5 was blurred due to ethical concerns. Once the participants have completed the discussion within a given time frame, they submit and log-out of the discussion, and are required to post a review about the discussion and use of the system in scaffolding their peer learning activity, discussions and overall learning experience using the post review board.

Figure 5.6: Participants review posts displayed at the system's lead page

Figure 5.6 displays the 'word of mouth' of the participants expressing their experience of using the system for scaffolding their peer learning. The submissions from both the experimental and control groups were marked and fairly assessed using an already constructed/designed marking scheme, after which the participants' marks were sorted according to the experimental and control groups. Another lecturer who served as a 'moderator' goes through the marking sheets to ensure fairness. The test scores were keyed into the SPSS statistical software for statistical analysis. In addition, a copy of these scores was stored in the department's excel spreadsheet as well as the university database for record keeping. Figure 5.7 summarizes the two phases of the peer learning approach as discussed, which consists of the preparation and discussion phases

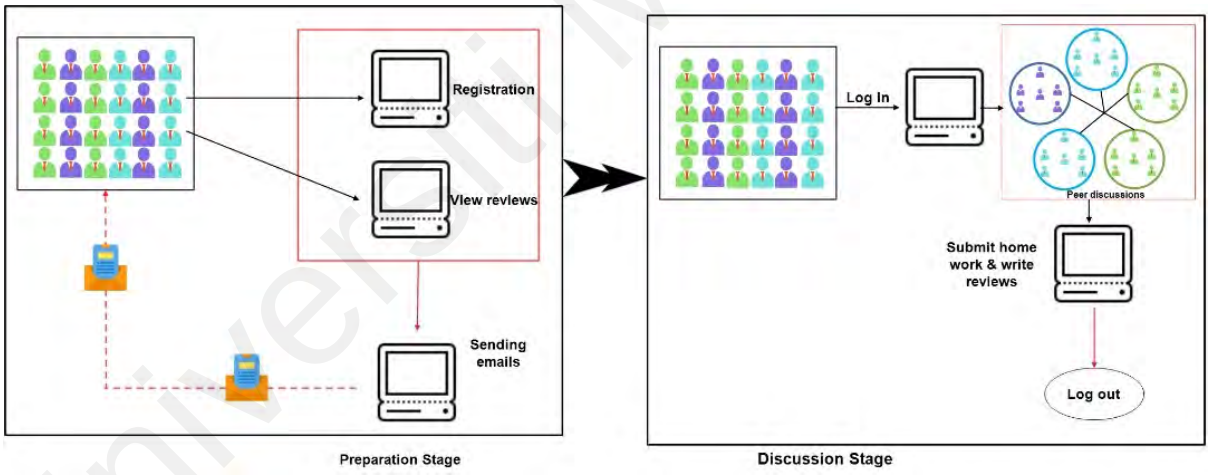


Figure 5.7: The two stages of preparation and discussion stages

5.4 Results

5.4.1 Test sample questions and answers

Tables 5.2 and 5.3 provide a sample of questions and correct answers from both the pre-test and post-tests used for this research peer learning scaffolding assessment. The lecturers tasked for assessing the test answers are encouraged to fairly allocate

marks/scores based on peer effort on each question as described in the description columns in Tables 5.2 and 5.3.

For this research, the assessment and student evaluation are conducted at the group level and not at an individual level. This is because peer learning self-regulation involves peers working together as a group and improving the small group learning aggregate as well as affinity inclination.

Table 5.2 Pre-test sample questions

S/N	Questions	Answers	Examiners assessments

1	Write a program in Java to display the first 10 natural numbers	Public class numbers {
		Public static void main (String [] args)
		Int i;
		System.out.println ("the final 10 natural numbers are:\n");
		For (i=1; i<=10; i++) }
		System.out.println (i);
		System.out.println("\n");
		}
		}
			A correct program writeup with proper indentation attracts 6 marks. Improper indentation or syntax errors such as column costs 1 or 2 marks. A student is awarded marks based on his/her attempt on answering the question.

2	How are software system requirements often classified? Briefly explain with examples.	Software system requirements are often classified as functional and non-functional requirements. Functional requirements are statements of services that the system should provide, how the system should react to particular inputs and how the system should behave in particular situations. Ins some cases, the functional requirements may also explicitly state what the system should not do. Example: A user shall be able to register for appointment to see a doctor. (hospital/clinic system) Non-functional requirements. These are constraints on the services or functions offered by the system. Example: The system should be easy to use by patients and medical staff of the hospital	Correct definition and correct examples attract 8 marks
3	Mention any four requirements elicitation techniques, and state	Any four of the following: Ethnography, prototyping, use cases, scenarios, interviewing.	8 marks in total (1 mark for each)

	the requirements elicitation process activities	Requirements discovery; requirements classification and organization; requirements prioritization and negotiation; requirements specification.	
4	Draw a use case diagram for online shopping system		8 marks for correct diagram

Table 5.3 Post test sample questions

S/N	Questions	Answers	Examiners score allocations

1	Write a program in Java to find the sum of natural numbers using while loop	Public class numbers2{
		Public static void main (string [] args{
		Int num = 10, count =1, total =0;
		While(count <=num)
		{
		total=total + count;
		Count++;}
		System.out.println("sum of first 10 natural numbers is: " +total);
		)
		}
			A correct program writeup with proper indentation attracts 10 marks. Improper indentation or syntax errors such as column costs 1 or 2 marks. A student is awarded marks based on his/her attempt on answering the question.

2	What do you understand by software testing?	Testing is intended to show that a program does what it is intended to do and to discover program defects before it is put into use.	4 marks
3	What do you understand by software validation and software verification in software testing	Validation and verification processes are concerned with checking the software being developed meets its specification and delivers the functionality expected. The aim of verification is to check that the software meets its stated functional and non-functional requirements. Validation however, is a more general process. The aim of validation is to ensure that the software meets the customers' expectations.	6 marks for correct definition (3 marks for each of the components)
4	Draw a use case diagram for a hotel management system	Students are required to draw the actors and the use case together with the arrow directions.	10 marks for a correct diagram

The first and second examiners compared their marking schemes describing their marks allocation and reached a consensus on the marks allocation all through the questions. Both of the examiners have agreed on the importance of alignments and indentations in writing the Java programs. However, there is no clear consensus or agreement on how to assess indentation. The only agreement is that proper indentation and alignment of codes attract 20% of the total marks assigned to a programming question involving writing a java program.

5.4.2 Learning gains between the experimental and control groups

The results of the two groups' learning gains are first presented using the standard bars of descriptive analysis. A descriptive analysis is an important first step for conducting statistical analyses. It gives an idea of the data distribution while helping to detect typos and outliners, associations among variables etc. which enables the preparation for further statistical analyses. As the experimental group used the PL-LPAD prototype and the control group used the PL-N, the mean score of each of the 11 subgroups of the pre-test and post test scores of both the experimental group and control group was calculated. Although, there is a slightly higher number of participants in the control group who used the PL-N system compared to the experimental group.

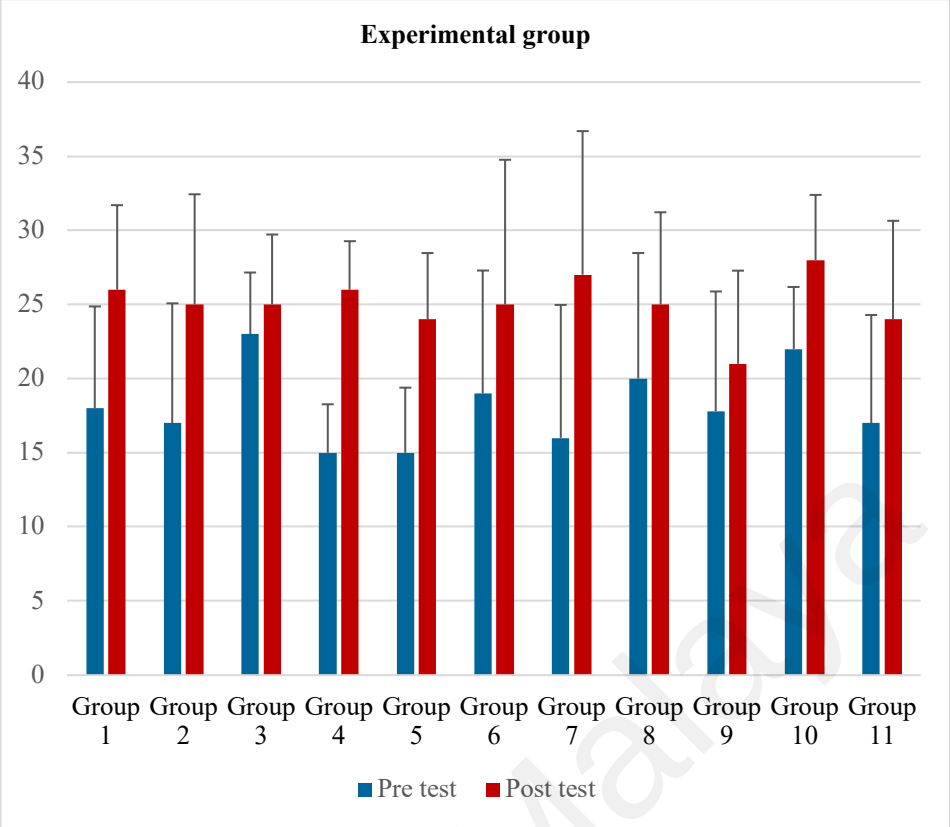


Figure 5.8: Descriptive analysis of pre-test and post-test of the experimental group and sub-groups scores

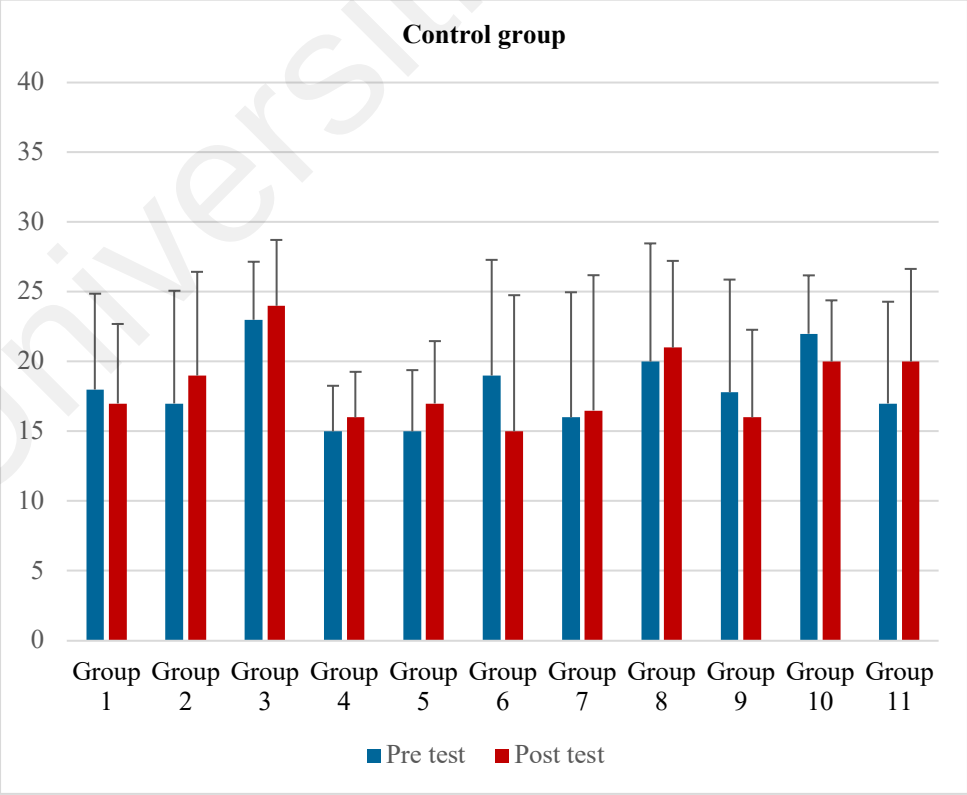


Figure 5.9: Descriptive analysis of pre-test and post-test of the control group and sub-groups scores

In order to measure and determine the differences in group scores between the experimental group and the control group, an independent sample t-test in SPSS was run to compare the improvement of learning outcomes from these two groups. The use of an independent sample t-test has been widely used in such situations. The Independent Sample *t* test is typically used for comparing the means of two independent groups in order to determine whether there is statistical evidence that the associated population means are significantly different. The Independent Samples *t* Test can only compare the means for two (and only two) groups. Table 5.3 describes the statistics of the experimental group and control group and Table 5.4 displays the results of the independent sample t-test generated from the SPSS statistical software. The independent sample t-test formula is expressed below:

$$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

where $\bar{x}_1$ and $\bar{x}_2$ are the means of the first and second group sample respectively; $\bar{n}_1$ and $\bar{n}_2$ are the sample size of the first and second group sample respectively; and $\bar{s}_1$ and $\bar{s}_2$ are the standard deviations of the first and second group samples, respectively. The results show that the use of PL-LPAD have resulted students in achieving significantly better academic scores that PL-N due to the significant difference of the post-test (F = 12.043; $t = -3.628$; $p < .001$), whereas there has been no significant difference between pre-test groups (F = 0.619; $t = -1.388$; $p > .05$); where *'F'* is the test statistic of Levene's test, '*SE'* is the standard error and '*Sig.'* is the p-value corresponding to this test statistic. The results show that the approach of setting students to engage in peer learning by grouping based on learning potential, affinity, instigation of group dynamics and incentivization through fostering pro-social behavior and empathy positively impacts students overall learning

achievements. The experiment yields the expected result due to the experimental group having a higher performance or score than the control group.

T-Test

Group Statistics

	Test	N	Mean	Std. Deviation	Std. Error Mean
Control	Pretest	57	63.47	12.910	1.928
	Posttest	57	66.95	14.295	2.390
Experimental	Pretest	55	62.83	14.074	2.097
	Posttest	55	83.65	7.9063	1.397

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Control	Equal variances assumed	0.619	.0429	-1.388	110	.155	3.480	2.867	47.37	82.51
	Equal variances not assumed			-1.527	96	.000	3.480	2.465	47.37	89.04
Experimental	Equal variances assumed	12.043	.001	-3.628	108	.000	20.82	2.741	61.08	91.97
	Equal variances not assumed			-3.801	108	.000	20.82	2.602	62.94	88.15

Figure 5.10: Statistical analysis tables of independent sample t-tests and results

Table 5.4: Group statistics

Group		***Size***	***Mean***	***SD***	***SE***
Control group	Pre-test	57	63.47	12.910	1.928
	Post-test	57	66.95	14.295	2.390
Experimental group	Pre-test	55	62.83	14.074	2.097
	Post-test	55	83.65	7.9063	1.397

Table 5.5: Independent sample test

Scores	***F***	***Sig.***	***SE***	***t-value***	***p-value (two-tailed)***
Pre-test	0.619	0.429	2.867	-1.388	.155
Post-test	12.043	0.001	2.713	-3.628	.000

Similarly, in order to interpret the results of the hypothesis test HI in relation to the difference in variation of the standard error *SE*, since the mean is calculated at the group level, the value of the *SE* from the results postulates how accurate the mean of any given sample from that population is likely to be compared to the true population mean. From table 5.4, the *SE* of the control group has increased slightly from 1.928 to 2.390, while the *SE* of the experimental group decreases significantly from 2.097 to 1.397. These variations show that the decrease in standard error value is a more accurate representation of the true population of the experimental group mean, while the slight increase of *SE* in the control group shows a slightly less accurate representation of the mean. However, the difference between the variations of the *SE* in the control group is significantly less compared to the difference in the variation of the *SE* in the experimental group. Similarly, the *SE* value of the post test result in the experimental group has decreased which signifies a more accurate representation of students learning gains/achievements.

Apart from improving the overall academic score and performance of all the subgroups, one of the objectives of this research is to pull up the lowest-skilled or weaker students in each sub-group. The computed results from the experimental group shows that

the gap between the lowest skilled or weaker students and highest skilled has significantly improved by referring to the SD values. This shows that the weaker students or less capable students have averagely gained an estimated 100% increase in academic scores through the use of PL-LPAD system as opposed to the students in the control group using the PL-N system.

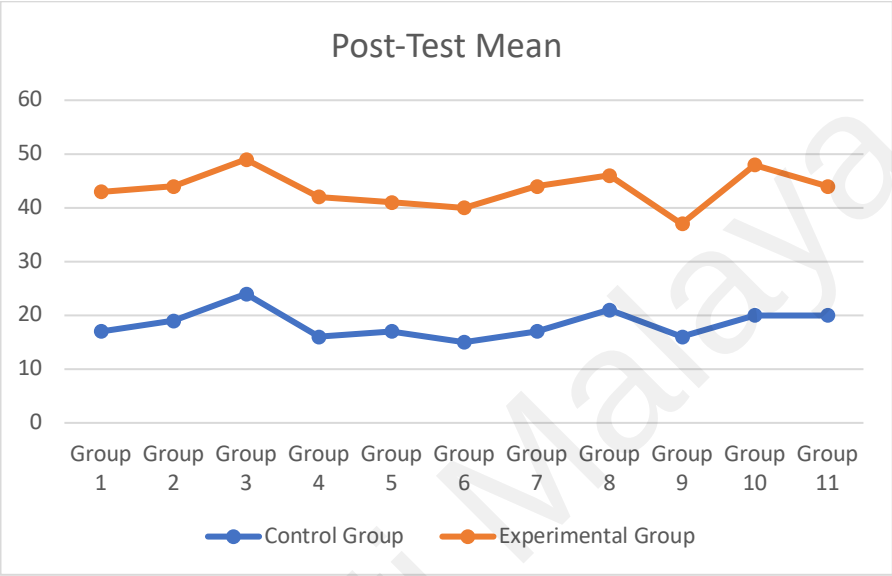


Figure 5.11: A graph illustrating the differences between the two groups post-test results

The results further show that the value of the standard deviation is significantly less in the experimental group compared to the control group (experimental group SD=7.9063 < control group SD =14.295). This means that the gap between the highest skilled and the lowest skilled students is reduced which means that the discussion and learning gains and sharing of skills is significantly higher in the peer learning subgroups of the experimental group compared to the control group. In the post reviews, several posts from the participants sharing their peer learning experience applauding the quality of discussion, the teamwork and the togetherness or stickiness of their group. This also reflects findings that many students from diverse backgrounds prefer the social nature of interacting with others while learning.

Results from this study shows a relatively few comments or reviews from students' participants of the experimental group. It seems that the students are more concerned with the peer discussion with their group members and have less interest in mentioning their experience with the peer learning system. The reviews or comments show the relative learning gains from the less skilled peers to the more skilled peers. Few of the reviews mentioned are

"The system is ok and we helped each other"

"It was a good experience, this is true peer learning, the questions are difficult"

"It was interactive and my colleagues were helpful. Hopefully we get good grades

5.5 Hypothesis testing results

This research's first hypothesis H1 is supported and holds by asserting that grouping students based on learning potential and strong affinity inclination in small group learning would ensure knowledge transfer and improved learning outcomes among peers. This is evident from the academic scores between the experimental group and the control group. The second hypothesis H2 postulating that designing peer learning systems with pro-social behavior functionalities would incentivize students towards peer learning participation. Although the results have shown a sizeable number of participants from both experimental and control groups. However, the number of participants of the control group is slightly higher than the experimental group. This has shown that both the indirect incentivization strategies have significantly impacted students' participation and combated reluctance and social loafing.

Table 5.6 Result of the research Hypothesis

S/N	Hypothesis	Result
1	**H1**: Grouping students based on learning potential and strong affinity inclination → knowledge transfer and improved learning outcomes	Supported
2	**H2**: Designing peer learning systems with pro-social behaviour functionalities → Incentivise students for peer learning participation	Supported
3	**H3**: Designing learning systems that foster the presence of group dynamics → coherent functioning of peer learning group	*Supported

The humanized email sent to students of the experimental group motivated and encouraged their participation, while the appearance and visibility of the positive comments from the experimental group participants validated the system and encouraged the control group students to participate and trust the system. Therefore, hypothesis H2 is supported and holds.

With regard to the third hypothesis H3 which postulates that 'designing learning systems that foster the presence of group dynamics would ensure the coherent functioning of a peer learning group in accomplishing a given learning task'. It is understandable that the mutual relationship built or developed by the presence of group dynamics that benefits learners in small groups become manifested and apparent over a longer period of time. However, it becomes necessary and essential to instigate and start off these vital small group learning influencers (group dynamic elements). In this research, the group dynamics relationships and stickiness have only been ignited in the short peer learning discussion of this research. H3 is arguably supported since it also supports the peer learning scaffolding process and is not expected to have an immediate impact on the individual peer learning groups. It requires a longer period of time to actually understand and measure the influence of these group dynamics on small group learning.

5.6 Research implications, discussion and conclusions

This study offers an entirely novel way of scaffolding students' self-regulated learning in blended learning instruction. The introduction and literature review chapters include definition, explanations and applicability of the various terms used in this research. This research work has discussed the various definitions, theories and explanations of the term scaffolding from various research disciplines. Although the scaffolding metaphor originated from building and construction literature and was later adopted in the educational technology literature, it has gradually gained relevance and is being used in online learning and educational technology literature to mainly explain how technology supports learning.

While self-regulation in online learning environments require students to learn autonomously with the support of either the technology or teachers or supporting themselves as peers, scaffolding term has been regularly used to describe the type of support that either these technologies with their functionalities offer to these students; or teachers offer support to their students using the technologies; or how technologies engage students to support each other's collaboratively.

This research study has shown the significant pedagogical benefits of peer learning self-regulation strategy in elevating students' academic performance as well as reducing other challenges found in blended learning. This research has strongly asserted and offered reliable evidence of scaffolding students self-regulation in blended learning. Contrary to research especially in other domains, this research study does not improve an existing self-regulation scaffold but rather, focused on proposing an entirely novel approach of dealing with a particular challenge/drawback – peer learning that blended learning instruction is deprived, as such does not involve comparison of previous reports, values or studies.

First, in order to establish a dependable online learning which would engage and support students in the peer learning discussion which takes place remotely (in the online component of blended learning), infrastructure including learning technologies and reliable internet connection, was one of the primary concerns that needed careful attention for both students and teachers.

The evaluation process in this research involves developing two identical prototype learning systems, these prototypes were initially evaluated using heuristics experts' evaluation to certify the functional requirements and capability of the prototype in meeting the self-regulation scaffolding expectations. The idea of adopting an experimental or intervention group with a control group evaluation methodology has been a common practice in blended learning and other technology mediated environments e.g. (see (Chou et al., 2018; Lin et al., 2016)) in evaluating learning systems functionalities typically with one of the systems having the built-in functionalities while the other been a dummy/placebo. Since peer learning participation takes place in small structured groups, the peer learning evaluation conducted for this research is based on the learning aggregate of each small group. This explains the aggregate learning gains in each of the peer learning groups.

This research employs the use of students' implicit data such as students' backgrounds, academic scores to build students' profiles. This profile would be used to autonomously allocate and pair each student with their appropriate learning peers to engage in discussions. Researchers over the years have used self-report (explicit data) to understand students' participants' or employees' preferences on a particular subject issue. However, this research has adopted a similar approach in (Rahman & Abdullah, 2018) to fully use implicit data from students records. The use of explicit data from students inquiring about their self-regulation might provide or offer a better or more accurate understanding of students' self-regulation. However, explicit data is usually associated

with drawbacks such as time consuming, in which this study experimental process might be a daunting task. Furthermore, the use of implicit data has been proven to be accurate and effective in autonomously building students' profiles as well as predicting learners' behavior. This would allow the peer learning discussion to seamlessly take place without eliciting any data input or information from the students. Keeping in mind that, the experience of using different platforms and technology can differ depending on how the students have an in-depth understanding of the virtual mode of peer discussion. One of the caveats that have already been significantly diminished with the experiment in this research is the employment of participants from Computer Science related discipline deemed as relatively competent for peer learning.

The strengths and uniqueness of this research lie in the deductive approach of understanding the best practices and approaches of peer learning from various research domains and then carefully piecing these ideas and theories together in a blended learning educational setting to provide blended learning students with an effective peer learning scaffolding experience. Another distinction of this research comes from a strong foundation and thorough understanding of the general concept of blended learning instruction, the basic types - blended and flipped, exploring and identifying the existing challenges that students, teachers and educational institutions face in the online component of blended learning in which the key challenge that halts blended learning moving forward which is scaffolding students for peer learning self-regulation strategy was identified.

This research explains the two main preparation and discussion phases involved in peer learning. It is understood that for an effective online peer learning scaffold, there are two major concerns to overcome: I) To prepare students before the online peer-learning discussion exercise so as to prevent social loafing and refusal to participate; II) to facilitate and fully engage students in the actual peer learning online discussion.

One of the most important questions to ask is “do students in blended learning need peer-learning scaffold all the time?,”; the answer is Yes! because self-regulation challenges particularly peer learning is not for example an ad-hoc challenge/issue, in which students require them at certain times, students in blended learning environments are constantly in dire need of peer learning self-regulation due to its sheer importance to their overall academic performances as well as their direct or indirect effect in alleviating the challenges and inherent worries they face with their online environments especially the hunger for social interaction, seclusion nature etc. (Kizilcec & Schneider, 2015; Kotturi et al., 2015).

Though, this research study does not involve live video chat in which group members (peers) would express their non-verbal communication such as voice, gestures, facial expressions, etc., the instigation of group dynamic elements in the first place has been a head-start to facilitate and motivate students to use texts in expressing their non-verbal cues. There is no reason why some of that richness cannot occur in text-based discussions especially when each group is maintained for a longer period of time - an entire academic semester *per se*. The study (Gajadhar & Green, 2003) evidenced that in a text-based discussions, where learners often use text-based nonverbal cues, the further they continue in their discussion, the further they integrate and perfect the use of non-verbal expressions. Gajadhar & Green (2003) claimed that students are constantly reinventing the tools they have in order to express their non-verbal cues that fit their small group learning. This involves the use of emoticons, repetition of words or punctuations for expressing such non-verbal cues.

Arguably, the proposed framework does not only apply or facilitate online peer learning self-regulation strategy, it also has other implications on the remaining self-regulation strategies such as procrastination, rehearsal, metacognition etc. (see (Broadbent & Poon, 2015)). Arguably, the features that promote pro-social behaviors,

norms and co-dependency have a huge impact on combating social loafing and a positive impact on self-regulation in general. While offering incentives to students in educational settings involves an indirect or different strategy, one of the most interesting findings of our research is that incentivization strategy can be applicable and used to support or promote group dynamic elements.

It is worth mentioning and affirming that throughout the course of this research, every step and process of this research was conducted ethically and professionally to the best of ability and does not involve any manipulation test for self-regulation. Thus, the mechanism by which academic performance is improved can only be inferred from the design criteria.

5.7 Summary

This chapter explains the experimental setup conducted in order to assess and evaluate the effectiveness of the proposed peer learning framework for scaffolding students peer learning self-regulation strategy in blended learning. The hypothetical assertions formulated were evaluated with the help of the statistical results of the experiment from the two experimental and control groups using the statistical software, the number of participants from each of the evaluation groups as well as other key outcomes and output results obtained from the experiment. In summary, the results show that the proposed framework is significantly effective in improving students' academic performance and learning achievement. This chapter have also discussed the implications of the findings, comparisons with other studies, the implication of the proposed peer learning approach on other self-regulation strategies, as well as other important issues such as the role of non-verbal cues.

CHAPTER 6: CONCLUSION

This research investigated the existing challenges that students, teachers and educational institutions face in their online component of blended learning. The lack of peer learning self-regulation strategy emerged as the missing learning strategy required for students to properly self-regulate their learning and combat the inherent challenges typically found in the online component of blended learning. This research shows the complex steps and challenge associated in establishing an effective peer learning self-regulation scaffold among students. The fact is that it is very difficult to fully understand and precisely determine and evaluate every learner's behavior, skill, attributes. However, this study has carefully studied and adopted the best and feasible approach in studying credible existing works, phenomena, theories and other related knowledge to form a framework for scaffolding students' self-regulation in blended learning. The experimental results involving undergraduate university students have led students in achieving better and improved academic outcome. Results of this research experiment appears to have bigger impact on the least skilled students, as these set of students have substantially benefited more using the peer learning scaffolding approach compared to the average skilled or higher skilled student, because these least skilled students or least capable students have averagely doubled their academic scored. This conclusion chapter presents summary of findings, the achievements of the study in the order of the research objectives, the limitations and possible future research directions.

6.1 Summary of findings

This research was motivated by the popularity and the dominant factor of blended learning in today's education. Therefore, blended learning literature from the last decade (2011 to 2020), especially the articles or publications deemed as high impact from was carefully studied. This led to a deep understanding of blended learning research area as a

whole. One of the standout issues from this empirical literature was the various reported challenges from students, teachers and educational institutions with their online component of blended learning. This chapter brings the thesis to the conclusion by reappraising the questions and objectives of this study. Moreover, the chapter presents the mapping of research-questions, research objectives, and the findings of this research.

1. **To investigate the state of the art challenges in the online component of blended learning from students, teachers and educational institutions perspectives.**

   To achieve this objective, extensive literature search was conducted using various databases namely; Web of Science, Scopus, science direct, IEEE Xplore, SpringerLink, ACM etc. in order to understand the existing challenges The articles were examined for relevance before the critical literature review. Various reported challenges in the online component of blended learning from students, teachers and educational institutional lenses were learned from the relevant literature from 2014 to 2019. The challenges from each of the three identified lenses of students, teachers and educational institutions were also categorized into related themes to form a taxonomy of challenges. In addition, other challenges in related articles from various related online and educational research domains such as MOOCs, recommender systems, personalised systems, distance education, fully online learning, were considered to better explain and understand these three categories of challenges.

2. **To investigate the existing approaches for scaffolding students self-regulated learning in the online component of blended learning.**

To achieve this objective, extensive literature search was conducted using various databases namely; Web of Science, Scopus, science direct, IEEE Xplore, SpringerLink, ACM, Google Scholar etc. The articles that specifically proposed scaffolding approaches in the online component of blended learning were selected and thoroughly examined for relevance. These articles were then categorised into self-regulation scaffolding articles and self-regulation strategies articles. The strengths and weaknesses of these articles were critically analysed. In addition, the overall limitation and drawback of these approaches were identified to be lack of peer learning scaffold which is needed to boost self-regulated learning in blended learning.

3. **To propose a tool for scaffolding students peer-learning self-regulation strategy in the online component of blended learning.**

   This involves understanding the related literature or works, phenomena carried out on peer learning from various research domains. Consequently, this motivated and led to further understanding and investigation of other key aspects and dimensions of peer learning that contribute to the success of small groups for learning. This involve understanding the formation of learning groups, learning potential, learning groups in educational settings, group size, group formation, group dynamics, group affinity, incentivization in educational settings, fostering pro social behaviours, humanization of learning systems etc. Then a prototype learning system is designed to offer and instigate these features so as to assert the applicability of the learning system into real life. The prototype was evaluated using the appropriate heuristic evaluation human computer interaction technique.

4. **To evaluate the effectiveness of the tool for scaffolding students' peer learning self-regulation strategy in the online component of blended learning.** Since this study does not involve comparing with another study or baseline results, the typical experimental and control group evaluation approach was used in which certain participants receive the variable or scaffolding intervention and the other widely used experimental and control grouping evaluation technique was used. The results show improved learning achievements from the experimental group students compared to the control group students.

6.2 Achievements of this research

This section highlights the key achievements of this study. These are discussed as follows:

1. Improving blended learning: Blended learning has grown in stature over the years and has been recognized as the most effective form of instruction globally. The main aim of this research is improving the already proven and widely adopted blended learning instruction which is widely regarded as the 'new norm' in today's educational institutions. This research has identified the lack of peer learning as the main obstacle that is halting blended learning instruction, and consequently proposes to blended learning educational institutions a framework for scaffolding student's peer learning self-regulation strategy in order to improve students' academic performance, learning achievements and combat the challenges that students face with blended learning and more importantly to their online components. Since most of today's educational higher institutions are blended, this research shows the need for these institutions to redesign and revise their learning systems as well as their blended learning as a whole so as to accommodate this rich form of learning strategy for the benefit of their students in alleviating the challenges that students face out of their online components,

which also positively impacts teachers and the educational institution as these three entities are interrelated.

2. Challenges in the online component of blended learning and taxonomy: This research has investigated the existing challenges in the online component of blended learning from students, teachers and educational institutions lenses. These challenges were categorized into five sets of categorical themes from students', four set of categorical themes from teachers', and three sets of categorical themes from educational institutions. This study has found that students mainly suffer from self-regulation challenges and the inability to effectively use technology for studying. Teachers main challenge is their unwillingness and negative perception of using technology for teaching. Educational institutions key challenge is providing the suitable and sufficient technological infrastructure, as well as providing effective training support to their teachers. Educational institutions which are mostly blended could asses and evaluate the level of technologies to be introduced and implemented for their students and teachers in order to align with their technological competence to avoid technology gold-plating, or on the other hand, could suffer from insufficient technology for delivering an effective blended learning instruction. In addition, this research has identified several challenges with competence in the use of modern technology for instruction and technological affordances. Consequently, this led to identifying, collating, categorizing, formation of a taxonomy of challenges, and explaining these challenges in relation to other related studies so as enable blended learning institutions in clearly understanding the way forward for addressing these sorts of challenges and the way forward for improving the overall blended learning instructional experience. This taxonomy will assist future

researchers in gaining more insights and understanding into the challenges in blended learning.

3. Self-regulation research trend: This research has found that the existing blended learning approaches for scaffolding students' self-regulation in the online component of blended learning are limited in primarily focusing on either designing learning systems and tools to scaffold self-regulation, or designing systems and techniques to scaffold online help-seeking self-regulation strategy, and have not proposed supports to other types of self-regulation strategies more importantly peer-learning self-regulation strategy. This research has also described and explained how students' self-regulation is supported, the systems, designs and techniques adopted by blended learning practitioners and researchers in scaffolding students learning out of their face-to-face classroom settings. The research has also shown and illustrated the trend in improving self-regulation as well as the attempts made to combat and alleviate the worries associated with the online component of blended learning.

4. Peer learning significance and system design: This research has uncovered and underlined the importance of the neglected and less researched yet valuable peer learning strategy. This resulted in adopting a deductive approach in which existing works, ideas and phenomena are studied and considered as inspiration for proposing this research novel framework for scaffolding students peer learning self-regulation strategy in blended learning. This led to designing a learning system that group students based on learning potential and affinity inclinations. More importantly, (1): This research has identified the five key group dynamics elements and has leverage the power of today's modern technological custom

features in implementing group dynamics to successfully propel peer learning groups. (II) This research has also offered incentives for small group peer learning by leveraging today's modern software tools in designing learning systems for reshaping the human minds to promote pro-social behaviors among peers, which offer indirect incentives in the form of co-dependency and peer empathy, as well as implicitly grouping learners for effective team learning in small peer learning groups. (III) This research has also brought forth the logistics of forming learning groups in educational settings, the affordances and power of today's modern technology, and various other less researched aspects for researchers and practitioners to better understand blended learning in general.

5. Two phases of peer learning: This research has shown and explained the two distinct phases of peer learning self-regulation approach which consists of the preparation and discussion phases. A successfully implemented and planned preparation stage ensures motivation and propel students towards the peer learning discussion so as to avoid reluctance as well as social loafing detrimental circumstances. Meanwhile, a successful discussion stage ensures the smooth discussion and transfer of knowledge, coordination and a successful team effort towards the team learning achievement. This shows how these two phases are related to one another and the implication of each phase on the other for the success of the entire peer learning self-regulation process.

6. Framework evaluation: This study has demonstrated the applicability of the proposed novel framework for scaffolding students peer learning self-regulation in blended learning by implementing a learning system prototype to ascertain the performance of the proposed framework functionalities in real life scenarios using

web-based interfaces. The framework has resulted in scaffolding students towards better learning achievements and overall better academic outcomes.

7. Transforming blended learning towards providing greener learning experience: This research could potentially transform and change learning patterns, the way blended learning is conducted by seamlessly connecting the right learners and suitable learners deemed fit for small group learning, and these learners can share their skills across and learn from one another. This empowers and motivate students learning desires and combats disparaging challenges of seclusion, alienation, lack of social ambience, procrastination behavior etc. One of the most important transforming factors is that this research has boosted the general online learning, where students are better engaged in the online learning and spend more time online due to scaffolding and innovative ways of motivating them to fully engage. Arguably, students would spend longer time with their technologies for online learning in their online environments especially if these systems are used for a longer period of time due to the manifestation of affinity, group dynamics, incentivization as well which would combat concerns such as social loafing, reluctance to use the system etc. As such, this research is on the course of transforming learners and the whole blended learning instruction as well as the society they live in. Students would be having higher academic grades and improved knowledge gains. Similarly, the satisfaction and fear of failure conundrum would drastically be suppressed in the academic environment and society at large. Thus, this research has the potential to bring happiness and joy in learning, reduce students hunger for social interaction and positively change the mind-sets of potential University and other higher educational institutions students.

6.3 Limitations of the study

The previous section has discussed the achievement of this study, which is aimed at designing a scaffolding peer learning tool for the online component of blended learning. However, during the cause of this study, a number of limitations and challenges were encountered, which are discussed as follows for future reference:

- Impact on longer duration: The mutual relationship built or developed by group dynamics that benefit learners in small groups become manifested and apparent over a longer period of time. However, it becomes necessary and essential to instigate and start off these vital small group learning influencers (group dynamics). Peer learning group dynamics relationship and stickiness in this research have only been ignited in the short peer learning discussion held by peers in this research. Therefore this research study is limited by measuring group dynamics in a one-off situation or a limited time duration. Similar experiments could be repeated over a longer period of time (e.g. a semester long or for a whole academic session).
- This research does not particularly measure the impact and significance of the individual elements of the peer learning framework which consist of five (5) elements of group dynamics, affinity, etc. This research could be improved further by investigating the influence of each elements of group dynamic over a longer period of time.
- Withdrawing scaffolds over time: The point of scaffold means that it is a temporary support and should be removed progressively as students develop the necessary foundation. One of the limitations of this research is that the scaffolding support is not removed progressively over time because the experiment was

conducted once. It would be interesting to see the impact of progressively removing the scaffolding features over time on the students' learning outcomes.

- Learning potential optimization: One of the limitations of this research is that it uses learning potential width by considering the two ends of the spectrum (highest skilled and lowest skilled) as the learning potential boundaries. It would be interesting to further optimize the learning potential aggregate possibly using machine learning algorithms to optimize learning potential in each of the small peer learning groups.
- Affinity: This research is limited by considering geographical and background information of students to form strong affinity. The system design is constrained to categorize affinity based on three geographical and three ethnic/background group data culled from the University database.
- Sample size: One of the limitations of this research is the population size of the experiment participants. Therefore, future research could conduct similar experiment involving larger number of participants. It would be interesting to explore this approach to other science disciplines and beyond such as humanities.
- Quality of discussion: Peer learning sub groups would differ in the quality of discussions among their peers. This research is therefore limited in measuring the quality of discussions and the correlation between the quality of discussion and learning outcome in each of the peer learning group.
- Peer learning for the disabled: This research is limited in scaffolding students deemed as competent without any known disability. Research is warranted in scaffolding peer learning self-regulation strategy for disabled students.
- One of the limitations of this research is that the experiments were conducted in a typical blended learning setting. With the recent emergence of blended learning

variants especially the flipped classrooms, similar experiments could be repeated in other types of blended learning such as the flipped classroom settings.

- The definitions of the conceptual terms used in this research is limited by only explaining the research terms mostly used in educational technology literature. This is because some of these conceptual terms used in this research such as affinity have been applied and used mostly in science related disciplines such as chemistry and biological sciences. It would be interesting to further investigate this terms and provide a broader definitions from various disciplines so as to bring out the deeper meaning and clearer understanding of these terms.

6.4 Suggestions for future work

This section highlights a number of suggestions for future research outside the scope of this study. These are discussed as follows:

- Implication of peer learning scaffold on other self-regulation strategies: Arguably, the peer learning scaffolding approach proposed in this research does not only apply or facilitate peer learning self-regulation strategy, it also has implications on the other self-regulation strategies such as procrastination, rehearsal, metacognition etc. In particular, one of the inherent challenges that deters students to flourish in their online components is procrastination. Procrastination is considered as a self-regulation dysfunction and is usually researched or linked to the medical and psychological domains. Therefore, future research is warranted to investigate the implication of peer learning scaffolding strategy on these self-regulation strategies. Additional research is warranted to leverage the use of learning systems in incorporating features that combat or reduce students' procrastination in the online component of blended learning.

- It would be interesting to investigate learning potential and affinity in smaller group sizes of three (3) and four (4) members, and possibly compere their performances.
- Students report of explicit data: This study has used students implicit data to autonomously group and offer scaffolding supports for peer learning. Future research is warranted to use students explicit data
- As peer learning in the online component of blended learning involves students from varying backgrounds, location and skills of a subject matter, teachers have key role to motivate and arrange for a sweet spot peer learning interaction. For example, the ideal time of the day suitable for peer learning interactions. Therefore, future research is warranted to investigate or repeat similar experiments in different times of the day to determine the most suitable time slot for such learning strategy.
- Another future research recommendation worth mentioning is investigating the elements of community of inquiry (CoI) online learning framework. CoI has received huge attention from online learning researchers in various domains. There have been considerable efforts in remodelling or adding an additional construct to the already existing social, teaching and cognitive presences. Future research should investigate these three CoI presences in the online component of blended learning in relation to peer learning self-regulation strategy.
- The use of negotiation mechanism between a student and learning system has shown to encourage students online studying in improving metacognition and the competence with learning systems. Future research should investigate the effect of incorporating a negotiation mechanism in the online component of blended learning particularly to peer learning systems.

- Recommendation capability: Future research should redesign the learning system to incorporate recommendation capabilities of learning materials to students, as recommender systems are believed to be the future of e-learning in such a way that learning materials are recommended to learners based on their learning capabilities. Therefore, learners can be engaged in peer learning discussions with various scaffolding features and capabilities, as well as recommending the appropriate learning materials based on students' capabilities, preferences and choices.
- Future research should also look at the impact of other different aspects of human dimensions in forming effective affinity within peer learning groups. This study could also be repeated with a different sort of cultural and background diversity classification as long as it satisfies and improves affinity inclinations.
- Research is warranted to compare the impact between forum posts and sending humanized or personalised emails in motivating and deriving students towards use of a peer learning system. Further research is also warranted to investigate the impact of forum posts on motivating students to adopt and use an online peer-learning system for self-regulation strategy scaffold in blended learning instruction.
- Text based peer learning scaffold. Further investigation is needed pertaining non-verbal communication in shaping engagement and self-regulation in the online component of blended learning, as nonverbal behaviours such as facial expressions play a critical role in shaping group dynamics and joint engagement.

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