CHAPTER 1

INTRODUCTION

1.1 Background of the Study

Sustainability is a characteristic of a process or state that can be maintained at a certain level indefinitely. The term, in its environmental usage, refers to the potential longevity of vital human ecological support systems, such as the planet's climatic system, systems of agriculture, industry, forestry, fisheries, and the systems on which they depend.

Sustainable agriculture refers to the ability of a farm to produce food indefinitely, without causing irreversible damage to ecosystem health. Two key issues are biophysical (the long-term effects of various practices on soil properties and processes essential for crop productivity) and socio-economic (the long-term ability of farmers to obtain inputs and manage resources such as labor).

In the context of this study, sustainable agriculture is exemplified by paddy farming in West Malaysia. Specifically, the study aims to examine how information and communication technology (ICT) as an innovation can help to promote and provide exposure for sustainable agriculture in paddy farming. Ismail (2006) states that sustainability in agriculture refers to the farm's ability to maintain production and offer benefits based on maintaining nature and the environment, accelerating social growth, stabilizing the economy and being commercially good competitor in the fast changing environment. Further, sustainable agriculture covers both aspects of production and preserving the environment.

Innovation is the process of bringing an invention to the users, to the market place and to industrial application. Innovation thus, is a very important element of economic and social progress and it should be widely encouraged. Eco-innovation is a term used to describe products and processes that contribute to sustainable development. Eco-innovation is the commercial application of knowledge to elicit direct or indirect ecological improvements. It is often used to describe a range of related ideas, from environmentally friendly technological advances to socially-acceptable innovative paths towards sustainability.

Currently, there are many innovations in ICT, and Virtual Reality (VR) had been utilised in various disciplines such as in promoting sustainablility (O'Connor, 2004; Kuo *et al.*, 2004; Ha & Woo, 2006 and Oka & Yamauchi, 2006), learning (Youngblut, 1998), training (Mazuryk & Gervautz, 1996: 9) and construction (Loh *et al.*, 2010 and Crosbie *et al.*, 2011).

Multimedia and VR also have advantages as a persuasive technology. Fogg (2003) coined the word ‘captology’ which explores how what is known about motivation and persuasion can be applied to computers and consumer devices. The objective is to change behavior and attitudes in predictable ways. Figure 1.1 shows the area of captology in persuasive technology, where computing technology and persuasion overlap. Captology focuses on attitude and behavior change resulting from human-computer interaction. Three persuasive principles have been applied in this study; the principle of cause and effect, the principle of praise and the principle of social learning.

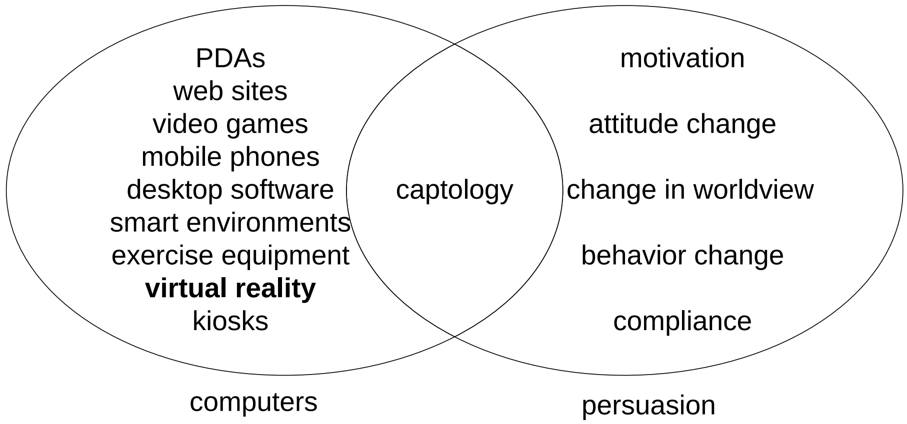


Figure 1.1: Area of Captology in Persuasive Technology (Fogg, 2003)

1.1.1 Current Issues in Rice Production

Global warming, environmental crisis, plant diseases and pests, have been the factors that disrupt food production in many countries all around the world. At this time when the world's population is increasing rapidly and the demand for food is high, these problems have threatened food security and people's health worldwide. 24,000 people die of hunger-related causes every day, including one child every five seconds. Malnutrition has impaired physical and mental development in 178 million under-fives worldwide. 967 million people are hungry as a result of the World Food Crisis. The numbers are frightening but people are not numbers. And millions of them are parents facing choices they shouldn't have to make, whether to give their sick child food or medicine (Wuthi-Arporn, 2009).

Rice is the staple food for more than three billion people all around the world. At least 114 countries grow rice and more than 50 have an annual production of 100,000 tonnes or more. Rice is the main food for most countries in Asia and, about 90% of the global rice area, production and consumption are concentrated on Asia. At this time, when the world's population is already reeling from higher food prices, many countries have already banned or restricted their rice exports, which pushes up the price of rice even higher. Paddy yields have been increasing since the 1960s, but since the 1990s, the increase in rice production has been slower than population growth. Indeed, it is anticipated that rice production will need to increase by 30% by 2025 in order to cater for the world's growing population (Wuthi-Arporn, 2009).

Malaysia is still unable to achieve self-sufficiency in food production for its population, refer to Table 1.1. However, there are many strategies to increase production in sustainable contexts; such as creation of paddy estate, Malaysia Organic Scheme (*Skim Organic Malaysia* - SOM) and Malaysia Good Plantation Resources Practices System (*Sistem Amalan Ladang Baik Malaysia* - SLAM) certificate, good agriculture practices and promoting organic farming.

Table 1.1: Malaysia's Population and Rice Production

POPULATION	**1990**	**2000**	**2008**	**2009**
Mid-year Population (million)	**17.76**	**23.27**	**27.73**	**28.31**
PRODUCTION, IMPORTS AND EXPORTS	**1990**	**2000**	**2007**	
RICE ('000 METRIC TONNES) **1**				
Production**,**	**215.1 1,**	**381.7 1,**	**535.8**	
Imports	**329.7**	**594.1 1,**	**088.0**	
Exports	0.1	#	0.8	

less than 50 metric tonnes

Source: Ministry of Agriculture (2009$_2$).

1.1.2 Organic Rice Farming in Malaysia

Organic farming is increasingly recognized worldwide as a suitable model for creating environmental, economic and social sustainability in agriculture. It is a crop production system that avoids the use of synthetic fertilizers and pesticides, hormones, antibiotics and takes measures to protect the environment. Crop pests and diseases are managed by cultural, biological, physical, mechanical methods and the use of bio-pesticides (Ministry of Agriculture, 2009_1). So, organic agriculture practices are committed to balance with nature.

The Department of Agriculture (DOA) is the agency under the Malaysian Ministry of Agriculture and Agro-based Industry that is involved in activities related to quality and productivity of crops. The department introduced the SOM to promote sustainable development. SOM is a certification programme to recognize farms which cultivate crops organically according to the criteria and requirement spelt out in the scheme. The standard is essentially based on the Malaysian Standard, MS 1529: 2001. In the context of paddy farming, Kahang Organic Rice Eco Farm (KOREF) which is one of the areas in my case study, is the first and only certified organic farm in Malaysia.

Organic rice farming in West Malaysia began in the early 1990's under the guidance of a Non-Governmental Organization (NGO), working with smallholder farmers on rice storage in the state of Selangor. They found that the system was not sustainable due to a number of factors, such as poor production technology support, marketing problems, certification, and farmers' commitment. Then, in 1999, KOREF pioneered the organic method of rice farming practices in West Malaysia. Other location which has fully integrated sustainable paddy fields is in Bandar Baru Tunjong, Tanjung Karang and Bario, Sarawak.

Currently, a popular system in organic farming in Asia is System of Rice Intensification (SRI) (Uphoff, 2011), started to be practice in Malaysia since year 2009. This was again seen in Bandar Baru Tunjong and Tanjung Karang field case study.

1.1.3 System of Rice Intensification

SRI is a way to manage organic farming. SRI was developed in Madagascar in 1983 as a revolutionary paddy cultivation method to achieve very high yields with reduced resources such as irrigation water, fertilisers and chemicals. The SRI planting tests have been carried out in 48 countries, and at present, the SRI planting areas have expanded in many developing countries of Asia, Africa and Latin America. Many SRI users report a reduction in pests, diseases, grain shattering, unfilled grains and lodging. Additional environmental benefits stem from the reduction of agricultural chemicals, water use and methane emissions that contribute to global warming (http://sri.ciifad.cornell.edu/index.html). SRI is also suitable for highland paddy farming, and it has currently been expanded to other types of crops such as sugar cane.

1.2 Research Problem

Currently, Malaysia is giving priority to commercial agriculture, so as to increase food crop production and increase farmers' income. In Malaysia, public awareness with regard to sustainable agriculture is low, especially in organic paddy farming. According to Datuk Naser Ismail (*Berita Harian*, 2010), a panel member of the round table conference on Eco Malaysia project and International Greentech 2010, the biggest obstacle faced by companies in implementing green technology is the lack of education and awareness among youth about the 'green thing'.

According to the National Green Technology Policy Malaysia, effective promotion and public awareness are two of the main factors that would affect the success of sustainable development through the Green Technology agenda. This is particularly significant as such adoption requires a change of mindset of the public through various approaches, including effective education and information dissemination to increase public awareness of sustainable agriculture and on ways to conserve the environment (Ministry of Energy, Green Technology and Water, 2009). Mustafa and Mohd Jani (1995) also state that greater public awareness about environmental pollution and depletion of resources can help Malaysia to develop sustainable agriculture. More intensive monitoring and investigating agricultural practices would enable Malaysia to achieve sustainability (Murad *et al.*, 2008).

Malaysia aims to transform current agricultural activities into advanced, innovative and sustainable practices. Recently, the Third National Agricultural Policy highlighted many issues to promote the sustainability of agricultural practices (Ministry of Agriculture, 1999). However, this is not an easy task because there are basic problems that the farmers will encounter, especially with regards to their understanding of sustainable agriculture. As a solution, increasing awareness regarding sustainable agricultural practices through VR and persuasive technology is a viable alternative.

Information can be obtained from various media. In this era, VR can be described as an advanced communication tool to promote and enhance awareness. VR technique was chosen because it produces high quality images and animation. It also produces the data in real time, thus making it easier for the user to navigate it, and easier for users to learn through experience (Kalawsky, 1996) and provides better user control. VR is also the best among printed media and video/film for its immersive, interactivity and information intensity (Barnett & Shih, 1998).

1.3 Preliminary Investigation

In this study, apart form observation, interviews were conducted with experts, researchers, institutions and farmers directly involved to understand sustainable agricultural practices in paddy farming in four locations selected. The main questions asked, were as follows:

i. Does sustainable agricultural practices in paddy farming in West Malaysia include land preparation, seed selection, water management, fertilizer control, weed, pest and disease control, and harvest?

ii. Is there any computer application used to promote sustainable practices in paddy farming?

As reviewed, presently, there is limited research being done on sustainable agriculture and VR learning, focusing on paddy farming. Furthermore, in Malaysia, there is no research that has been done in this area.

The experts from the Malaysian Agricultural Research and Development Institute (MARDI), Muda Agricultural Development Authority (MADA), Sabak Bernam Agriculture Department, said that there is no computer application used to promote sustainable practices in paddy farming. The Kahang Organic Rice Eco Farm manager, the National University of Malaysia (Universiti Kebangsaan Malaysia – UKM) researchers at Tanjung Karang and Sunnah Tani Sdn Bhd officers also agreed with the statement.

In short, paddy farming practices in Malaysia generally is not sustainable, thus, that become a real problem for creating sustainable agri-food and for that reason, ICT application with the element of captology, integrated in a persuasive learning environment can play an innovative role in promoting sustainable practices in agriculture.

1.4 Research Objectives

The main objective of this research is to discuss and identify the sustainable agriculture practices of paddy farming in West Malaysia. This research also aims to relate the issues of sustainable agriculture using ICT in order to disseminate information about sustainable paddy farming practices.

Based on the main objectives, the research attempts to:

i. understand and identify sustainable agriculture practices in paddy farming including land preparation, seed selection, water management, fertilizer use, weed, pest and disease control, and harvest.

ii. to compare the conventional and organic paddy farming practices

iii. to design and build a prototype of persuasive learning in virtual paddy farming, called as Sustainable Paddy Farming System (*Sistem Pertanian Padi Lestari - SiPadi*) as a tool to promote sustainable development in paddy practices.

iv. to evaluate the *SiPadi* prototype.

1.5 Research Question

Based on the research objectives, the followings are the research questions:

i. What are the sustainable agriculture practices in paddy farming in West Malaysia?
ii. What are the differences between organic and conventional paddy farming practices?
iii. What is the suitable ICT application to promote information about sustainable practices in paddy farming?
iv. How to design and build the learning application based on real paddy farming practices?
v. How to evaluate the learning application?

1.6 Scope

The scope of this study is sustainable practice in paddy farming in selected areas in West Malaysia; Northern West Malaysia, Northwest Selangor, Bandar Baru Tunjong and Kahang.

Northern West Malaysia covers the MADA area, while Northwest Selangor covers Sabak Bernam and Tanjung Karang. Bandar Baru Tunjong covers the Sunnah Tani Sdn. Bhd. Farm and Kahang covers Kahang Organic Rice Eco Farm. The actual practices in sustainable paddy farming was used as a basis to design the prototype of learning programme as a persuasive tool in promoting awareness of sustainable practices.

Subsequently, students from Biological and Agricultural Engineering Department were chosen to evaluate this prototype. A lab experiment was conducted to measure the awareness level (knowledge and understanding) of sustainable practice of prototype during pre-test and post-test experiment. This study also measured the user satisfaction based on Overall Reaction to the Software, Screen, Terminology and System Information, Learning and System Capabilites.

1.7 Significance of the Study

The proposed research is significant because:

i. Recommendations and guidelines can be made for the implementation of innovation and sustainability using ICT to educate people about sustainable paddy farming.

ii. ICT is a powerful medium to generate and disseminate rice-related knowledge and technology for short and long-term environmental, social, and economic benefits.

iii. The guidelines and practices will help to improve farmers' livelihood and the government to acheive high productivity in the paddy sector.

1.8 Definition of Terms

The study uses the following terms as defined below:

Biodiversity is the variety of life forms and ecosystem types on Earth. It includes genetic diversity (i.e. diversity within species), species diversity (for example, the number and variety of species) and ecosystem diversity (total number of ecosystem types).

Captology is the study of computer as persuasive technology. This includes the design, research, and analysis of interactive computing products created for the purpose of changing people's attitudes or behaviors (Fogg, 2003).

Granary Areas refer to major irrigation schemes (above 4,000 hectares) recognised by the Malaysia government in the National Agriculture Policy as the main paddy producing areas. There are eight Granary Areas in Malaysia, namely, MADA, Kemubu Agricultural Development Authority (KADA), Kerian Sungai Manik Integrated Agricultural Development Area (IADA KSM), Northwest Selangor Integrated Agricultural Development Area (IADA BLS), Penang Integrated Agricultural Development Area (IADA P. Pinang), Seberang Perak Integrated Agricultural Development Area (IADA Seberang Perak), Northern Terengganu Integrated Agricultural Development Area (IADA KETARA) and Kemasin Semerak Integrated Agricultural Development Area (IADA Kemasin Semerak).

Irrigation Scheme refers to an irrigation project which is completed, commissioned, operated and declared by the authority as an irrigation area. Most of these schemes are managed by government organisations such as the Drainage and Irrigation Department (DID), MADA and KADA. These schemes have gazetted boundaries. Very often this boundary is the same as the boundary stated when the project was first determined. There are a few irrigation schemes gazetted as irrigation areas based on the Irrigation Ordinance Act 1953 - Amended 1989.

` **Organic farming** is a crop production system that avoids the use of synthetic fertilizers and pesticides, hormones, antibiotics and takes measures to protect the environment. Crop pests and diseases are managed by cultural, biological physical, mechanical methods and the use of bio-pesticides (Ministry of Agriculture, 2009_1).

Paddy Season refers to the activities of paddy planting from the preparation of land to harvesting. There are two seasons, the Main Season is a period whereby paddy planting is very suitable based on the local climate (rainy season) and it does not depend totally on irrigation system. The Off Season is a dry period and paddy planting normally depends on the irrigation system.

Persuasive technology is the attempt to shape, reinforce or change behaviors, feelings, or thoughts about an issue, object or action (Fogg, 2003).

Synthetic input is manufactured by chemical and industrial processes. It may include products not found in nature, or simulation of products from natural sources (but not extracted from natural raw materials.

System of Rice Intensification (SRI) is a revolutionary paddy cultivation method to achieve very high yields with reduced resources such as irrigation water, fertilizers and chemicals.

Virtual reality (VR) is a technology which allows a user to interact with a computer-simulated environment, be it a real or imagined one. It means using computer technology to create a simulated, three-dimensional world that a user can manipulate and explore while feeling as if he were in that world. The simulated environment can be similar to the real world, for example, simulations for pilot or combat training.

Yearly Data for paddy refers to data reported in both seasons, the Main Season and the Off Season. This applies to average yield of paddy, area planted and estimates of paddy production.

Wetland Paddy is the primary paddy type planted in Malaysia.

1.9 Organisation of Thesis

This thesis is organized into seven chapters. The first chapter provides an overview of the study which covers the problem statement and research objectives. In addition, the research question, research significance and definition of the key terms are also outlined. Chapter 2 reviews the related literature on sustainability and ICT as a learning tool to create sustainability awareness. The research methodology is presented in Chapter 3, whilst Chapter 4 describes in detail the field study at selected paddy growing area in West Malaysia. Chapter 5 discusses the prototype design and its development phases in detail as created by Alessi and Trollip (2001) that comprises three stages: planning, design and implementation. The findings and discussed are described in Chapter 6. Finally, Chapter 7 concludes the thesis with a summary of the main findings and offers some recommendations. Figure 1.2 outlines the organisation of the thesis.

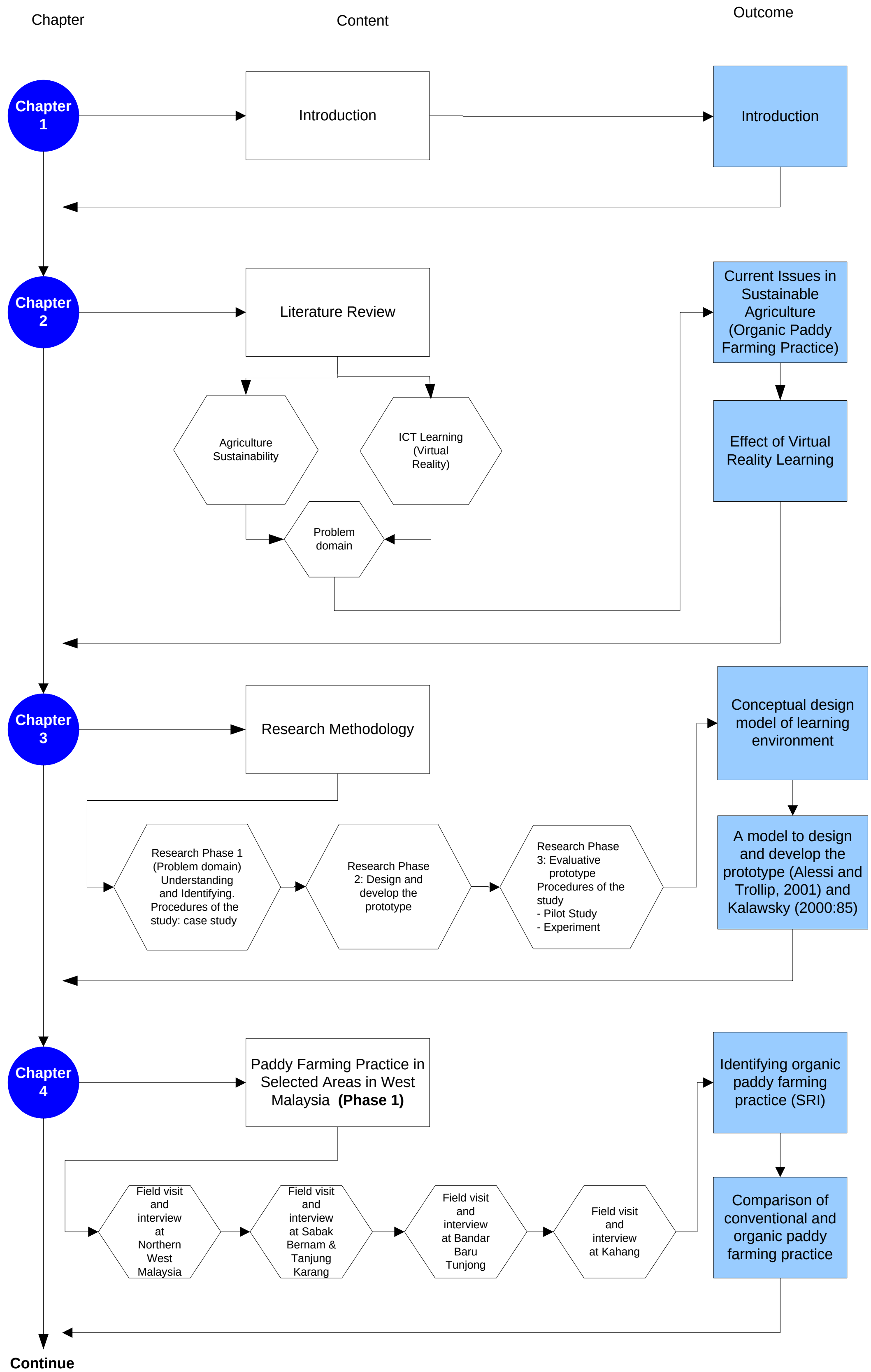
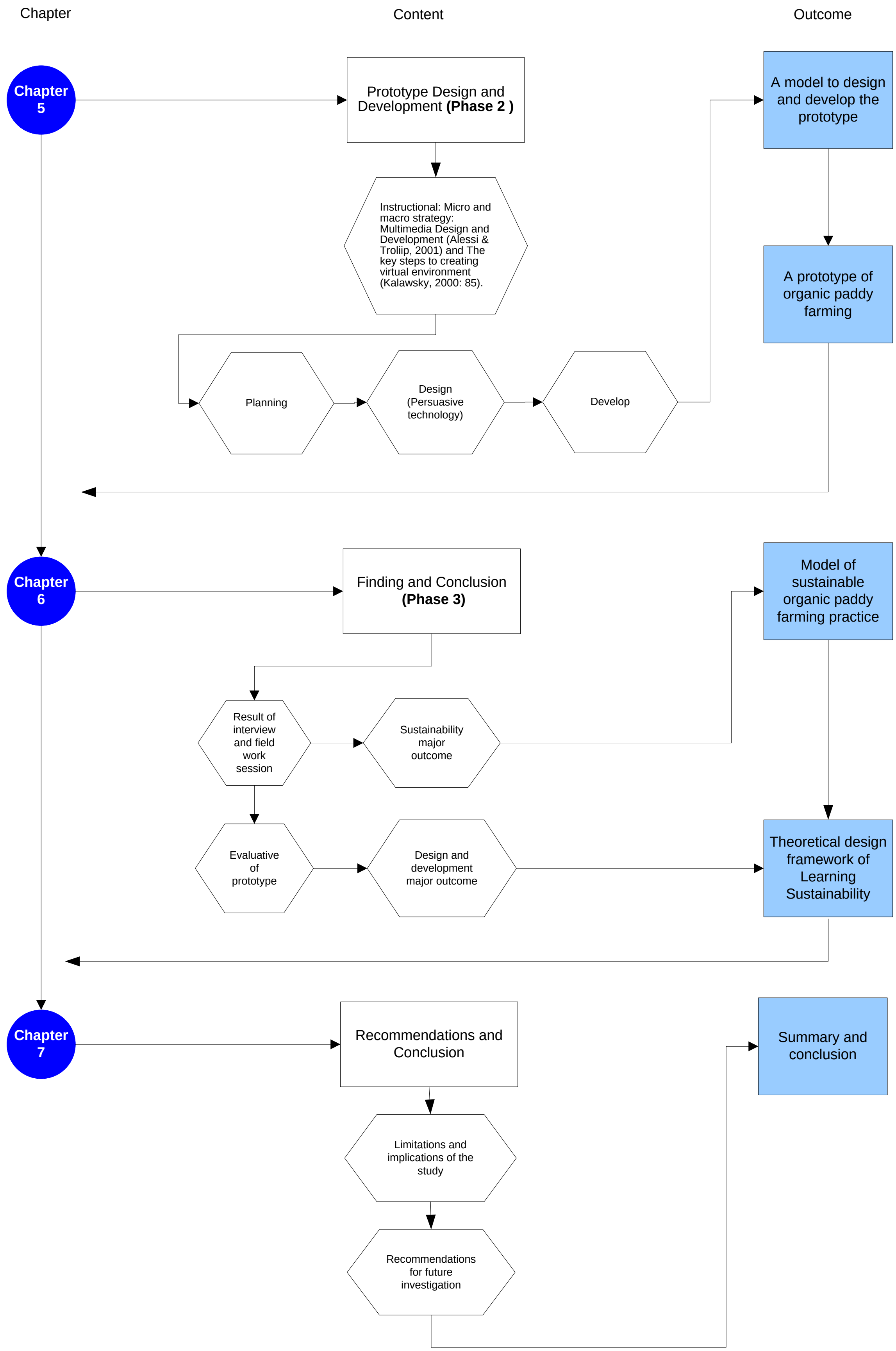


Figure 1.1: Organisation of Thesis


Chapter
Content
Outcome
Chapter 5
Prototype Design and Development (Phase 2)
Instructional: Micro and macro strategy: Multimedia Design and Development (Alessi & Troliip, 2001) and The key steps to creating virtual environment (Kalawsky, 2000: 85).
Planning
Design (Persuasive technology)
Develop
A model to design and develop the prototype
A prototype of organic paddy farming
Chapter 6
Finding and Conclusion (Phase 3)
Result of interview and field work session
Sustainability major outcome
Evaluative of prototype
Design and development major outcome
Model of sustainable organic paddy farming practice
Theoretical design framework of Learning Sustainability
Chapter 7
Recommendations and Conclusion
Limitations and implications of the study
Recommendations for future investigation
Summary and conclusion

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review covers introduction to sustainable agriculture and organic practices, paddy and rice sector in Malaysia and ICT applications in learning and promoting sustainability issues.

2.2 Sustainable Agriculture

Sustainability is now becoming both an important concept and a practice for society, economics and the environment (Goodland 1995; Ismail, 2006; Kajikawa, *et al*., 2007). The words *sustainable* and *agriculture* derive from Latin. Sustainable is from “sustinere”, which means sustain current situation, create sustainable or long term support (Gold, 2007). The word *Agri* is from “*ager”,* it means "a field" and culture means "cultivation”. So, agriculture is *tillage of the soil of a field*. In the moden context, the word *agriculture* covers all important activities in food production, fiber and other goods by the systematic growing or harvesting of plants, animals and other life forms. "Agriculture" may also be commonly refered to the study of the practice of agriculture (also, "agronomy" or "agricultural science").

According to Siwar *et al*., (2009), there is no universal definition for the concept of sustainable agriculture and there has been an extensive debate on its definition. The concept of sustainable agriculture is still evolving. What is important nonetheless is that, the meaning of sustainability depends on the context in which it is applied (Brown *et al.*, 1987; Shearman 1990).

The Food and Agricultural Organisation (FAO) of the United Nations provides a specific description of sustainable agriculture, "*where the usage of resources and environmental management are combined with increased and sustained production, secured livehoods, food security, social equity and people's participation in the development process in considered in the development path. If these conditions can be fulfilled, sustainable agricultural development will be environmentally non-degrading, technically appropriate, economically viable and social acceptable*" (Siwar *et al*., 2009).

Sustainable agriculture was also addressed by the US 1990 Farm Bill (Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA), 1990). It was defined as follows:

> "*the term sustainable agriculture means an integrated system of plant and animal production practices having a site-specific application that will, over the long term:*
>
> *i. satisfy human food and fiber needs*
>
> *ii. enhance environmental quality and the natural resource base upon which the agricultural economy depends*
>
> *iii. make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls*
>
> *iv. sustain the economic viability of farm operations*
>
> v. *enhance the quality of life for farmers and society as a whole*".

Sustainable agriculture, therefore, integrates three main goals; environmental health, economic profitability, and social and economic equity. These goals have been defined by a variety of philosophies, policies and practices, and also from the vision or perceptions of the farmers and the consumers.

In this research, sustainability in agriculture refers to the farmer's ability to maintain sustainable yield while preserving natural environment, promoting social development, creating economic opportunities and being a commercially good competitor in the fast changing environment (Ismail, 2006). Sustainable agriculture system includes organic agriculture system, controlled agriculture system and integrated agriculture system. However, this research focuses and discusses only organic agriculture system.

2.3 Paddy and Rice Industry in Malaysia

Oryza sativa is one of the well known rice variety in Asian, including Malaysia. This rice crop is normally grown in rainy season unless water irrigation scheme is available. Normally, there are two seasons for wetland paddy in West Malaysia, the Main season and Off season. Table 2.1 shows paddy planted areas in Malaysia from 2005 to 2009.

Table 2.1: Key Statistics of Planted Paddy - Main Season

Planted paddy areas	**2005/2006**	**2006/2007**	**2007/2008**	**2008/2009**
Malaysia (Area, hectares)	**417,930**	**415,791**	**399,614**	**345,275**
Peninsular Malaysia	**261,309**	**261,862**	**258,102**	**264,704**
Granary Areas	**193,510**	**193,725**	**1 93,198**	**197,279**
Sabah	**29,564**	**31,271**	**2 6,161**	**22,460**
Sarawak	**127,057**	**122,658**	**115,351**	**58,111**

Source: Ministry of Agriculture (2009_2).

The largest paddy Granary Area in Malaysia is MADA Granary Area (Table 2.2). Two institutions are involved in rice industry in Malaysia. There are National Rice Company and MARDI.

Table 2.2: General Information of Integrated Agriculture Development Projects (IADA) – Granary Area

Granary Area	Year established	Planted area (hectare)		
		Project	Agriculture	Paddy
MADA	1965	126,155	109,501	96,558
KADA	1968	89,500	64,555	31,464
KSM	1979	66,282	30,560	28,488
BLS	1979	199,199	82,044	19,701
Seberang Perak	1981	17,307	16,437	8,529
KETARA	1992	258,736	65,828	5,110
Kemasin Semerak	1982	68,350	46,560	5,560
P.Pinang	1983	104,636	67,095	10,138

Source: Ministry of Agriculture and Agro-based Industry Malaysia, 2008

National Rice Company or Padiberas Nasional Berhad (BERNAS), initially known as the National Paddy and Rice Board, is the national agency in the domestic paddy and rice industry, BERNAS and its group of companies are involved in the procurement and processing of paddy; such as the importation, warehousing, distribution and marketing of rice in Malaysia. BERNAS currently controls about 45% of the local rice demand and 24% of the paddy market.

MARDI is the center for research and development of innovative technologies for the food sector, including rice cultivation research. Currently there are 36 varieties of paddy that MARDI has developed.

2.3.1 Current Issues

Good Agricultural Practice (GAP) is a standard guideline in implementing technology transfer in the extension programme. Under crop production, the focused activities are field preparation, selection of planting materials, weed and pest control, and fertilizer application. For example, in paddy production, with regards to field preparation, land leveling and liming are crucial. Good land leveling will facilitate good water management in the field and enhance weed control. Application of lime at the right time and in the right amount would reduce soil acidity. In paddy planting, the use of certified seeds is encouraged. The use of chemical fertilizers in crops is suggested for fast and effective plant nutrient uptake needed for normal plant growth and enhanced crop productivity. Organic fertilizers and manures are preferred for regular use to benefit from the long term effects as this improves soil structure, enhances soil microbial activity and harmonizes soil biodiversity. Biodegradable plant residues can be processed into compost. Organic fertilizers like compost, chicken dung, cow dung and bat guano are all good sources of plant nutrients and in certain instances can substantially replace chemical fertilizer and could be extensively used in organic farming (Samsudin, 2009).

Crop rotation is suggested as an important practice, especially in areas planted with extensive and recurring mono-crop. The main purpose of crop rotation is to break the life-cycle and destroy noxious pests and diseases. Thus, pesticide usage is reduced. Less pesticide usage is seen to establish sustainability aspects of pest-predator vector relationship balance in farming ecosystems while maintaining an environmentally friendly situation (Samsudin, 2009).

SLAM is the Malaysian Farm Certification Scheme which was started in 2002. It has consequently become a national programme to recognize and certify farms which adopt Good Agriculture Practice (GAP) that operate in an environmentally friendly way yielding products that are of quality, safe and suitable for human consumption.

To achieve high rice production, the Malaysian government developed two strategies. First, in the Ninth Malaysia Plan (2006-2010), the agricultural sector is the third pillar of the country's economy. The focus is on increasing productivity using modern agricultural methods and ICT; improving research and development (R&D); and innovations, especially in paddy farming (Department of the Prime Minister, 2006). The second strategy is the launching of the Northern Corridor Economic Region (NCER). In agriculture, the objectives of the NCER initiative include, making the Northern Corridor Malaysia's main food production zone and increasing the country's efficiency in food production.

However, in Malaysia, the application of sustainable agricultural practice in paddy farming is still in its preliminary stage. The Kahang Organic Rice Eco Farm in Johor which sprawls over 260 acres and the only certified organic rice farm in Peninsular Malaysia, uses natural resources to produce brown rice.

2.3.2 Rice Industry Policy

The performance of the rice industry in Malaysia though largely influenced by the government, has also been affected by changes in the world rice market. For example, in the year of 2008, Malaysia a country dependent on imported food was impacted by the international rice crisis, which is the staple food in Malaysia. Hence government stepped up its efforts through the National Agricultural Policy. Government policies and programmes designed to help the Malaysian rice industry include paddy production incentives, guaranteed minimum price programme, paddy price subsidy, fertilizer subsidies and infrastructure investment (irrigation canals, farm roads etc.). In terms of research funding, for the Seventh and Eight Malaysian Plan, a total of about RM 50 million was allocated to MARDI alone for R&D activities in the paddy industry (Tawang & Nik Ahmad Kamil, 2003).

2.3.3 Sustainable Agriculture in the National Agricultural Policy

The Third National Agricultural Policy (NAP3) (1998-2010) introduced the need to adopt sustainable agriculture as one of its policy thrusts. It calls for the adoption of sustainable management in the utilization of natural resources as the guiding principle in pursuing agricultural development. Rules, regulations and incentives will be strengthened to encourage environment-friendly agricultural practices and to minimize the negative impacts of these activities on the environment. One of the main indications that paddy production is not sustainable is that there is a need to apply high dosages of fertilizer inputs to maintain the current yield (Ministry of Agriculture, 1999; Tawang & Nik Ahmad Kamil, 2003).

The government also plans to increase the usage of ICT in all sectors to increase productivity. Mastery of the use of information technologies will be emphasized to enhance the acquisition and dissemination of new knowledge and technologies, and to motivate greater youth participation in technology development and transfer. Advances in "expert systems" or computer simulated scenario analysis will be exploited to enhance on-farm advice and information exchange to agriculture producers through extension.

2.3.4 National Green Technology Policy

According to Ministry of Energy, Green Technology and Water (2009), Green Technology refers to products, equipment or systems which satisfy the following criteria;

- Minimizes the degradation of the environment
- Reduces the green house gas emission
- Promotes healthy and improved environment for all forms of life
- Conserves the use of energy and natural resources and,
- Promotes the use of renewable resources.

The National Green Technology Policy was introduced by the Ministry of Energy, Green Technology and Water, Malaysia in April 2009. Green Technology is the development and application of products, equipment, and systems used to conserve the natural environment and resources, which minimizes and reduces the negative impacts of human activities (Ministry of Energy, Green Technology and Water, 2009). It means green technology shall be the driver to accelerate the national economy and promote sustainable development.

The four pillars of National Green Technology Policy are: energy (seek to attain energy independence and promote efficient utilization); environment (conserve and minimize the impact on the environment); economy (enhance the national economic development through the use of technology) and society (improve the quality of life for all) (Ministry of Energy, Green Technology and Water, 2009).

Two specific objectives of the National Green Technology Policy are related to this study. They are to ensure sustainable development and to conserve the environment for future generations and; to enhance public education and awareness in green technology and encourage its widespread use.

2.4 Rice Cultivation Techniques

Rice cultivation involves: (1) preparing the site for cultivation; (2) ploughing using ploughing machines for grinding and leveling. After three to seven days, water will be let in; (3) sowing the seeds: Seeds are obtained from MARDI and the Department of Agriculture. Germination occurs after 24 hours immersion in water and 48 hours in a wet sack. It can also be spread by using a spray, or sown by hand; (4) planting the seedlings: three days before planting, water will be let in. Good water management will result in high production of rice. Water is collected from rainfall (50%), dam (30%), rivers (15%) and drainage (5%); (5) controlling the weeds and pests, and fertilizer application.

2.4.1 The Management of Organic Farming

The management of organic farming is quite similar to that of conventional farming. However, the distinctive difference in organic farming is in the way pests are managed and weeds discarded. Thus organic farming does not use pesticides and chemical fertilisers.

2.4.1.1 The Management of Pests

The basic principle of the natural management of pests is that the attack of insects is seen as a symptom and not a problem. If the symptom emerges, the cause or the discuptive factor needs to be identified and eliminated. Consequently, this will help maintain the ecological balance.

In the eco-system, everything is inter-related and all the elements are necessary to preserve the ecological balance of the nature. In a balanced eco-system, the insect population in controlled naturally so that it does not harm the plants. The number of insects become alarmingly large when there is an external disturbance. This causes an imbalance to the eco-system, and as a result, the number of insects will increase. The continuous planting of the crops, the use of pesticides and chemical fertilisers are deemed as disruption factors (Department of Environment Malaysia, 2010).

There are two approaches in overcoming this problem, namely through prevention, and control (Department of Environment Malaysia, 2010). Nonetheless, prevention needs to be given utmost priority, whilst control is needed during the early phase of organic gardening.

a) Preventive steps

Preventive steps do not have any immediate effect, and are thus considered as long term measures. There are basically two preventive steps; buildng an agricultural eco-system that is balanced, and building a land eco-system that is balanced. Building a balanced agricultural eco-system entails: (1) planting a variety of plants, including various herbs and medical plants that repel insects. Examples of insect repellant plants are sunflowers, gingseng, mint, lemongrass and raw vegetables; and (2) planting a trees that function as a wind blocker and attract birds that prey on insects. The variety of the plants plays an important role in building the balance of the agricultural soil. It also eliminates disruption factors.

The second step is the building of a balanced soil eco-system, which maintains a balance of the living micro-organisms in the soil. Nearly all plant diseases originate from this imbalance, and this occurs due to the lack of organic substances, continuous planting and the use of chemical intensive agriculture that kills micro-organisms. Measures that can be taken to create a balanced soil eco-system are: (1) rotating the crops planted; (2) providing a fixed supply of organic substances (covers, green fertiliser, compost and others); (3) avoiding mixing of raw organic substances, for instance raw fertiliser (fertiliser that originates from animal dung) and weeds that have been fertilised into the soil; (4) avoiding the use of chemical substances in agricultural activity.

Other preventive steps that can be taken are selecting good seeds that are not diseased, planting at a suitable time and appropriate spacing.

b) Control Steps.

There are two methods of control, physical and natural control. Physical control is through the use of physical equipment. For instance, a net cover for protection from the attack of insects; light captures, namely by placing lamps in containers filled with water, which will attract insects to the light and as a result fall into the water. Another physical means is through the capture of insects by bare hands, and then destroying it.

The natural control of insects, however, is through the use of natural substances to dissipate or fumigate insects. Among the examples of natural substances are ash, powder and tobacco leaves, neem leaves and seeds, pounded chilli and ginger.

2.4.1.2 Applying Fertiliser

According to (Department of Environment Malaysia, 2010), fertiliser is a substance which is natural or has been manufactured at the factory, that contains one or more food plant elements. Fertilisers are of two types, organic and non-organic (chemical). The physical form of the fertiliser can be in small pieces, pellets, powder and liquid.

Organic fertiliser is produced from substances that were originally living things, such as animals, microbes or plants, which have died and have subsequently undergone the proses of decay. Organic fertilisers can be obtained either from suppliers in a modern form or as manually-prepared substances by compost, ‘bokashi’, ‘kuntan’ and green fertilisers.

Non-organic fertiliser is produced in the factory through a chemical process, a combination or mixtures. Non-organic fertilisers include urea fertiliser, Kieserite, Muriate of Potash (MOP) and Nitophoska 15:15:15.

Organic fertilisers have a multitude of advantages, among them are:

i. It increases activities of the soil microorganisms, which then increases the speed of organic decomposing.
ii. It repairs the soil texture and structure, which in turn aids in the development of the root, repairs the water channels and eases the work of land/soil preparation.
iii. It elevates the soil capacity to withold nutrients.
iv. Improves the airing of the soil which increases the soil cavity and the level of water absorption.

2.5 Sustainable Paddy Practices in Other Countries

There are many studies that indicate that sustainable agriculture has improved food production. Uphoff (2011) reported that most of the interest and action for the sustainable agriculture mainly SRI has been in Asia. The first validations of SRI methods outside of Madagascar were done in China and Indonesia in 1999-2000, demonstrating that more productive and robust rice crops (phenotypes) can be grown from any given variety (genotype). In the subsequent decade, demonstrations of SRI productivity have spread to practically all of the countries in Asia. SRI methods are now being promoted by governments in leading rice-producing countries which together produce two-thirds of the world's rice: China, India, Indonesia and Cambodia. Below are summaries of their respective experiences with SRI:

2.5.1 Case 1: China

Since the 1980s, in China, a campaign of ecological development has been flourishing all over the country, led by ecologists, but with the involvement of local people at different levels. The emphasis is on how to make trade-offs among the different social, economic and environment goals, how to build a human unit with high efficiency, harmonious relationships, and a reasonable standard of living, and how to help local people to guide their own community in a healthy development process.

After 1992, sustainable development strategies have been formulated at different levels for the state, regional, and local governments respectively. Guided by China's *Agenda 21*, many provinces, autonomous regions, and municipalities have developed, or are in the process of developing, their respective *Agenda 21* or Action Plans. China's *Agenda 21* highlights overall strategies for sustainable development more concisely (Sun *et al.,* 2008).

The strategy for raising rice production has focused primarily on the spread and use of hybrid varieties T and SRI method. The most active institutions for SRI research have been the China National Rice Research Institute (CNRRI) in Hangzhou, Zhejiang province, and the Sichuan Academy of Agricultural Sciences (SAAS) in Chengdu. Both collaborate with their respective Provincial Departments of Agriculture (PDAs) for extension of SRI in these two provinces. Sichuan's PDA started promoting SRI on 1,140 hectares in 2004; by 2009, the SRI area was over 250,000 hectares. The PDA for Zhejiang province calculated that the use of SRI methods on 688,000 hectares over the period 2005-09 added 862,000 tonnes of paddy rice to that province's production.

2.5.2 Case 2: Cambodia

SRI is a method of rice cultivation that combines using less water, less seeds and more organic fertilizer. The government of Cambodia has integrated SRI promotion into its national development plan for 2006-2010. SRI method was used by Dr. Koma Sang Yaing, Director of the Center for Studies and Development of Cambodian Agriculture (CEDAC) in 1999. The good results encouraged 400 farmers to use SRI in 2001, and 3000 farmers in 2002, and at least 40,000 farmers at the end of 2005.

The evaluation of the SRI experience in three years, from 2001 to 2003, shows fertilizer use was reduced from 116 kg/ha to 67 kg/ha on average, and chemical pesticide use declined from 35 kg/ha to 7 kg/ha. The cost of production was reduced by half, and household income, even with use of SRI on only part of the rice land, almost doubled (Jhamtani, 2007).

In summary, in the Cambodia case, it was the research institution that became the agent of change together with farmers, leading to the adoption of alternative methods by the government. Farmers adopted this method partly because of the increased yield, and they were free to modify and adapt the method, unlike a foreign technology that cannot be easily adapted locally.

2.5.3 Case 3: India

The first evaluation of SRI in this country was conducted in 2000 by Dr. Thiyagarajan, director of the Centre for Crop and Soil Management at Tamil Nadu Agricultural University (TNAU). In 2004, large-scale evaluation trials were carried out by TNAU in the Tamiraparani river basin, where 100 farmers used SRI and conventional methods side-by-side on 0.4 ha comparison plots. While yield increases averaged 28% (7.3 vs. 5.7 tonnes/ha), given the lower costs of production using SRI, net income per hectare more than doubled, to $519 compared to $242 with conventional methods.

In Tamil Nadu, the World Bank began funding a large irrigation improvement project in 2007 which supported extension of SRI methods to 250,000 hectares, with TNAU participating in the extension and evaluation. The state government of Tamil Nadu set an ambitious total state target of 750,000 hectares of SRI, which should soon be reached. The Minister of Agriculture reported in 2009 that, thanks to SRI, the state was able to increase its paddy production despite a reduction in acreage due to serious drought. The Minister stated that SRI yields were usually 6-9 tonnes/ha compared to the state average yield of 3.45 tonnes/ha (Norman, 2011; Anas *et al*., 2011).

2.5.4 Case 4: SRI in Indonesia

The first SRI trials were done at the Ministry of Agriculture’s Sukamandi rice research station in 1999-2000. Encouraging results led to trials in eight provinces across Indonesia, and SRI methods were made part of the Ministry’s strategy for integrated crop management.

SRI trials started in the Eastern Indonesia under the Decentralized Irrigation System Improvement Project (DISIMP) in 2002 in just two locations; but over the next eight seasons they expanded so that by 2006, a total of 12,133 on-farm comparison trials had been done on 9,429 hectares across eight provinces. Average SRI yields were 7.61 tonnes/ha compared with an average of 4.27 tonnes/ha on neighboring plots under conventional management, a 78% increase, using 40% less water, with a 50% reduction in chemical fertilizer, and 20% lower costs of production.

From the above cases, several lessons can be learnt; the roles of government agency, as well as institutions in sustainable paddy farming.

2.6 Innovation

Innovation is the process whereby new and improved products, processes, materials, and services are developed and utilized (White & Bruton, 2006). According to White and Bruton (2006), innovation efforts found in the research and development (R&D) process include: (1) basic or pure research and development. It involves the creation of new knowledge; (2) applied: new product development which utilizes the new knowledge developed by the basic research to create new products. The purpose of applied research is to add value to the firm and its customers in the marketplace; (3) system integration: product improvement or market expansion. System integration is aimed at supporting existing business improvement in established products or opening new markets with an existing product.

Based on types of innovation efforts, this research will involve new product development.

2.6.1 Innovation in ICT

The most innovative approach is the development of a new product or process to solve a new problem or usage. An example is the Digital Video Disk (DVD), which illustrates an old process with a new usage. DVDs employ the same basic technology as CDs; however, the means for compression and reading hardware are more advanced. Another example of product innovation is electronic mail security that involves virus protection software. However, almost as quickly as new software and processes are developed for protecting a firm's information, new problems emerge. It is a constant war of innovation (White & Bruton, 2006). Nowadays, there are many innovations in ICT that have been introduced such as in education.

2.6.2 Educational Games

Educational games, including video games are designed to teach people about a certain subject or help them learn a skill as they play. Some people call these types of games *edutainment* because they combine education and entertainment.

There are many educational games. Some examples include subjects become so complex (for example: calculus) that teaching via a game is impractical. Numerous subgenres exist, each for a different field (math games, typing games and so on). Most of these games target young users from the ages of about three years to mid-teens; as well as past the mid-teens. In addition, games that parents and teachers play with children usually have some kind of educational values. Learning games also can be categorized as action games, classical or traditional games, sports games, puzzle games, mind games, kids games and arcade game (http://www.alfy.com/games/learning/?p=3).

With reported anecdotes about digital game natives being better surgeons, or "Nintendo surgeons", and anecdotes about digital game natives displaying exceptional business skills, it is clear that games are a medium that can be deployed for societal good, and in fact, can be deployed for training.

Nowadays, computer games have more realistic environment (e.g. *Conflict Zone*; *Doom;* and *Unreal*) and supported by new technology application such as simulation, artificial intelligence and virtual environment or virtual reality. Closely related to the use of educational games is the use of what is known as serious games.

2.6.3 Serious games

Serious game can be defined "as a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives" (Zyda, 2005_1).

Serious games have more than just story, art, and software, however, as Figure 2.1 shows, they involve pedagogy: activities that educate or instruct, thereby imparting knowledge or skills. This addition makes games serious. Pedagogy must, however, be subordinate to story - the entertainment component comes first. Once it is worked out, the pedagogy follows. Serious games use pedagogy to infuse instruction into the game play experience.

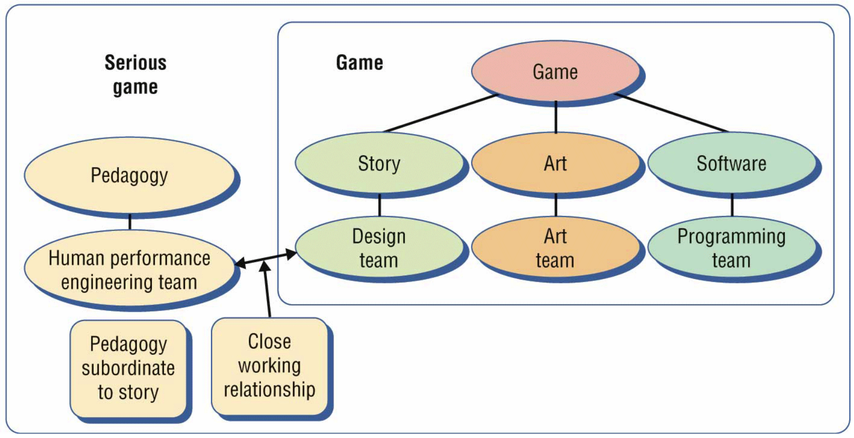


Figure 2.1: Serious Game and Game
Source: Zyda, 2005[2]

2.7 ICT Application in Learning and Promoting Sustainable Issues

In the ICT experts' discussion, sustainability is defined as: "Investment which continues to produce a return". 'Return' is defined in its broadest sense, for example, beyond financial and including other aspects such as educational, social and economic. The use of emerging ICT capacities, user-friendly interfaces and virtual reality technology has allowed structured learning about personal and aggregate societal impacts on environmental resources (Batchelor & April, 2002).

There are several examples of successful implementation of ICT in paddy farming, such as in the International Rice Research Institute (IRRI) which was established in 1960 by the Ford and Rockefeller Foundations in cooperation with the Philippine government. Covering a 252-hectare experimental farm (University of the Philippines Los Baños), the IRRI is the oldest and largest international agricultural research institute in Asia. It is an autonomous, nonprofit rice research and education organization with staff based in 14 countries in Asia and Africa. This institute was established to reduce poverty and hunger, improve the health of rice farmers and consumers, and ensure that rice production is environmentally sustainable. Since 2000, IRRI has been using ICT application to disseminate information about their research (International Rice Research Institute, 2008; Bell, 2003).

According to Ninomiya (2006), Japan uses ICT more for collecting and disseminating information like grid computing technology, decision support system, mobile phone with internet connection and knowledge based system (Ninomiya, 2006). Japan also uses sustainable system in planning soil, fertilizers and controlling paddy farming. They use a more natural eco-system in paddy farming as compared to Malaysia.

The following are key points in making information technology successful for agriculture (Ninomiya, 2006).

i. Project management policy
ii. Utilization of distributed resources
iii. Standardized interface
iv. Efficient and low cost field data acquisition
v. Useful and attractive client applications
vi. Case-based knowledge management
vii. Evaluation with end users
viii. Venture incubation and commercialization
ix. International activities

2.7.1 Learning through Virtual Reality

Virtual Reality (VR) has been spoken of as the third era in human-computer interfaces. In the first era, the computer was a very simple, straightforward inanimate machine which received input and produced output. In the second era, computer systems gained some intelligence and carried on a dialog between the system and users. In the third era, the system emulates a particular environment that is constructed within the computer. Users interact with the reality rather than the computer. The goal is to remove the barriers between the human mind and the computer. VR system offers presentation in three dimensions for the eyes, ears and hands (Mandel, 1994. p.392-393).

VR is a way for humans to visualize, manipulate and interact with computers and extremely complex data (Isdale, 1998). It is defined as a technology that provides an interactive, spatial, real-time medium and VR enables real-time viewing of, and interaction with, spatial information (Whyte, 2003). It uses the same or overlapping groups of technologies, and has a similar concepts include virtual environments, visualizations, interactive three dimension (i3D), digital prototypes and visual simulation. In summary, VR means using computer technology to create a simulated, three dimensional world that a user can manipulate and explore while feeling as if he were in that world.

In the early 1960s, Sutherland (1963) prototyped the first graphical computer system, Sketchpad, which allowed the drawing of vector lines on a computer screen using a light pen. Two years later in a paper, *The Ultimate Display*, Sutherland (1965) described the concept of the head-mounted display (HMD) and an immersive three dimension (3D) computer environment. Sutherland wrote, "*The fundamental idea behind the 3D display is* *to present the user with a perspective image which changes when he (six) moves.*" Development of flight simulators, by the US Air Force and NASA contributed to understanding of the technical requirements for VR (Earnshaw *et al.,* 1995). At the same time, research into civilian uses of computer-generated images was being conducted.

In the late 1980s, the term "virtual reality" was popularized by Jaron Lanier, one of the modern pioneers of the field. Lanier had founded the company VPL Research (from "Virtual Programming Languages") in 1985, which developed and built some of the seminal "goggles n' gloves" systems of that decade.

VR is also the best among printed media and video or film for its immersive, interactivity and information intensity (Barnett & Shih, 1999). It will solve problem on how to get the realistic view at an affordable price and at the right time easily. As a result, VR is a medium in visualization and complex information presentation.

The simulated environment can be similar to the real world, for example, simulations for pilot or combat training, or it can differ significantly from reality, as in VR games. In practice, it is currently very difficult to create a high-fidelity virtual reality experience, due largely to technical limitations on processing power, image resolution and communication bandwidth. However, those limitations are expected to eventually be overcome as processor, imaging and data communication technologies become more powerful and cost-effective over time.

VR systems can be split into two groups, immersive VR and desktop VR (Kalawsky, 1993. p.37). Immersive VR systems attempt to present the viewer with the convincing illusion of being fully immersed in an artificial world. Enabling technologies are wide-angle stereoscopic displays, tracking, haptic feedback, and binaural (3D) sound and voice input or output as well as real-time computer graphics on a computer screen.

2.7.2 The Effectiveness of VR as a Communication and Learning Tool

There is considerable research on the effectiveness of VR. Via virtual environment, a user will be able to navigate through it and interact with it to assemble those elements relevant to solving his or her particular problem. By visually encountering the knowledge, concepts and expertise residing there, a user can easily and intuitively discern which portions to select and which to disregard (Larijani, 1993).

Table 2.3: Human Sense Passed to our Brain and Captures Most of our Attention
Source: Cited by M. L. Heilig (1992), derived from Marzuryk and Gervautz, (1996)

Sense	Percentage
Sight	70%
Hearing	20%
Smell	5%
Touch	4%
Taste	1%

Table 2.3 shows clearly that human vision plays the most important role in passing information to our brain and captures most of our attention. The second most important of sense is hearing. Touch in general, does not play a significant role, except for precise

manipulation tasks. Smell and taste are not yet considered in most VR systems, because of their marginal role and difficulty in implementation (Marzuryk & Gervautz, 1996).

Youngblut (1998), a researcher at the Arlington, Virginia-based Institute of Defense Analysis, reviewed more than sixty VR educational efforts around the world. She has come to the conclusion that VR-based instruction will particularly benefit those students who are visually based. Another research that has been carried by Gay and Greschler (1993; 1994) has found that VR is an effective tool in Informal Science.

2.7.3 Multimedia and VR

Multimedia and VR, encompasses audio, video, and computer graphics, all seamlessly composited as a functional interactive programme. While not as immersive as a VR experience, multimedia programmes function like VR, presenting information or entertainment in a precise, easy-to-use and understandable manner.

A major difference between VR and multimedia is on user interface. The future trend is quite clear – increasing fractions of the total computing performance will be allocated to making the user interface "richer" (Figure 2.2).

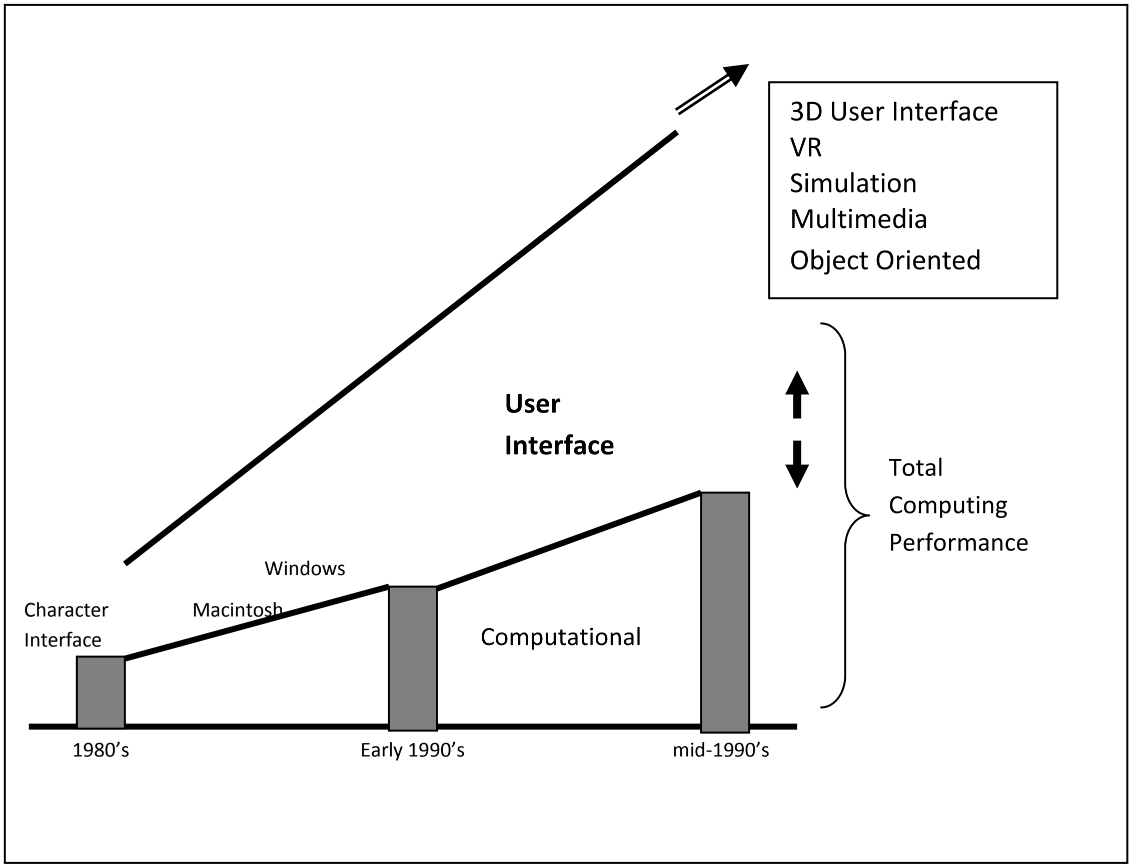


Figure 2.2: Changing User Interface
Source: Latta, 1991

When examined in this context, the user interface can take many forms – multimedia, VR or a 3D graphics user interface. Any implementation is left to the user, based on need. In this context, VR is just another approach in enhancing the user interface. From a market perspective, the user interface has also become a means to differentiate products (Latta, 1991).

The synergism of VR and multimedia is seen in their union (Figure 2.3). They share in common the need for system performance and the integration of time. Multimedia is distinct in its interfaces to media and the input or output devices it uses. VR is focused on the human interface, the appliances used by the participants and the definition of the virtual space. We can also expect to see increasing convergence of the two technologies. For example, as VR makes greater use of textures and video input it will use the same technology employed in multimedia such as compression and data bases designed for time-based media. Like wise, as lessons are learned from the human interface developments in VR, it is reasonable to expect multimedia to adopt those which best suits its application (Latta, 1991).

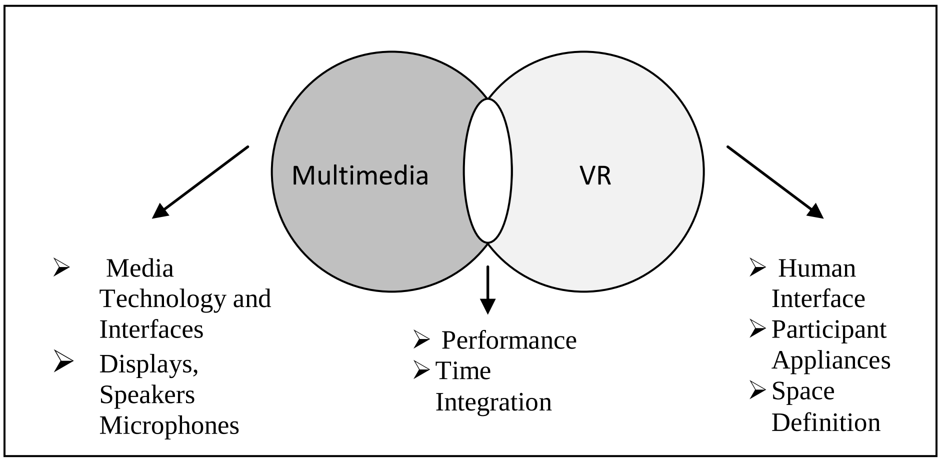


Figure 2.3: Union of Technology
Source: Latta, 1991

2.7.4 Active Learning as a Way to Promote Meaningful Learning

According to Mayer (2001) and Fink (1999), the best way to promote learning is through active learning. A clear concept of active learning has been explained by Fink (1999) in the model of active learning in Figure 2.4, which is involving some kind of experience or some kind of dialogue. The two main kinds of dialogue are dialogue with self and dialogue with others. The two main kinds of experience are observing and doing. In dialogue with self, learners ask themselves what they think or should think what they feel about the topic in reflecting the topic that they have learned.

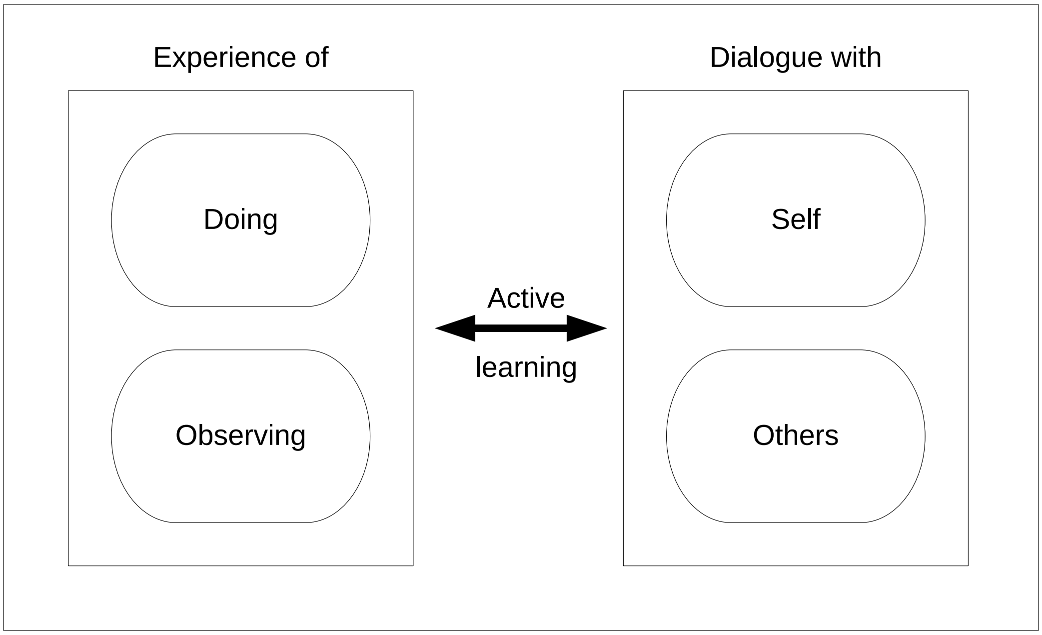


Figure 2.4: A Model of Active Learning
Source: Fink, 1999

In dialogue with other people, learners learn through communicating with others such as their parents, teacher or peers. In experience of doing, learners actually do something in any learning activities. In experience of observing, learners listen to watch someone else. This model of learning is good to be practiced in designing learning activities for learners (Sobihatun Nur, 2010).

2.7.5 Multimedia and VR Application in Sustainable Agriculture

The use of VR in a learning programme in sustainable agriculture has grown exponentially in recent years. The potential of VR technology for supporting education is widely recognized. Many researchers such as Youngblut (1998); O'Connor (2004); Kuo *et al*., (2004); Ha and Woo (2006) and Oka and Yamauchi (2006) found that VR offers many benefits that can support learning. Some of the benefits include the meaningful learning, easy and better understanding of the learning contents.

There are several successful implementations of learning programme and VR in the agriculture sector such as those discussed in the next section.

a) *SimFarm, Harvest Moon and Plant Tycoon*

SimFarm is SimCity's country cousin programme. While the SimFarm provides the same kind of building and planning atmosphere of SimCity, much of the player's time is spent in micromanaging crops. SimFarm consists of descriptions of all the animals, buildings, vehicles and chemicals in the games. It also has descriptions of all crops and methods on how to grow them. There are altogether 24 different crops, each documented with a picture. In addition to SimFarm, the agricultural games can also be found in Plant Tycoon and Harvest Moon from Nintendo.

b) VIRTU@LIS

VIRTU@LIS, funded under the Information Society Technologies (IST) Programme, explored the potential of new digital and multimedia technologies to increase awareness of environmental management and risks in four domains-agricultural pollution, climate change, freshwater and fisheries. The 11 member consortium, consisting of specialists in information technology, sustainable development, environmental modeling, public policy and governance, learning psychology and open learning, used emerging ICT innovation to study interactively with users during the prototype development phases. The prototype enables visitors to learn about how their lifestyle and behavior affects the environment (Pereira, 2006; O'Connor, 2004).

c) VGAS

VGAS was developed under the VIRTU@LIS project. VGAS is a computer game that consists of a set of models that relate lifestyles to emissions of three greenhouse gases, carbon dioxide, methane and nitrous oxide. It is designed on virtual reality concepts and was customized for five countries: England, France, Italy, Portugal and Spain (Pereira, 2006).

d) Ecological farmland navigating system

The Council of Agriculture, Taiwan (COA), promoted the importance of farmland conservation to help the elementary education authority on basic agricultural and ecological education. In this study, a 3-D virtual environment was developed to display the virtual farmland theme and associated temporal and spatial data and information. The system features include (1) construction and visualization of the virtual farmland environment, (2) speed up and animation of the embedded objects, (3) multimedia effects, (4) display of the numerical analysis results of crops growing which are affected by nitrogen in land simulated by the 2DSOIL model, and (5) display of the numerical analysis results of groundwater flow and nitrogen transport in the farmland simulated by GMS-FEMWATER (Kuo *et al*., 2004; 2007).

e) Garden Alive

Garden Alive from Korea research aims to provide both entertainment and education. The system is composed of three modules. In the first module, the tangible user inter-phase bridge to the garden in a virtual world. In the second module, an artificial intelligent module consists of two sub-modules: an evolution module and an emotion module. The third module is the virtual garden, which displays growth and the reactions of virtual plants. Virtual Garden has adapted the L-system, so the virtual plants grow in a similar manner to real plants. In this proposed "Garden Alive" system, there are several kinds of plants and each has different genes that are individually unique (Ha & Woo, 2006).

The above examples provide evidence that virtual reality, games and multimedia applications have been used to improve the sustainable agricultural sector.

2.7.6 Criteria to Choose the Learning Game

The choice of employing the use of adequate software is directly related to the need to have more congruent instructional purposes, criteria or types of activities involved in the game. According to Dempsey (2002), the criteria for choice could be: (1) the game should be relatively simple to play; (2) it can be adapted and re-programmed without additional cost; (3) has the identifiable potential to be used for educational purposes; (4) is different from other games in its category (Zavaleta *et al*., 2005).

According to Overmars (2004; 2005), to design an effective game, one must think about the rules that define the game play. Such rules must be consistent and fair, requiring logical thinking and some probability calculus. A gripping storyline is often important for a game. The user-interface must be designed and effective artwork and sounds must be created or sought. Then, after the programming, the game must be tested and tuned for best performance. Finally, documentation must be written.

Another research by Klopfer (2005), states that video games can be potential powerful learning tools. First, video games are designed to motivate players to successfully learn and improve their skills. Second, many entertainment games also draw heavily upon important 21-st century skills – problem-solving, collaboration, communication.

Thus, Donald Norman describes seven characteristics of an environment in which people, specially adults, learn successfully and quickly (Grice & Strianese, 2000). These environments: (1) provide a high intensity of interaction and feedback; (2) have specific goals and established procedures; (3) motivate; (4) provide a continual feeling of challenge that is neither too difficult as to create a sense of hopelessness and frustration, nor so easy as to produce boredom; (5) provide a sense of direct engagement, producing the feeling of directly experiencing the environment, directly working on the task; (6) provide appropriate tools that fit the user and task so well that they aid and do not distract; (7) avoid distractions and disruptions that intervene and destroy the subjective experience.

In their study, Grice and Strianese (2000) discuss some hypotheses in applying games design as follows: (1) games really are more fun than work; this does have an effect; (2) we learn to play games easily and develop strategies for improving; our skill level with business applications often does not progress after the first week; (3) computer games that are simulations of real-world games may be seen differently than games developed for computers; (4) there is a lot to be learned from games interfaces that can be applied to human computer interaction design.

2.7.7 Positive Impact of Computer Games for Education and Training

There are many studies about the positive impacts of computer games. Research has begun to show that playing video games can be beneficial for improving many cognitive and motor skills (Othman & Mat Yamin, 2006; 2007; Klopfer, 2005; Kozuki *et al.*, 2002; Zavaleta *et al*., 2005; Baba & Kita, 1995), and new games that capitalize on the power of this medium to motivate and engage players are now being explicitly designed for learning (Klopfer, 2005).

Siang and Rao (2003) in their research, summarize that learning by using computer games is more effective because it is simpler to use and easy to understand. Furthermore, learning with computer games also has psychological impact, as students have greater motivation and give feedback immediately compared to conventional learning. Examples of computer games used in the classroom are *SimCity*, *Railroad Tycoon* and *Civilization* III. Among the popular research related to computer games in education were shown in studies by Baba and Kita (1995); Li *et al.,* 2004; Miles *et al.*, 2004; and online discussion forum at http://www.seriousgames.org/index2.html.

It is also supported by Kamil Othman in The Star (2005, October 20), who stated children learned faster by using games as a learning tool. For example, kids by playing games such as *Age of Empires*, can easily remember how European civilizations evolved (Christy Lee, 2005).

According to Grice and Strianese (2000), popular games can be applied to the design of business software and to education-especially for classes delivered through distance education. Tortell and Morie (2006) also stated that playing video game can give effectiveness element in virtual environments for training. The result is relevant to training methodology, and applies to players of all types of video games. This is an obvious way in which the above results apply to the practical business of combat training.

According to Zavaleta *et al*., (2005) games can be considered as an important educational strategy that allow the cognitive emotional, linguistic, social, moral and motor development, as well as make each player more autonomous, critical, creative responsible and cooperative. For the educational game to be useful it must be interesting and challenging for the students, allowing self-evaluation of the individual and group performance (Becta, 2004). The activities with computer games allow the teacher to identify and diagnose some of the student's learning errors, attitudes and disabilities, as well as discipline, socialize, build moral values, improve common sense and stimulate the creation of teamwork. Motivation can be a positive force, but games that generate too much interest can addict the player and not benefit them (Becta, 2004).

2.7.8 Persuasive Technology

There is considerable research that provens that persuasive technology is an innovation in improving awareness and motivation in education (Fogg, 2002; 2003). Thus, this is an alternative strategy to persuade people to receive information. Table 2.4 provides a summary of persuasive technology studies to improve awareness.

Table 2.4: Summary of Persuasive Technology Studies

Persuasive Element	**Reference**
Introduce **persuasive technology** in computer learning	Fogg (2002; 2003).
Using pervasive **games** technique for domestic energy awareness among teenagers.	Gustafsson, Katzeff and Bang (2009); Gustafsson and Bang (2008); Bang, Torstensson and Katzeff (2006).
Praise, will praise the player or provide a general hint (reward). Molarcropolis, a mobile persuasive game to raise adolescents' oral health and detal hygiene awareness, During the game, players receive information on oral illnesses and their causes, habits and activities that put adolescents in a special risk situation, as well as tips on ways to improve oral health.	Soler, Zacarias and Lucero (2009).
Using the principle of **virtual rehearsal, similarity, praise and social learning,** with the persuasive aid of multimedia learning environment in reducing childrens' dental anxiety.	Sobihatun Nur (2010); Sobihatun Nur, *et al.*, (2010). Badioze Zaman, *et al*, (2009).
Users' actions in a persuasive game for household electricity conservation.	Gamberini, *et al.*, (2012)
Using computer-based **narrative** to persuade and promote environmental awareness	Lin, Liu and Sambasivan (2008).
Motivating people through visualization	Gamberini, Breda and Grassi (2007; 2009).

2.8 Summary

This chapter mainly provides a description of organic practices in sustainable agriculture which focuses on paddy farming practices in West Malaysia. It continues with the current issues in Malaysia’s paddy and rice industry, including agricultural policy in the rice industry, sustainable agriculture in the National Policy and National Green Technology policy. This chapter also covers sustainable agriculture in other countries. This chapter continues with integration of ICT in learning and promoting sustainable issues, including learning through VR, sustainable agriculture in multimedia and VR application, persuasive technology, educational games, serious games, criteria in choosing the learning games and positive impact of computer games for education and training. The next chapter discusses the methodology used in this study.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This research employed a qualitative and quantitative research design. Data were collected through review of existing literature, interviews, participant observation, lab experiments and focus group interview. This research focused on promoting sustainable agriculture awareness in paddy farming through ICT innovation.

This study involved three phases:

i. Phase 1 – understanding and identification of sustainable practices in paddy farming
ii. Phase 2 – design and development of educational prototype
iii. Phase 3 – evaluation of the prototype

Specifically, the first phase was to identify and understand sustainable practices in paddy farming in selected areas in West Malaysia to show the differences between the conventional system and the organic farming system.

The result of first stage has been adapted in the second stage. It means that the actual practices in sustainable paddy farming have been used as a basis to design the educational prototype using multimedia and virtual reality software. The final stage is testing and evaluating the prototype as a tool to promote sustainability awareness. This study is summarized in Figure 3.1.

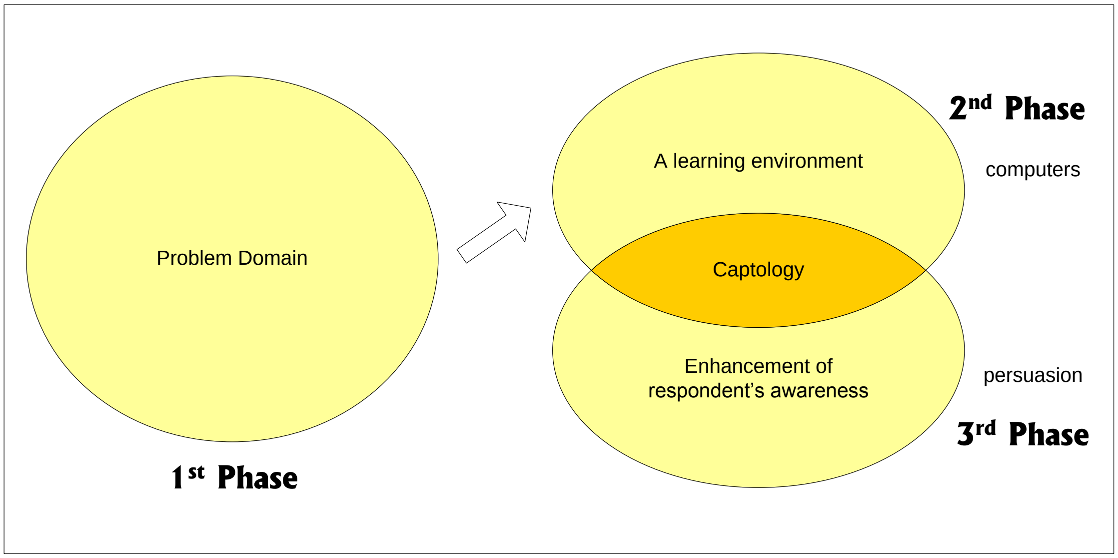


Figure 3.1: Generic Model of the Study

3.2 Data Collection

There are several types of data collection. In Phase 1, this study employed a qualitative case study. This is the type of study conducted for an in-depth investigation and classification of one small group/cluster. This involves extensive gathering of information to understand the entity that is being studied (Sabitha Marican, 2006; p. 152). The information gathered in this study centered on the paddy farming practice at four different places. In addition, this case study also deals with explanations by individuals involved, and their experiences. In general, it provides an in-depth description of particular unit. Data were collected through interview sessions and observation.

In Phase 2, this study reviewed the existing literature in books, annual reports, journals, proceedings and online information.

In Phase 3, interviews were conducted with experts, lab experimenters and focus groups. An experimental study is a type of research conducted to verify knowledge on the impact of a stimulus. Researcher, who employ this research deliberately and systematically use the stimulus to see a string of changes that will occur, these studies are often used in explanatory studies or descriptive studies (Sabitha Marican, 2006, p. 141).

According to Sabitha Marican (2006, p. 143) a pure experimental research is defined as the following:

i. Only one dependent variable is manipulated at one particular time.

ii. There must be a control group.

iii. The respondent or subject must be chosen at random. The number of respondents does not have to be clearly defined (Brown, *et al.*, 1999), but the minimum number of 10 to 20 participants can be accepted.

iv. All the variables must be controlled. The control may be carried out through the manipulation of physical, statistical or random selection.

This study was carried out by using laboratory experiments. It provides an opportunity for the researchers to control their environmental effects on the variables that are studied. Consequently, the responses received were recorded.

In addition, the use of focus group method was also included in this study. The focus group, a form of group interview, is often used by researchers to investigate the opinions of someone on a product, service, political candidates, political parties and others (Fontana and Frey, 1994). It is also often used in sampling aims, group of experts or assessors (proposive or judgment).

3.2.1 Phase 1 – Understanding and Identification of Sustainable Practices in Paddy Farming

In the first stage, the method involved participatory observation and interviews at four selected locations in West Malaysia.

The locations for the case study include the paddy farming areas in Northern West Malaysia (MADA), Northwest Selangor (Sabak Bernam and Tanjung Karang), Bandar Baru Tunjong (Sunnah Tani Sdn. Bhd. Farm) and Kahang (Kahang Organic Rice Eco Farm). The reason for selecting the Sunnah Tani Sdn. Bhd. Farm and Kahang Organic Rice Eco Farm is because both these locations adopt fully sustainable practices in organic paddy farming.

The MADA Granary Area was selected because it is the largest paddy farming area in Malaysia with 96,558 ha (Refer Table 3.1), while the Sabak Bernam area under IADA BLS granary was selected because it had the most productive paddy fields with 5,465 average yields or 102,354 metric tonnes production in the main season of 2008/2009 (Table 3.2). Futhermore, it is also in second highest production in the main season of 2006/2007 and main season of 2007/2008 (Table 3.1).

Table 3.1: Average Yield and Planted Area of Wetland Paddy by Granary and Main Season, Peninsular Malaysia, 2006-2009

Granary Area	***Main Season 2006/2007***		***Main Season 2007/2008***		***Main Season 2008/2009***	
	Yield (Kg/Ha)	***Area (Ha)***	***Yield (Kg/Ha)***	***Area (Ha)***	***Yield (Kg/Ha)***	***Area (Ha)***
MADA	*4,403*	*96,410*	*4,462*	*96,558*	*5,073*	*96,547*
KADA	*3,593*	*25,634*	*3,558*	*24,470*	*3,738*	*28,137*
IADA KSM	*3,303*	*25,920*	*3,010*	*27,071*	*3,386*	*26,846*
IADA BLS	*4,942*	*18,340*	*4,542*	*18,310*	*5,465*	*18,729*
IADA P. PINANG	*5,002*	*10,305*	*4,328*	*10,305*	*5,063*	*10,305*
IADA SEBERANG PERAK	*3,032*	*7,951*	*3,604*	*7,272*	*4,225*	*7,272*
IADA KETARA	*4,818*	*4,923*	*5,231*	*4,923*	*5,167*	*4,923*
IADA KEMASIN SEMERAK	*2,257*	*4,923*	*2,413*	*4,298*	*2,817*	*4,520*
Total	***4,088***	***193,776***	***4,032***	***193,198***	***4,545***	***197,279***

Source: Department of Agriculture Peninsular Malaysia, 2009. p. 38

Table 3.2: Average Yields of Cleaned Paddy and Production of Paddy by Granary Areas, Peninsular Malaysia, Main Season 2008/2009

Granary Areas	Average yield of cleaned paddy (kg/ha)	Production (Metric Tonne)
MADA	5,073	489,783
KADA	3,738	105,176
IADA KSM	3,386	90,901
IADA BLS	5,465	102,354
IADA P. Pinang	5,063	52,174
IADA Seberang Perak	4,225	30,724
IADA KETARA	5,167	25,437
IADA Kemasin Semerak	2,817	12,733

Source: Department of Agriculture Peninsular Malaysia, 2009. p 81

The respondents were nine farmers and four agricultural officers. The paddy farming practice in the Sabak Bernam and MADA areas is under the jurisdiction of the Agricultural Department of Malaysia, so the same technique or practice is employed in all the paddy field in this area. The interviews were conducted with Department of Agriculture (DOA) officers because they are in strategic positions in the top management and represent the farmers involved with activities related to paddy farming in the chosen areas or locations of this research. These MADA officers were from different departments (Accounts, Planning and Information Technology, Statistics, Section of Paddy Industry, Department of Dissemination and Monitoring). Others who were interviewed included the DOA officer at Sabak Bernam.

Interviews were conducted with a Sabak Bernam farmer and a Tanjung Karang farmer. In MADA, interviews were conducted with two farmers. Interviews were also conducted with Sunnah Tani Sdn. Bhd. project supervisor and leader of workers, and an expert in SRI-Organic farming from Indonesia. In the Kahang Organic Rice location, the interviews were conducted with the managing director and leader of workers.

The observations were carried out from 28th June 2008 until the 12th November 2009. The observations were easy to handle and understood because the researcher grew up amongst paddy cultivation (MADA), where her parents and neighbors worked as paddy farmers. In addition, a visit to the Paddy Museum in Kedah was conducted to obtain further information.

The main questions asked during the interviews were related to the steps involved in paddy farming practices including land preparation, seed selection, water management, fertilizer use, weed, pest and disease control, and harvest. Some of the respondents allowed the interviews to be recorded on videotape. However, interview summary were also written in a notebook. After observations and field work, the phone conversation was used to reinforce the information given by the respondents.

Data related to paddy farming, mainly in sustainable practices were compared and analysed based on the criteria in Malaysia Organic Principle (SOM). It is a standard that sets out the requirements for the production of, the labeling and claims for organically produced foods. The requirements cover all stages of production, including farm operations, preparation, storage, transport, and labeling (Ministry of Agriculture, 2009_1). However, this study only covers elements based on the objective of this study that includes:

1. Land and Soil Management

- Farms shall take reasonable and appropriate measures to minimize loss of topsoil through minimal tillage, contour plowing, crop selection, maintenance of cover crops and other management practices that conserve soil.
- Land clearing and preparation through burning vegetation, e.g. slash and burn, shall only be allowed and restricted to the minimum when other measures are not feasible.
- Burning of crop residues, e.g. straw burning is prohibited except in case of need to control a serious insect or disease infestation.
- The fertility and biological activity of the soil should be maintained or increased, using appropriate methods by a) cultivation of legumes, green manures or deep-rooting plants in an appropriate multi-annual rotation programme, b) incorporation in the soil of organic material, composted or not, from holdings produced in accordance with this standard.

2. Water Management

- Operators shall take reasonable and appropriate measures to prevent excessive and improper use of water.
- Operators shall take reasonable and appropriate measures to prevent the pollution of ground and surface water.
- Organic handlers shall install systems that permit the responsible use and recycling of water without pollution or contamination, either by chemicals, or by animal or human pathogens.
- Untreated sewage water is prohibited for use.

3. Seeds and Planting Material

- Use of genetically modified organisms (GMOs) and products thereof is prohibited in all aspects of organic production and handling without exception.
- Seeds and vegetative reproductive material should be from plants grown in accordance with the provisions of this standard for at least one generation or in the case of perennial crops, two growing seasons.
- Use of conventional seed and planting material is only allowed where there is no organic seed or propagation material of the appropriate sort available.
- Seeds and propagation material shall not be treated with prohibited substances. Exceptions should be allowed where there is no untreated seed or propagation material of the appropriate sort available.
- Where varieties protected under the Plant Variety Protection Act are used, the farm shall respect intellectual property rights legislation.

4. Fertility Management

- Crop production systems shall return nutrients, organic matter and other resources removed from the soil through harvesting by recycling, regeneration and addition of organic matter and nutrients with respect to the nutrient requirement of crops and the nutrient balance of the soil.
- Operators shall plan their fertility management to maximize the use of plant and animal organic matter produced within the farm and minimized the use of brought-in organic materials or mineral fertilizers.
- Where applicable, in annual crop production, an appropriate green manure crop shall be included in the crop rotation plan to maintain organic matter content and soil fertility.
- Organic materials and mineral fertilizers shall not be used if their production and use have an unacceptable impact on the environment.
- Allowance on the maximum amount of brought-in organic materials and mineral fertilizers used in the farm, shall be established on a case by case basis taking into account local conditions and the nature of the crop.
- Imported microbial inoculums used for enhancing soil fertility shall undergo quarantine procedures before use.

5. Soil Conditioners and Fertilization Material

- The permitted organic materials and mineral fertilizers are listed in SOM.
- Use of organic material (plant and animal) from conventional systems should be allowed where there is no organic material from organic systems available.
- Organic industrial by-products should be allowed if they are not contaminated with non-permitted substances or other contaminants exceeding applicable health and sanitary regulations.
- Animal manures shall not be used directly on food crops, unless they have been composted or measures are taken to prevent risk of contamination exceeding applicable health and sanitary regulations.
- Use of human and pig excrement is prohibited.
- Poultry manure from battery production systems should be allowed if manure from non-battery based production systems (e.g. free range) is not available.
- Use of trace elements should only be allowed as supplements and only where exhaustive measures to maximize the use of plant and animal organic matter produced within the farm as well as brought-in organic materials have been taken.

6. Prevention and Control of Pests, Diseases and Weeds

- Pests, diseases and weeds shall be controlled by cultural, mechanical, physical and biological methods.
- Use of inputs for pest, disease, weed control and plastic mulch material shall be allowed only where cultural, biological and mechanical measures are ineffective under the production condition in question. Spent plastic mulch material shall be disposed or properly and not ploughed back into the soil.
- Use of plant waste material from conventional systems shall be allowed for mulching where there is no plant material from organic systems of the appropriate sort available. e.g.: paddy straw, grasses, oil palm leaves etc. Where the substances are restricted, the conditions of use as set by the certification body shall be strictly adhered by the farm.
- All substances used for pest control shall comply with the relevant national regulations.
- Farms shall used the approved substances with care and abide with their conditions of use, so as to avoid altering the ecosystem of the soil and farm.

7. Harvest

- The crop must be harvested at proper maturity.
- Waste from handling shall be managed so as to have minimum effect on the environment. Where appropriate, organic waste shall be used for nutrient recycling in production fields.

3.2.2 Phase 2 – Design and Development of Educational Prototype

The second phase is designing and developing a prototype of sustainable paddy farming practices. Most of the data for the second research phase were gathered from books, journals, research reports and proceedings.

The methodology used for the design and development of the prototype is adapted from the model created by Alessi and Trollip (2001). There are three main components in this model: *planning, design and development.* Figure 3.2 illustrates how each component is linked to the others. The Model of Instructional Design by Alessi and Trollip was chosen for this study because this model proposes a set of standards that should guide the design and development study, suggest ways of being creative and introduce techniques for designing, developing and integrating the various components of multimedia application (Alessi & Trollip, 2001).

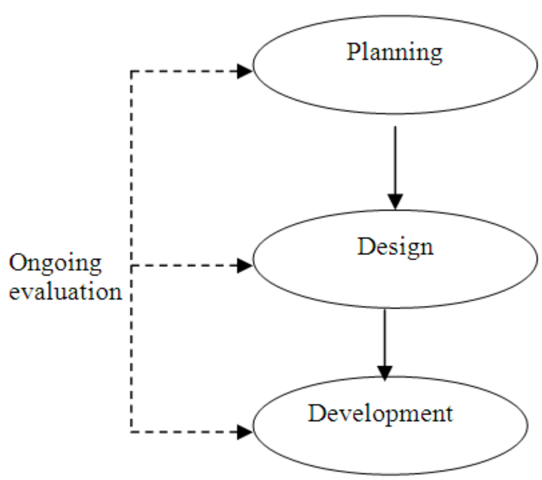


Figure 3.2: The Alessi and Trollip (2001) Model of Instructional Design

In design, there are two strategies involved in this prototype: macro and micro strategies. In the macro strategies, the persuasive design principle by Fogg (2003) has been applied in this study. They are the principle of social learning, principle of praise and principle of cause and effect. In the micro strategies, the virtual reality designed by Kalawsky (2000) and education games designed for learning (Alessi & Trollip, 2001) have been applied for the design of the prototype. There are seven factors of what people consider games to be and these comprise goals, rules, competition, challenge, fantasy, safety and entertainment. The design and development of prototype are discussed in Chapter five.

For the development of the prototype, two undergraduates from multimedia department of a public university were employed as assistants. They had been trained as developers and given proper guidance to ensure that they followed the design and purpose of study. The development of the prototype commenced on 15 December 2009 and completed on 22 March 2010.

3.2.1.1 Virtual Environment Design

The design of the development cycle involves a virtual environment and user interaction model as shown in Figure 3.3. This simple representation of a virtual environment system identifies the closed loop nature of a VR system involving a user, input/output peripherals and a simulation environment. In order to provide an educational perspective it is important to control the simulation by an education programme.

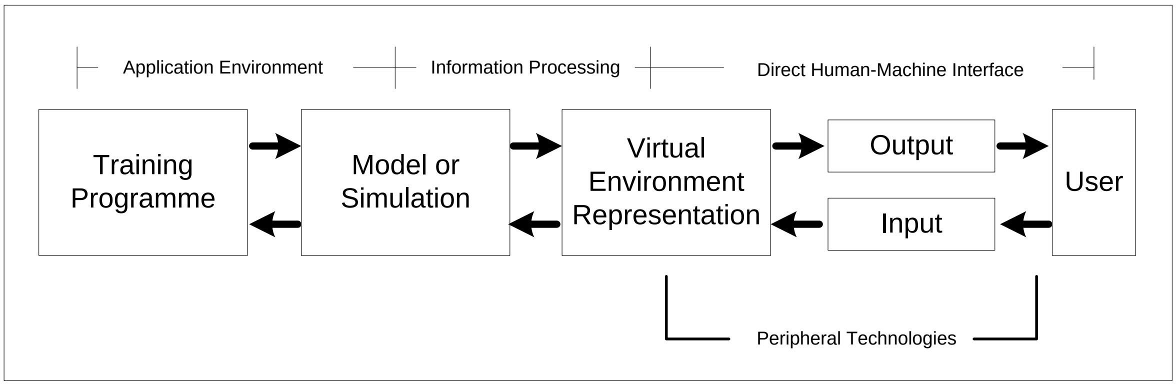


Figure 3.3: Generic Model of an Educational Virtual Environment
Source: Kalawsky, 2000: p. 65.

Based on this generic model (Figure 3.3), Table 3.3 describes the key steps in creating virtual environment (Kalawsky, 2000: p. 85).

Table 3.3: Key Steps in Creating a Virtual Environment

Key Step	Sub-Task
1. Scene Definition	3D Object definition Model accuracy/detail – could involve specification of different levels of detail Material definitions Description of textures to be applied to models Definition of preferred performance trade-offs (e.g. High polygon count versus low polygon count and texture mapping) Scene lighting description Definition of environmental effects Definition of interaction between individual objects (user initiated behaviour or autonomous behaviour)
2. Object Modelling	Geometric modelling – may involve creating models with different levels of detail Material application Texture map application
3. Optional Database Conversion	Object scaling Polygon flipping Polygon reduction
4. Virtual Environment Authoring	Scene building (placing of objects in the environment) Integration of level of detail models Lighting implementation Autonomous behaviour implementation User initiated behaviour implementation Inverse kinematics linking Integration with other modalities (e.g. audio properties)
5. Testing/Debugging	Performance testing Optimisation User interface testing

Source: Kalawsky, 2000; p: 83

3.2.3 Phase 3 – Evaluation of the Prototype

In the third phase, the prototype was evaluated as a tool to promote sustainability awareness. The evaluation was carried out to assess and test the developed system, and to identify problems that may arise in this system. This was done to ensure that the system is operational and fulfills the needs of the users. Four tests were conducted on the prototype. They are expert review, pilot lab experiment, Lab Experiment 1 and Lab Experiment 2.

3.2.3.1 Expert Review

Expert reviews are needed to go through the programme to evaluate the content, the flow of the material, the user interface and its usability. Two experts were identified for this study:

i. The subject matter expert

The subject matter expert's responsibility is to review the accuracy, significance and comprehensiveness of the content. The content is about sustainable paddy farming. An expert reviewer from UKM was chosen to evaluate the content. Three interview sessions and discussions were conducted. The question form is available at Appendix A.

ii. The instructional design expert

The responsibility of the instructional design expert is to examine the interface of the prototype and judge its compliance with recognized usability principles (the heuristics). Two instructional design experts from University Utara Malaysia were selected for this phase (ongoing evaluation design process). The question form is available at Appendix B.

3.2.3.2 Pilot Lab Experiment

The pilot lab experiment was conducted in the Computer Laboratory of the Engineering Department, University Putra Malaysia (UPM) on 2nd April 2010. 23 respondents from the Department of Biological and Agricultural Engineering, Faculty of Engineering were selected randomly to answer the usability and awareness (knowledge and understanding) questionnaire. Then, the result from the pilot study was used to improve the study on the

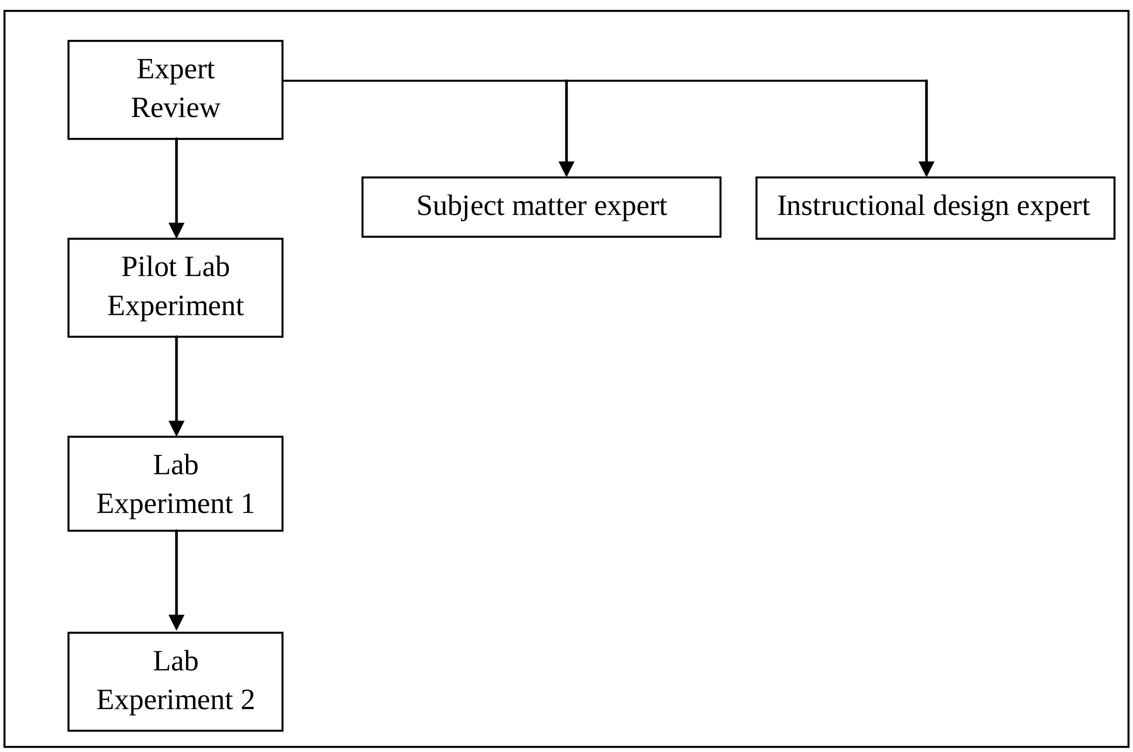
8nd of April 2010, namely Lab Experiment 1. This question also was applied in focus group interview. The question form is available in Appendix C.

3.2.3.2 Lab Experiment 2

In addition, a focus group interview (namely Lab Experiment 2) was conducted in the Computer Laboratory of the Engineering Department, University Putra Malaysia (UPM) on the 5th of October 2010. 13 students from the Department of Biological and Agricultural Engineering, Faculty of Engineering were selected randomly to answer the usability and awareness (knowledge and understanding) questionnaire.

A summary of a steps in evaluation of the prototype is shown in Figure 3.4.

Figure 3.4: Steps in Evaluation of the Prototype



3.3 Justification in Selection of Respondents

The respondents were UPM students. UPM, previously known as the Agriculture University, used to produce most of the agriculture professionals in Malaysia. Three criteria were used in choosing the respondents:

i. Respondents must be computer literate and able to use the software.

ii. Respondents must have basic information and understanding of the agricultural sector.

iii. Students in this field (Department of Biological and Agricultural Engineering, Faculty of Engineering) are expected to be involved in agriculture sector and technology in the future based on their academic training background.

3.4 Location of Experiment

The lab experiment was conducted at Putra 2.8, Block E of the Engineering Faculty. There were 20 computers with specifications as shown in Table 3.4.

Table 3.4: Specification of Computers at Lab Experiment

Model	Dell Inc., OptiPlex 755
Monitor	Dell inc.
Centra Processing Unit (CPU)	Intel(R) Core(TM)2 Duo CPU E4600 @ 2.40GHz
Operating System	Microsoft Windows XP Professional

3.5 Lab Experiment Procedure

The lab experiment research was divided into two phases; before the test and during the test.

3.5.1 Pre-Test Phase

Before carrying out the test, a letter seeking for permission to use students as test subjects was sent to the Dean of the Faculty (Appendix D). After that, this research began with notification to the respondents by letter (Appendix E) and telephone calls.

3.5.2 Test Phase

The respondents assembled at the Computer Laboratory of the Biological and Agricultural Engineering Department during the test. The test session started with an introduction from the researcher, a brief description of the research goals, tasks and procedures to be followed as well as information on the confidentiality of personal information. In addition, the respondents were also given the opportunity to ask questions regarding the research. After that, a declaration forms were distributed to respondent (Appendix F).

After the respondents consented and signed the consent agreement, they were asked to answer the questions in part 1 and 2. Then, the respondents were asked to use the prototype of *SiPadi* (Figure 3.5). The period of time provided for visiting the *SiPadi* system was not informed to the respondents so as not to discrupt their focus and reduce their satisfaction. However, the time slot that was given for the exploration of *SiPadi* was 20 minutes. After the participants had finished exploring the prototype, they answered to a questionnaire about their experience. The questionnaire included questions about how they felt and viewed the prototype. This test phase was recorded using video cameras as well as written notes.

Figure 3.5: *SiPadi* Interface

3.6 Data Analysis Procedure and Method

Traditional and computer-based qualitative methodologies were used to analyze the data for emerging themes and to compare and contrast the observation obtains from the participants.

3.6.1 Qualitative Data Analysis

The methods of analysis suggested by Strauss and Corbin (1990), Merriam (2001) and Saat (2009) were used in the data analysis. The data from video-tapes (interview) and written notes were also transcribed (see the sample at Appendix G). All the data were first reviewed and coded. Only data related to understanding and identifying organic paddy farming practices were used in the analysis of this study. Then, the data were categorised. The primary analysis helped the researcher to focus on the data that could be used to design the prototype, especially in organic practices. The second stage involved a more rigorous and detailed analysis. According to Saat (2009), all data are to be organized in a manageable format where data is placed in assigned electronic files and folders. This is done to ensure that data is easily retrievable. Yin (1989) calls this manageable format as 'case study database', and Patton (1990) as 'case record' (Saat, 2009). The analysis revealed that the process of understanding and identifying organic paddy farming practices presents three major themes; they are (1) sustainability characteristics, (2) sustainable paddy farming practices and, (3) challenges. Lastly, the text and visualization data were validated by an expert reviewer.

3.6.2 Quantitative Data Analysis

The Statistical Package for the Social Sciences (SPSS version 12 for Windows) was used for data analysis. The first step in analyzing the results of the pilot experiment was to compute descriptive statistics. After that, the evaluation of prototype in computer lab was conducted on the 8th of April 2010, followed by the second evaluation on the 5th of October 2010.

In the pilot lab experiment, expert reviews were needed to assess the usability of the contents of the programme to evaluate the content, the flow of the material, the user interface and the usability of the prototype. Two experts were identified for this purpose: a subject matter expert and a user interface expert. The subject matter expert's responsibility was to review the accuracy, significance and comprehensiveness of the content, specifically, the content of the prototype that deals with sustainable paddy farming. For the evaluation of the content, an expert reviewer from UKM was chosen. Three interview sessions and discussions were conducted.

The responsibility of the instructional design expert was to examine the interface of the prototype and judge its compliance with recognized usability principles (the heuristics). Two instructional design experts from University Utara Malaysia were selected for this phase.

To sum up, the usability results revealed that the learning prototype has the potential to be a communication tool, particularly to be used in promoting sustainable issues and enhancing the level of awareness in sustainability.

The finding of this pilot study shows that respondents understood the questions. All the respondents agreed that this system provided greater understanding of organic paddy farming practices as well as experience in organic practice in paddy farming. Table 3.5 shows the result of user interface satisfaction, and the overall answers were satisfactory.

Table 3.5: Mean of Interface User Satisfaction

Dimension	**Mean (Scale: 5)**
Overall Reaction to the software	4.42
Screen	4.64
Terminology and sytem information	4.36
Learning	3.57
System capabilites	4.38

Nevertheless, some changes were made to clarify the questionnaire: (1) Part 2 question 2.3, ‘Have you ever heard of sustainable programs in Malaysia’ was changed to ‘Do you know of any other sustainable practice programs in Malaysia? in order for the respondent to understand the information; (2) Part 2 question 2.6 the abbreviation ‘SLAM’ was changed to ‘SALM’ due to a minor typing error.

The results of this pilot study were then used for the actual study. But it should be noted that during the test the researcher provided explanations for question which were unclear and answered questions posed by respondents. The comments from the pilot study are in Figure 3.6.

Comments

1. Best.
2. Very enjoyable. Anyone can use it as an effective system for continuous learning.
3. Interface program like computer games available and I always play. So, quite happy to use this program.
4. This system is highly effective in creating awareness.
5. The system is able to provide basic knowledge to the public and suitable for all ages.
6. Beneficial to students.
7. Stimulating.
8. Congratulations on your efforts in producing a good and useful software like this.
9. The system is able to provide basic knowledge to the public and suitable for all ages.
10. Increases knowledge of rice farming systems.
11. Interesting system.
12. The system is very effective to expose the public to sustainable agriculture.
13. The system is very good and interesting. Users can not only gain knowledge but also experience a true practice of organic farming.
14. Congratulations.
15. Presentation is clear. Lessons can be conveyed clearly and correctly.
16. Lack of special effects.
17. The system is very good and interesting. Users gain knowledge and, have experience the view of organic rice farming practices.

Figure 3.6: Comments from Pilot Study (See Original Text at Appendix H, part B)

3.7 Summary

This chapter elaborated on the research design, research procedures and data analysis procedures. This section also discussed the research design in phase 1 (understanding and identification of sustainable practices in paddy farming), 2 (design and development of educational prototype) and 3 (evaluation of the prototype). The discussion and elaboration of research phase 1, 2 and 3 will continue in Chapter 4, 5 and 6. This chapter also has provided a statistical analysis for the pilot experiment.

CHAPTER 4

FIELD STUDY

4.1 Introduction

The field study, carried out from 28 June 2008 until 12 November 2009, included visits to the Paddy Museum in Kedah and in-depth interviews with farmers to obtain further information to reinforce the data collected. The goal of field study is to understand the practices of paddy farming in selected areas in West Malaysia. Four locations were selected for this study; in this study; there are (1) Northern region of West Malaysia, (2) Northwest Selangor (i) Sabak Bernam, (ii) Tanjung Karang (3) Bandar Baru Tunjong, and (4) Kahang (refer Figure 4.1).

Figure 4.1: Four Selected Paddy Farming Areas

i. Paddy Farming in Northern Region of Malaysia

The first location for the study was Northern Peninsular of Malaysia as illustrated in Figure 4.2. This includes the areas of Kota Star, Kubang Pasu, Pendang, Yan, Kuala Muda and Southern Perlis with a total area of 96,558 hectares of planted paddy areas and is called MADA. MADA is one of the lead agencies in Malaysia rice industry and a key driver of socio-economic development of the farming community in the region. MADA has existed since June 30, 1970 under the supervision of Department of Agriculture Malaysia (DOA). The two main objectives set for the MADA are based on human development and commodity production i.e. to improve the socio-economic well-being of a large portion of the rural population in the area, and to increase the rice yields for the national requirement (MADA, 2008).

Figure 4.2: Location of MADA

The interviews and observation were done at Kota Star. There were seven visits to the paddy farms and MADA main office. The respondents were four officers at MADA, Farmer 3 and Farmer 9. Farmer 3 who has 20 years of paddy farming experience and owns two-hectare farm at Kampung Telok, Bukit Pinang. He works at MADA and plants a paddy as a part time job. Farmer 9 has been a farmer since the age of 28 years ago and has 30 years of paddy farming experience. He plants paddy at Kampung Padang Hassan, Kepala Batas. He owns two acres of paddy land and rents four acres from the neighbouring field. Both of them farming began from early their young age.

ii. Paddy Farming in Northwest Selangor

The second location for the study was Northwest Selangor, namely IADA BLS.The focus was on two areas, (i) Sabak Bernam (Figure 4.3) and (ii) Tanjung Karang. Sabak Bernam is located in the western-coastal area of Peninsular of Malaysia and consist of Sekinchan, Sungai Leman, Pasir Panjang, Sungai Nipah, Pulau Bedena and Bagan Terap areas with a total area of 13,144 hectares of paddy cultavation in 2009. The Sabak Bernam district has the most productive paddy fields in Malaysia with an average yield of 5.5 tonnes per hectare in the main season of 2008/2009.

According to Agriculture Department Officer 1, from the Sabak Bernam Agriculture Department, this high productivity is achievable because of the well-constructed irrigation system and the excellent adaptation of farmers to technology promoted by the Agricultural Department. However, the ever rising cost of production, especially of pesticides and fertilizers has reduced the profit margin of the farmers. Therefore, in helping the farmers, the Department has embarked on vermicomposting and Integrated Pest Management (IPM) practices. Under the guidance of the Department, the farmers have successfully utilized paddy straws as a medium for vermicomposting. Normally, the paddy straws are considered as waste and burned, but now with the introduction of the vermicomposting, paddy straws are recycled.

Figure 4.3: Location of Sabak Bernam

The focus of the second location is Tanjung Karang. Here there is a SRI project, led by Dr. Anizan Isahak (Farmer 8) from the UKM, who has formed a research group at UKM called SRI-PADI in July 2008 (http://sripadiukm.blogspot.com/). It includes soil scientists and plant physiologists together with a geneticist, an environmental scientist, a microbiologist, a food scientist, and an engineering geologist. They obtained some Research University Funding (GUP) to carry out SRI research and activities. Two locations, Tanjung Karang and Beranang were identified as SRI experimental plots (Anizan Isahak, 2012). Consultants from Nagrak Organic Sri Centre (NOSC), Indonesia were invited to start off organic SRI at these sites. The researcher visited and interviewed Farmer 8 four times.

iii. Bandar Baru Tunjong

The third location of this field study was the Bandar Baru Tunjong (Figure 4.4) area which is owned by the Sunnah Tani Sdn Bhd, a state-based company in Kelantan in the East Coast of Peninsular Malaysia. This area is also trying to adopt organic rice farming practices. It is a new project and they started as a pilot project on 12 May 2009 on eight hectares of land at Kampung Tunjong, Bandar Baru Tunjong. Sunnah Tani Sdn. Bhd. has adopted the System of Rice Intensification (SRI) method as its paddy farming practice.

Figure 4.4: Location of Bandar Baru Tunjong

The interviews were conducted with the supervisor of the project (Farmer 5), co-supervisor (Farmer 6) and Farmer 4 on 23 July 2009 and 3 March 2011. Farmer 4, an experienced practitioner in the SRI planting technique from Indonesia helped to run this project. He holds onto certain principles in the planting of paddy. His philosophy is that farming ought to safeguard the eco-system bestowed by God. This is evident in his words:

"*To ensure that this (pointing to his paddy field) is good, more sacrifice is required. It requires wisdom. By doing this, the outcome is better. When a farmer face pests they just spray insecticide directly on them, the paddy will not grow well, and hence, not much profit will be gained* (The worker compared it with the conventional planting method).

It is the decree of God that nature needs to be preserved. We, as vice-gerant on this earth have to save this world. Not much capital is required but there is a lot of hard work and ultimately will get used to it, gradually there will be results. It is not in visible results of the paddy, but rather in the feeling of self satisfaction".

(Farmer 4, personal communication, July 23, 2009)
Original text at Appendix H, Part A

The concept lies in the intent and manner of managing paddy farming, which is by being attentive to the journey and life cycle of mankind, plants and animals which are organically related. This is further established by the Farmer 5, who places great importance on the concept of safeguarding the eco-system and act of worship. According to him:

" *This system is more of an act of worship to Allah Taala. That is the best part!. This is as we serve the land, we will reap returns from the Al-mighty*".

(Farmer 5, personal communication, July 23, 2009)
Original text at Appendix H, Part A

Thus, organic farming, from the perspective of farmers in Bandar Baru Tunjong, requires patience, sacrifice and guidance from God.

iv. Kahang

The final location for the study was Kahang at Johor where KOREF is situated (Figure 4.5). KOREF is a fully integrated organic agro-ecological farm irrigated with pollution-free river water which originates from the 1,010 meter Belumut Mountain in Southern Peninsular of Malaysia. It obtained full certification of organic status from the Malaysian Department of Agriculture in December 2005. The Kahang farm provides a unique back-to-nature health enhancing eco-lifestyle farm experience to the visitors. In addition, the organic farm organizes life enrichment activities. Hence, the farm not only provides agro-tourism services but also actively promotes awareness on sustainable lifestyles. The organic farm also produces high quality dragon fruits, coconuts, vegetables, herbs, farm fish and ducks. Its overall aim is to promote biodiversity and ecology conservation which is environmentally, economically and socially acceptable through organic agriculture.

Figure 4.5: Location of KOREF

The interview was conducted with the Farmer 2 and Farmer 7. Farmer 7 has worked at KOREF for three years. Before that, he was a paddy farmer in Indonesia. Visits were made to Kahang on 11 January 2011, 1 August 2009 and 2 August 2009.

4.2 Paddy Farming in MADA

MADA which contributes as much as 40% to the national paddy production has 48,000 farmers in its area. The checklist of paddy planting or ’Rice Check’ acts as a guide to the management of paddy planting, to abide to the targeted production goal. The method that is used, which is issued by the Malaysian Agriculture Department acts as a guide. Each main ‘Rice Check’ must be followed accurately to ensure smooth growth of the paddy plant which is geared towards high yields.

The supervision and observation of the crops, as well as the status of the farms in terms of growth, management of water, use of fertilisers, attack from weeds and pests, and harvesting is integral in identifying the problem(s) and finding a solution to the planting problems encountered by the farmers. The growth of the paddy plants need to observed, recorded and action taken to overcome the problems. These data acts as a guide for the management for the following season.

Before MADA was established, the production of rice in 1965 was 3.4 tonnes/ha a year. However, after MADA began its operation in 1970, planting was successfully carried out twice a year (double cropping). This was proven for the 1/2005 season, a production of 6.1 tonnes/ha was recorded, an increase of as much as 79.41%.

However, the MADA area faces a problem of labour shortage. Thus, MADA had planned and implemented various approaches to overcome this problem such as the introduction of the paddy estate programme. This programme is run on the concept of centralised farm management, which is managed by the district farmers' association. Besides that, the workforce required is minimized with the use of machinery for the process of scattering seeds, applying fertilizers spraying poison and harvesting.

Paddy farming at the MADA area is carried out in the following manner:

4.2.1 Preparation of Soil

The planting of paddy begins with the preparation of the soil. The soil for paddy cultivation is of the non-acidic alluvium type, and the land surface of the paddy must be flat. The soil must also be free of dry paddy stalks, stumps, weeds and wild paddy to avoid spread of diseases. After harvesting, the dry paddy stalks are burnt to eliminate the empty seeds paddy at the surface of the soil.

Following that, the soil will be ploughed using tractors. The first cycle is carried out seven to fourteen days after the burning of the dry paddy stalks. The ploughing of the soil differs between the first and second seasons. The second cycle is carried out when the soil is wet. Ploughing is done either once or twice according to the condition of the soil. The soil is spun till it reaches a depth of 10 cm – 15 cm. The difference between the lowest and highest parts of the soil is more or less 5 cm. Following that, work lanes are constructed at a distance of 10 feet between the lanes.

Then, the soil is flattenned using a small tractor or what the farmer call 'kabota'. When the soil is flattened, water pathways are constructed to drain out any additional water from 'dumping drain' as illustrated at Figure 4.6. This water pathway also functions as a means to control the rapid breeding of snails. Following this, limes is scattered if the pH of the soil is less than five. The most suitable soil pH for the planting of paddy is 5.5 – 6.5. Analysis of the fertility status of the soil is conducted by MADA or DOA.

Figure 4.6: 'Dumping Drain'

4.2.2 Selection of Seeds and Planting

The method that is frequently used, based on the interviews with Farmer 3 and Farmer 9, is the wet scattering method. A majority of farmers in the MADA area practice this type of planting method. However, when problems such as floods (for example in December 2010) and attacks from snails (*Pomacea Canaliculata* and *Pomacea Incerlarus)* or wind paddy disease arise, manual planting is employed. This method of planting produces better and bigger clumps of rice in comparison with the wet scattering method.

A variety of seeds officially issued by MARDI is used. These seeds are soaked in catalyst or booster material to help in the germination of seedlings. Following that, 140 kg of seed per hectare is used for to get at least 400 germinated seedlings for one square meter. Seeds are sown by using a mechanical sprayer to gain uniform seed dissemination.

4.2.3 Management of Water

The water management system in Malaysia, in general, is based on the objective to conserve and enhance the efficiency of water use. The irrigation schedule for all of the paddy fields is produced by the management of MADA. This schedule should be adhered to obtain good results. The depth of water in a paddy field is five to ten cm, depending on the height of the paddy plants during the growing stage.

A telemetry system that uses a network station and a rainfall level recorder is used to obtain systematic data. Thus, information such as rainfall and water levels throughout the catchment areas and major rivers can be obtained within a short duration. In addition, the actual amount of water supplied to the fields through the evaporation stations, can be calculated and the data recorded. This telemetry system ensures that the water resources will be used effectively and not wasted.

Double cropping of paddy is assisted by the reticulation system. Through this system, the reservoir water will be channeled from the rivers, into the canals before being channeled into the paddy fields. Along the boundaries of the paddy field, dumping ditches will be constructed to speed up the drainage and irrigation (Ahmad, 2008).

4.2.4 Applying Fertilisers

Fertilisers are used so that the pH of the soil is raised from 5.5 to 6.5. Fertilisers are used at least four times. Through interviews with Farmer 3 and Farmer 9 on October 1, 2009, the following information was gathered about the schedule for applying fertilizers:

i. Firstly when the plant is 15 days old or when three leaves begin to sprout.

ii. Secondly, when the paddy plant is actively growing, namely when it is 35 days.

iii. Thirdly, when the weight of the paddy plant at the age of 55 days.

iv. The grains start to grow, which is equivalent to about 70 days after planting.

Table 4.1 shows the schedules for applying fertilisers and pesticides in farm owned by Farmers 3 and 9.

Table 4.1: Schedules for Applying Fertiliser

Age of (MR217) Paddy Plant According to Days after Scattering (HLT)	**Fertiliser**	
	Growth	**Type of fertiliser**
15 days	Begin growing	Ash fertiliser or mixture fertiliser (Government Aid)
35 days	Active growth	Urea fertiliser (Government Aid), Planting Tonik (Vitamins)
55 days	Formation of stalk	Additional mixture fertiliser or NPK (Government Aid)
70 days	Seed Filling	Additional mixture fertiliser or NPK (Government Aid)

Figure 4.7 shows the sample paddy plants from Farmer 3's field when it is 50 days old. The seed variety used is MR217.

Figure 4.7: Paddy Plant when it's 50 Days Old

During fertilisation, the pesticides sprayed include Score and Nativo, which are also used to eradicate pests (caterpillars) and fungus. Figure 4.8 shows the types of fertilisers used.

Figure 4.8: Example of Fertilisers

4.2.5 Pest Control

The proper preparation of soil and the management of water aids the control of weeds. Ongoing monitoring and supervision is required to control the pests. The following explains how pests are controlled at the Farmer 3's farm.

A month before the first wet cycle (ploughing), glyphosate herbicide paraquat (for example: *Spark*), is sprayed if there is instance of empty seed paddy after the first ploughing cycle. Three days after scattering the paddy, water is released to avoid the growth of grass after is has been sprayed with pesticide. Then, a week after the scattering of the paddy, the pesticide *Suternil* is sprayed to eradicate grass or weeds like *menerung* and *sambau*. Following that, the paddy seedling of 20 days old, is sprayed with pesticide *Amen Altmex* or also known as *Ally* to eradicate *cabai kera* and 'menerung'. When the paddy plant has begun to fruit, *Fujione* is sprayed to eliminate grasshoppers.

Several compounds are used in the MADA area. Examples of chemicals used are saponin, niclosamide, buprofezin, cartap hydrochlride, fipronil carbaryl, imidaclopid and difenochonqiale, paraquat and glufosinate glyphosate. The continuous use of poisons/pesticide for three consecutive seasons is not recommended since it can lead to the paddy becoming resistant to the chemicals. Figure 4.9 provides examples of pesticides used.

Figure 4.9: Examples of Pesticides

4.2.6 Harvesting

The paddy will be harvested when 85% of the grains in the paddy stalks are yellow in colour. The harvesting machine used must be free of dirt and the seeds of wind paddy seeeds. The MRR 220 and 219 will be harvested when it reaches 110 to 115 days, meanwhile, the MR217 variety will be harvested about 100 days after planting.

4.3 Paddy Farming at Northwest Selangor

There are two planting methods used in Northwest Selangor. Sabak Bernam follows the Rice Planting Checklist or ‘Rice Check’, and Tanjung Karang follows the SRI organic practices. So, paddy planting in Sabak Bernam is quite similar to that of MADA area. However there are differences in irrigation systems in both locations.

Below are the systems used in the cultivation of SRI paddy conducted by Farmer 8 from research group called SRI-PADI. The process begins with preparing the land.

4.3.1 Preparation of the Soil

The first step is soil preparation. The paddy straw and weeds need to be cleared and the paddy straw is spun together with the soil in a dry condition, once or twice. Then, wet hoeing is done twice with tractors. The soil is twisted until a depth of 10 cm – 15 cm. Before planting the seedlings, the soil is well-meshed. The surface of the paddy field must be flat. The difference of soil levels between the lowest and highest level is less than 5 cm. Then, a work lane is built at a distance of 10 feet between them.

Each plot of paddy has a water entry and exit channel. The entry channel functions to bring water to the planting area, whereas, the exit channel let’s out unwanted water, especially during the process of drying up the paddy fields. Finally, before the planting process, organic fertilizer or compost is scattered at a rate of seven tonnes per hectare.

4.3.2 Selecting Seeds and Planting

The second step is the selection of seeds. The best quality seeds used are from official sources such as MR219 and UKMR2 (previously known as UKM 7). To ensure that the best seeds are used, the seeds are soaked in salt water with a viscosity of 10%. The salt content of the salt water is tested by placing a chicken egg into it. When the egg emerges upwards from the salt water mixture, this means that the salt water is ready for use. Then, the egg is taken out. After that, the paddy seeds are poured into the salt water. Seeds that float are a lesser quality and are, thus, not used. Then, the seeds are planted at the dry nursery. It is ensured that the soil is constantly damp, but not the extent of being saturated. Subsequently, between the 8 to the 12 days, the paddy seedlings will be transferred or transplanted to the paddy field.

The seedling is planted at a depth of one to two cm in the soil (Figure 4.10). The distance between the seedlings is usually at 30 cm times 30 cm, which are 11 plants per square meter. The distance between the plants seedling is to provide ample room for ventilation, lighting and soil nutrients, while also helping the weeding process.

Figure 4.10: Paddy Seedlings

4.3.3 Management of Water

The third stage is water management. Water is obtained from sources from the Irrigation Department. The *Parit Kilik* (trenches) are built along the paddy field boundaries to accelerate the drainage and irrigation of water. The water depth in the plots is up to 2 cm in the beginning stages of growth. Water is released gradually to the field when the grass and weeds are being removed. After the paddy plants begin to mature, the soil can be left to dry until it cracks up a bit to facilitate the growth of the roots.

At the initial stage of the formation of the stalks or better known as early paddy insemination, the water is to be a level of 2 – 4 cm. Then, 20 days before harvesting is carried out, the soil gradually dries out.

4.3.4 Applying Fertilisers

The fourth step is applying fertilizers. Organic fertilizer that can be bought in the market or self processed is used. In Sabak Bernam, the fertiliser is self processed and among the main ingredient is rice water. The fertiliser is scattered onto the soil and sprayed onto the leaves, beginning from day ten, after planting the seedlings. Following this, the fertilizer will be sprayed on the paddy seedlings on days, 18, 28, 38, 48, 58 and 70.

4.3.5 Pest Control

The fifth step is control of pests, which can be in the form of weeds, pests and paddy diseases. The growth of grass and weeds is controlled by discarding it with weeding equipment or a twist hoe, such as shown at figure 4.11. The grass and weed will plough onto the soil at least four times in a single planting season, namely on days, 18, 28, 38 and 48. After the 48th day, there is no need for weeding.

Figure 4.11: Weeding Equipment

With the occurrence of attacks from insects, such as leaf folding caterpillars and stem borer maggots/caterpillars, the natural method is used in controlling these insects, and among the natural methods utilised is to spray tobacco water together with neem seeds (Othman & Muhammad, 2012)

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4.3.6 Harvesting

Paddy is harvested when it is 85 percent ripe. The yield for Tanjung Karang stood at about 4 tonnes per ha for both varieties (MR219 and UKMR2). SRI-PADI yields are higher than the national average by about three tonnes per ha obtained from organic irrigated rice and matches or exceeds the national average of about four tonnes per ha. from conventional irrigated rice (Anizan Isahak, 2012).

4.4 Paddy Farming in Bandar Baru Tunjong, Kelantan

It is evident that the SRI method used here leads to higher productivity compared to the conventional method. However, practicing the correct and accurate planting technique is a challenge faced by the SRI project. The success story is proven with the experience of the farmers and ongoing research carried out by various institutions.

The aim of this project is to produce paddy that has better quality, better harvest, and minimal management cost as well as reducing environmental pollution. The SRI method which is used for this project has aided the biological balance of the soil. The result is, it does not pollute the environment, does not require a lot of water and is also cost efficient, while ensuring the fertility of soil. During my visit on 23rd July, 2009, a pilot study was conducted by Sunnah Tani Sdn. Bhd.

The planting of organic paddy at Bandar Baru Tunjong is explained below:

4.4.1 Preparation of the Soil

Initially, the soil is ploughed by tractor. Subsequently, water is let in to help in the decay of grass, rice straw and stubble. After two days, drains will be constructed on the edge of a paddy plots, so that the paddy field rice is always flooded and the soil moist. Then, the soil is flattened with a flattening tool called a ‘ruler’ or *pembaris* (Figure 4.12). After that a ‘distance tool’ or *penjarak* is used (Figure 4.13), which functions as a means of determining the distances between the seedings that to be planted.

Figure 4.12: *Pembaris*

Figure 4.13: *Penjarak*

4.4.2 Selection of Seeds and Planting

Planting begins with soil treatment. In this trial project, five to seven tonnes of organic fertiliser were placed into the soil a week before planting was carried out. It begins with the selection of quality seeds. The seed selection procedure at Bandar Baru Tunjong is similar to Tanjung Karang. Then, the seeds are planted at the nursery. After that, they are transplanted to the paddy field manually. The method requires time and a bountiful workforce in comparison to the direct scattering technique or through the use of machine transplanting. The MR220 variety was used at the trial site.

4.4.3 Management of Water

Water is obtained from the nearby river through drain. Water is drained into a nearby pool of water and allowed to stagnate and drained to the paddy field when it is required.

4.4.4 Applying Fertilisers

Organic fertiliser is self-made by the Farmer 4. Local Micro-organism (MOL), is used as the main component for the fertiliser. This MOL can be used as an activator in the preparation of compost. Other than being used as compost, it is also mixed with water and sprayed directly to the soil. This is done for the purpose of fertilising the soil and increasing the nutrients of the plant. Self-made fertiliser can reduce the cost of production, apart from preserving sources.

According to Farmer 4, the main (mother) fertiliser is made from tender bamboo shoots or the soft base of the banana tree stump (Figure 4.14). All these crushed and mixed with sugar contributes to a type of fertilisers. Following this, the materials are soaked with water up to day 14. Later, one litre of this fertiliser is added to 10 litres of water, 25 litres can be used for one acre of the land area. This similar method is used to produce other types of fertiliser and is done by mixing animal dung with paddy straw, tree leaves and limes which are left to soak for a duration of 14 days.

Figure 4.14: Banana Tree Stump

4.4.5 Pest Control

The rice stem borer caterpillar is the main pest in this area. The method used to eradicate it is by capturing the mother caterpillar (butterfly) by using oil lamp (Figure 4.15) during the night. The butterfly will be attracted to light at night and when it is close to the light, they will be trapped in the oil that is placed nearby.

Figure 4.15: Oil Lamp

Rats are another troublesome pests. However, owls (*Tyto Alba*) do help a lot in resolving this problem. Another example of pests found at the field are birds. As the paddy in that area is planted outside of the planting season, birds focus on the area and eat up the ripened paddy. Among methods employed to curb this problem is to hang, a line of tins up along the fields. The tins will produce sounds when the rope is shaken, and this would chase away the birds. Meanwhile, for problems such as grass and weeds, they are discarded using an equipment called the ‘porcupine’ or *landak* (Figure 4.16). It is also known as a twist hoe in Tanjung Karang. The porcupine is an equipment to plough the soil and discard grass. It also functions as a tool to loosen the soil. This method of discarding the grass is employed from the time the paddy seedlings are 10 days old until day 40.

Figure 4.16: The ‘Porcupine’ (*landak*)

4.4.6 Harvesting

After four months, around mid September 2009, the paddy was harvested at a proper mature age. The paddy yield for this pilot project was three tonnes per hectare. Subsequently, the soil is replanted after two months and the second season produced 6.2 tonnes per hectare. However, the third season was destroyed due to the flood. Paddy straw was used for nutrient recycling in production fields. Along the process of managing the paddy farms, animal such as shrimps, eels and fishes are bought back to life.

4.5 Paddy Farming in Kahang

The KOREF in Kahang is the first paddy farm to practice organic farming in test trials since the year 1999. Based on a site visit conducted in August 2009, it was observed that close to 77 hectares was used for planting organic paddy during this season. The photo in Figure 4.17 were taken during the site visit. This farm has 11 workers: five locals, three Indonesian and three Myanmarese.

Figure 4.17: Site Visit to KOREF

The principle of farming at this farm is focussed on the balance of the eco-system, awareness and education of sustainable farming. Thus, an of array eco-tourism activities are provided and, this includes lodging and camping facilities. The management and administration of this farm also share information related to sustainable farming by providing exposure and experience of farm life. The Figure 4.18 shows the campaign and information disseminated to camp participants and students.

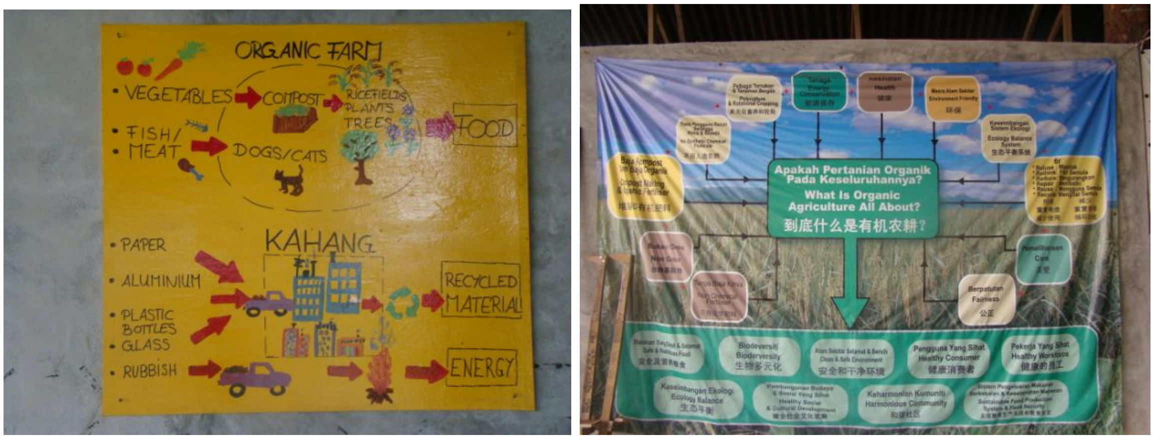


Figure 4.18: Example of Campaign and Information Disseminated to Camp Participants and Students

The paddy planting method in KOREF is as follows:

4.5.1 Preparation of the Soil

First, paddy straw is spun together with soil in a dry state once or twice. Following this, the soil is ploughed twice in a wet condition using a tractor. The remaining paddy straw and weeds need to be discarded. Following this, the surface of the paddy field is flattened.

4.5.2 Selecting Seeds and Planting

The planting method employed at this farm is direct seeding. Nonetheless, the transplanting method is also employed. During the site visit, it was found that the paddy variety planted here is MR220.

4.5.3 Management of Water

Madek river which is located nearby is the source of irrigation for the farm.

4.5.4 Applying Fertilisers

A month after the paddy has been planted, organic fertilisers are scattered onto the paddy fields. One hectre of paddy area requires around 500 kilogrammes of organic fertiliser. After discarding the weeds, fertilisers are scattered again at an estimated period of two and a half to three months. The organic fertiliser (Figure 4.19) can be obtained from distributors in Kuala Lumpur.

Figure 4.19: Organic Fertiliser

4.5.5 Pest Control

During the growing stage, grass and weeds will be discarded or through the use of a hoe or *cangkul* (Figure 4.20). Uncontrollable growth of plants and weeds can reduce the yield by as much as 90%. Weeding will be carried out until the paddy produces flowers, when it is three months.

Figure 4.20: The Hoe or *Cangkul*

As the farm practices organic farming, the principle of a balanced eco-system is maintained through fish and duck rearing. A KOREF natural methods are used to control plant diseases. During an interview conducted during the second visit to KOREF, on the 1st of August, 2009, the researcher was informed that rats, stem drill-worms and sparrows were common pests.

Nets are used to trap rats. This method requires knowledge of the entry and exit holes of the rats to the paddy fields. Subsequently, a net is set up at one of the holes. Next, the hole that is not plugged up will be gushed in with water until it floods the rat’s nest. When this is done, the rats will try to escape to the other hole which has been netted, hence, they will be trapped.

As for other pests like snails, they are controlled by draining out the water at the paddy fields. Meanwhile, caterpillars are controlled by pouring oil into the fields. Other pests can be controlled through the rearing of ducks at the fields. Usually, around 150 to 250 ducks are used to control one hectare of the paddy land. However, the ducks (Figure 4.21) are taken out of the fields once the paddy starts to ripen or about three weeks before harvesting.

Figure 4.21: Ducks to Control Snails

4.5.6 Harvesting

Harvesting, using a harvesting machine is carried out when 85% of the paddy is golden ripe in colour.

4.6 Summary of Paddy Farming by Day

A summary of paddy farming (MR219) at the MADA area is shown in Table 4.2.

Table 4.2: A Summary of Paddy Farming (MR219) at MADA by Day

The stump of the paddy is cut between the first and fifth day of harvesting.

Day (D)	**Note**	**Activity**
D 1	Preparation of soil	Burn straw
D7- D14		Ploughing (dry) by tractor
D7 – D10		Pestiside the weeds (Glyphosate discards wind paddy)
D10		Release water into the paddy field
D11		Ploughing (wet soil) by small tractor *(kabota*)
D12		Petilachlor (Sophite), a pestiside is sprayed and water drained out after seven days.
D20 – 22		Third spin, making lanes
D23		Add limes if the ph of the soil is less than ph 5
D24	Planting	Soak the seeds with a catalyst substance
D26		Drain out the water and scatter the seeds

Day After the Planting (DAP)	**Note**	**Activity**
DAP 8		Release water into the paddy field
DAP 7 – 14		Pestiside the weeds (Suternil, *sambau* and grass)
DAP 15 - 20	Add Fertiliser	Mixed fertiliser (ash), Mixed fertiliser
DAP 15 -30		Pestiside (Amen Altmen, Ally)
DAP 35 -40		Urea fertliser (Government Aid)
DAP 50-55		Fertiliser mixture additional NPK
DAP 70 -75		Fertiliser mixture (growth enhancer)
DAP 100		Drain out the water
D110 -115		Harvesting

A summary of paddy farming using the organic method is as shown in Table 4.3. There are several similarities between the organic method, namely SRI at Tanjung Karang and Bandar Baru Tunjong (Othman, Muhammad & Abu Bakar, 2010).

Table 4.3: A Summary of Paddy Farming using Organic (SRI) Method by Day

Method of SRI farming (Tanjung Karang)

Day (D)	**Note**	**Activity**
D1- D14	Preparation of soil	Ploughing by tractor
D10		Release water into the paddy field
D11		Ploughing by small tractor *(kabota*)
D13		Third cycle, making lanes
D14		Scattering of organic fertiliser
D24	Planting	Soak seeds for planting

Day After Planting (DAP)	**Note**	**Activity**
DAP 8 - 12		Paddy seedlings are transferred to the paddy fields
DAP 90		Drain out the water
DAP 110 -115		Harvesting

- Fertiliser is scattered out on the following days: 18, 28, 38, 48, 58 and 70.
- Weeding and ploughing of the soil is carried out on the following days: DAP 18, 28, 38 and 48.

There are major differences of paddy farming between Tanjung Karang, Bandar Baru Tunjong and Kahang in term of time applying fertiliser and weeding (Table 4.4).

Table 4.4: Applying Fertiliser and Weeding at Kahang and Bandar Baru Tunjong

Paddy Farming at Kahang

- The first cycle of applying fertiliser is carried out on the 30th DAP (about 500 kilos of fertilizer for one hectare of land).
- The second cycle of fertilisation is carried on 75 to 90 DAP.
- Weeding is done until day 90.

Paddy Farming at Bandar Baru Tunjong

- Organic fertilizer is put into the soil one week before planting.
- Weeding is carried out as much as four times from the 10th to the 40th day.

4.7 Application of Information and Communication Technology

According to the Planning and Information Technology Department of MADA, the usage of ICT was existing in their daily operations. This is especially true when they convey information to the public through their website (http://www.mada.gov.my/). It is similar in Kahang, Bandar Baru Tunjong, Tanjung Karang and Sabak Bernam Agriculture Departments. They have all developed their own web-based information systems for the purpose of disseminate information.

Other ICT applications have been employed in the farms' management in various departments in MADA. For example, the databases for the usage of ICT include 10 tonnes per hectare system, irrigation system, estate paddy system, coupon subsidy system, and pest control system (Othman & Muhammad, 2009). Beside that, there are two technologies that are used to increase rice production. They are the paddy production control and forecasting, system using remote sensing technology, and Geographical Information System (GIS).

4.8 Summary

This is an empirical study aimed at developing educational software on sustainability practices in paddy farming. The results show, several similarities and differences in the practice of paddy farming in four selected locations in West Malaysia (Othman & Muhammad, 2012; Othman, Muhammad & Abu Bakar, 2010). Paddy farming methods in Sabak Bernam and MADA can be categorized as conventional while the farming practices in the other places can be categorized as sustainable (Othman & Muhammad, 2008; 2009). Findings of this study also show that the level of awareness on sustainable farming and usage of ICT innovation among farmers is considered low. The data on sustainable paddy farming practices has been utilised in the design of educational prototype using multimedia and virtual reality software. The detailed discussion is in next chapter.

CHAPTER 5

PROTOTYPE DESIGN AND DEVELOPMENT

5.1 Introduction

Introducing ICT innovation is an alternative platform to promote sustainability awareness in paddy farming. The prototype is designed to takes place “down on the farm” where paddy farming begins, where individuals can see, hear, and sometimes taste the firsthand knowledge. This information is offered as a guide or starting point.

This chapter covers the different phases in the design and development of a persuasive learning environment. Several design and development models were used in developing this prototype (Figure 5.1). There are two design principles involved in this prototype: persuasive design principles and key steps to creating a virtual environment.

Figure 3.1 in Chapter 3 describes a generic model of designing and developing the persuasive learning environment in solving problem from any possible domain. The generic model represents the problem domain understanding as a start as it can be generalized to the other domains. The solution model of the problem domain is adapted from a model of persuasive technology which consists of three ovals. The first oval is about real problem domain, followed by second oval which is about the design strategy of learning environment (Macro and Micro strategy). This study has taken such an approach by combining the macro and micro strategies. Macro strategies are described as the overall strategic plan and micro strategies are characterized as presentation strategies (Sobihatun

Nur, 2010). The third oval is the intention of the prototype which is the enhancement of respondent's awareness. Therefore, in this model, captology is the subset between persuasive learning environment and enhancement of respondent's awareness.

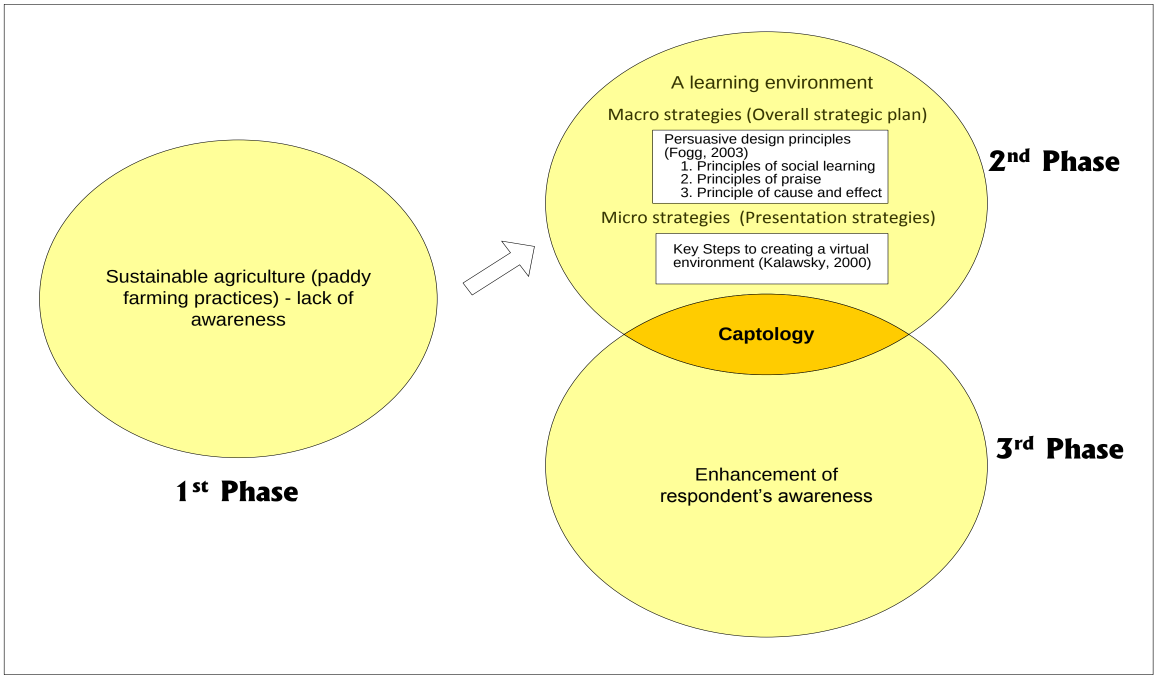


Figure 5.1: Specific Model of the Study

The design strategy for this study will combine the macro and micro strategies (Reigeluth & Merrill, 1978). Macro strategies are concerned with the selection, sequence, and organization of the subject-matter that are to be presented, also described as the overall strategic plan (Gibbons, *et al.*, 1997). Micro strategies are concerned with the individual displays, including their characteristics, interrelationship and sequence, that are to be presented to the learners. Micro strategies may also be characterized as presentation strategies because they are concerned with the details of each individual presentation to the learner (Chen, 2005). Macro strategy in this study is a persuasive design principle, whereas micro strategies are a virtual environment.

5.2 Educational Design for Learning

The methodology used for the prototype design and development in this study is adapted from the model created by Alessi and Trollip (2001), please refer to Figure 3.2.

5.3 Planning

There are four steps identified in this phase for planning the design of a persuasive learning environment. The steps are (1) determining the scope of the project, (2) identifying the characteristics of the learner, (3) establishing the constraints and (4) determining and collecting the resources (Figure 5.2).

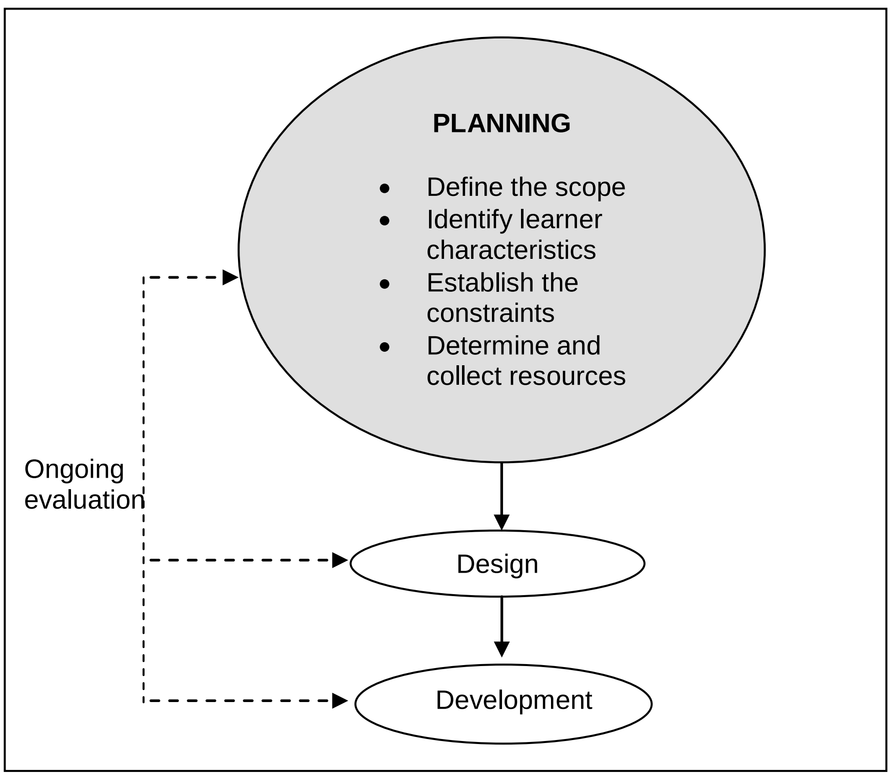


Figure 5.2: Planning Phases and the Steps Involved

5.3.1 Defining the Scope

The first step in the planning is ensuring the scope of the content to be learned. In this study, the goal of the prototype is to investigate the use of learning system as a persuasive tool in promoting awareness of sustainable paddy farming. This learning environment is intended to create awareness on the sustainable approach in paddy farming, that is to provide information on how to handle paddy farming practice and care for the environment. The language used in the prototype is Malay language because the students use this language as the medium of interaction and instruction at the university.

5.3.2 Identifing Learners' Characteristics

Good instructional design understands the nature of the intended target respondents in terms of age and educational level. The age's group of the students as the users of the prototype is around 22 to 30 years. The respondents were students from the Department of Biological and Agricultural Engineering who study both technology and agriculture. Besides, the respondents are computer literate. Furthermore, UPM, previously known as the University of Agriculture, Malaysia was the main institution for producing agriculture professionals in the country. Hence, with regards to respondent selection, it is assumed that the respondents would be involved or directly employed in the agricultural sector in the near future.

5.3.3 Establish Constraints

A common constraint in developing a prototype is the hardware, software, content, graphics, audio and video. The specifications of the hardware used to develop this application are:

- Operating system: Windows XP or later
- Processor: Intel Centrino Duo T2250@1.73 GHz
- Read Access Memory (RAM): 2.49 Gigabyte (GB)

For the software constraint, the prototype required some authoring software to create animation, programming, three dimension (3D) modeling, audio, movie and drawing. The software used are *Autodesk 3D Studio Max* 8, *Adobe Photoshop* CS 3, *Macromedia Flash*, *Window Movie Maker*, *Macromedia Director* 8.5, *Sound Forge* 5 and *Quest 3D* 4.2.2.

3D models are needed to create the virtual environment. The 3D models are created using *3D Studio Max* 8, and *3D Studio Max* 2009. The modeling technique for this courseware was not the same as modeling for photorealistic or animation because the 3D models are used for virtual environment where the number of polygons count matters (Othman, 2002).

Polygons are used in computer graphics to compose images that are three-dimensional in appearance. Usually (although not always) triangular, polygons arise when an object's surface is modeled, vertices are selected, and the object is rendered in a wire frame model. This is faster to display virtual environment and animation than a shaded model. The polygon count refers to the number of polygons being rendered per frame. Because the virtual environment use real-time rendering, so as to avoid too much rendering time, the models need to create with as low as possible polygons which affect the quality of models (not too smooth or not too realistic).

Quest 3D 4.2.2 is like authoring software that usually is used to create virtual environment and 3D games. To use this software some basic knowledge of programming algorithm is needed. Compared to similar software such as *Anark* and *VirTool, Quest 3D* is more powerful because developers can implement the algorithm with less limitation. The files can be exported into .cgr file and publish into executable application, installer or web based application. For this project, the files and all execute applications were published into *Macromedia Flash* executable files.

The specification of hardware and software are needed to run this application. The minimum computer specification to run the application is Windows XP, Window Vista and Window 7 with hard disk space 70 Megabyte (MB) and 2 Gigabyte (GB) Read Access Memory (RAM). However, the recommended running the prototype is on Windows XP/Vista/7 with hard disk space 100 MB and 2.5 GB RAM, with video card, sound card, graphic card, speaker and Compact Disc-Read-Only Memory (CD-ROM) drive. The prototype will be a stand alone application that will be programmed in a CD-ROM.

5.3.4 Determine Resources and Data Gathering Resources

The next part of the planning process is gathering all the resource materials. There are three kinds of resource materials: those relevant to the subject matter; those relevant to the instructional development; and those relevant to the delivery system. In this case, the computer and authoring software intend to use. In all cases, the most important resources is knowledgeable people, so an interview was conducted with the subject matter expert from UKM in order to get the relevant information on paddy farming practices since she is a consultant from SRI group. According to (Alessi & Trollip, 2001), the two primary uses of subject matter resources are to provide actual content and to show how experts have organized the content.

Relevant resource materials for the instructional development process include texts and manuals about instructional design. These figures are prominent in the generation and organisation of ideas and the production of individual displays. The instructional design of the prototype for this study is referred to as persuasive principles. This is further elaborated in the Kalawski design, as described in Chapter 3 (page 66).

5.4 Design

In this research, the learning outcome is to enhance sustainability awareness in paddy farming. In the design phase, the intended outcomes will link to the requirements and constraints of the prototype. Furthermore, a conceptual model including theories, principles and guidelines are used to engage people in such a way that learning takes place in an effective and efficient manner.

There are four steps identified in this phase for planning a design of a persuasive learning environment. The steps are (1) developing the content ideas, (2) preparing storyboards, (3) preparing scripts and (4) preparing a prototype (Figure 5.3).

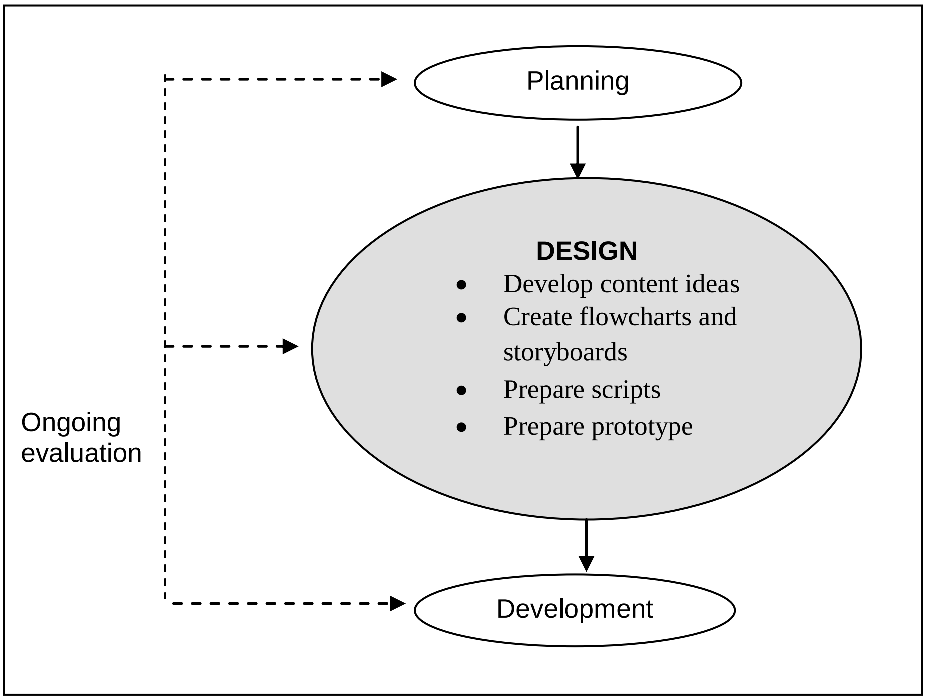


Figure 5.3: Design Phase and the Steps Involved

5.4.1 Developing Content Ideas

In the first design phase, there are two components of content ideas. They are persuasive principle and the real organic paddy farming by day to create virtual environment games. This section explains how the design included the persuasive learning environment to design process as a macro strategy, followed by the steps in virtual environment games.

5.4.1.1 Persuasive Design Principles

VR and multimedia have the advantage of being used as persuasive technology. Fogg (2003) coined the term 'captology' that is about understanding how what is known about motivation and persuasion can be applied to computers. Captology focuses on attitude and behavior change resulting from human-computer interaction.

There are three persuasive principles that have been applied in this study. They are the principle of cause and effect, the principles of praise and the principle of social learning (Othman & Muhammad, 2011_1 ; 2011_2).

a) Principles of Cause and Effect

In the principle of cause and effect, simulation can persuade people to change their attitudes or behaviors by enabling them to observe immediately the link between cause and effect (Fogg, 2003). In this study, the example of persuasive cause and effect simulation is a simulation game in paddy farming (Figure. 5.4). The narrative of paddy farming is based on real data, started in the first day of planting. Based on it, if a user gives the correct answer to handle paddy farming practices, a character called 'planet earth' will appear in 'happy' condition and it will be supported by 'chear' sound. In contrast, if the user chooses the wrong answer, the broken planet earth character will appear to show the bad impact on the environment.

Figure 5.4: A Snap-Shot Screen of the Simulated Paddy Farming Practices

b) Principle of Praise

One of the most powerful persuasive uses of language is to offer praise. By offering praise, via words, images, symbols, or sounds, computing technology can lead users to be more open to persuasion (Fogg, 2003). In this learning prototype, praise is provided through words, sound, symbols and visuals. For example, at the end of the game of simulation paddy farming as illustrated in Figure 5.5, the user will receive feedback like “Tahniah” or ‘Congratulations’, when he finishes the game. This prototype also offers praise via the star symbol.

Figure 5.5: A Snap-shot Screen of the Prototype after User Finishes the Game

c) Principle of Social Learning

Research on social learning theory has shown that people learn new attitudes and behaviors by observing the actions of others and then acknowledge the consequences of those actions. According to Fogg (2003), a person will be more motivated to perform a target behavior if he or she can use computing technology to observe other performing the behavior and being rewarded for it. In this learning environment, the experience at the four selected paddy farming locations was shown in video clip, image and virtual environment (Figure 5.6). Using this technique, users can observe the real practices in paddy farming.

Figure: 5.6: A Snap-shot Screen of the Experience at Four Selected Paddy Farming Locations

5.4.1.2 Steps in Virtual Environment Games

Table 5.1 illustrates the steps in virtual environment game based on real practices of paddy farming (MR 215 variety) as discussed in Chapter 4. The steps based on the selected days cover all major activities in organic paddy farming, namely SRI in Tanjung Karang as done k;.l;;kmby Farmer 8.

Table 5.1: Design Paddy Farming Flow to Games Environment

Day (D) in Games	Note	Activity
D 01	Land Preparation	Ploughing (dry soil) by tractor
D 10		Release water into the paddy field
D 17		Ploughing by tractor
D 18	Seeding	Sowing of seeds at the nursery site
D 24		Ploughing by 'kabota'
D 25		Scattering of organic fertiliser
D 26	Planting	Paddy seedlings are transferred to the paddy field (age the paddy is 8 days)

Day in Games	Age paddy	Activity
D 26	D 08	Paddy seedlings are transferred to the paddy field
D 36	D 18	Weed management
D 37	D 19	Fertilizer
D 38	D 20	Pest control (snail)
D 46	D 28	Weed management
D 53	D 35	Pest control (worm)
D 56	D 38	Weed management
D 58	D 40	Fertilizer
D 63	D 45	Pest control (rat)
D 66	D 48	Weed management
D 73	D 55	Fertilizer
D 123	D 105	Harvesting

5.4.2 Creating of Flowcharts and Storyboards

Flowcharts are a bird's eye view showing the structure and sequence of the programme, whereas storyboards show the details of what learners see. In other words, flowcharts are a way to lay out the big picture of the content followed by the storyboarding to fill in the visual details. In practice, flowcharting and storyboarding may occur simultaneously because changes in one require modifications to the other. The basic flowchart of the organisation of prototype is illustrated in Figure 5.7. The yellow color table in the flowchart shows the focus of the prototype. It is about virtual environment organic paddy farming.

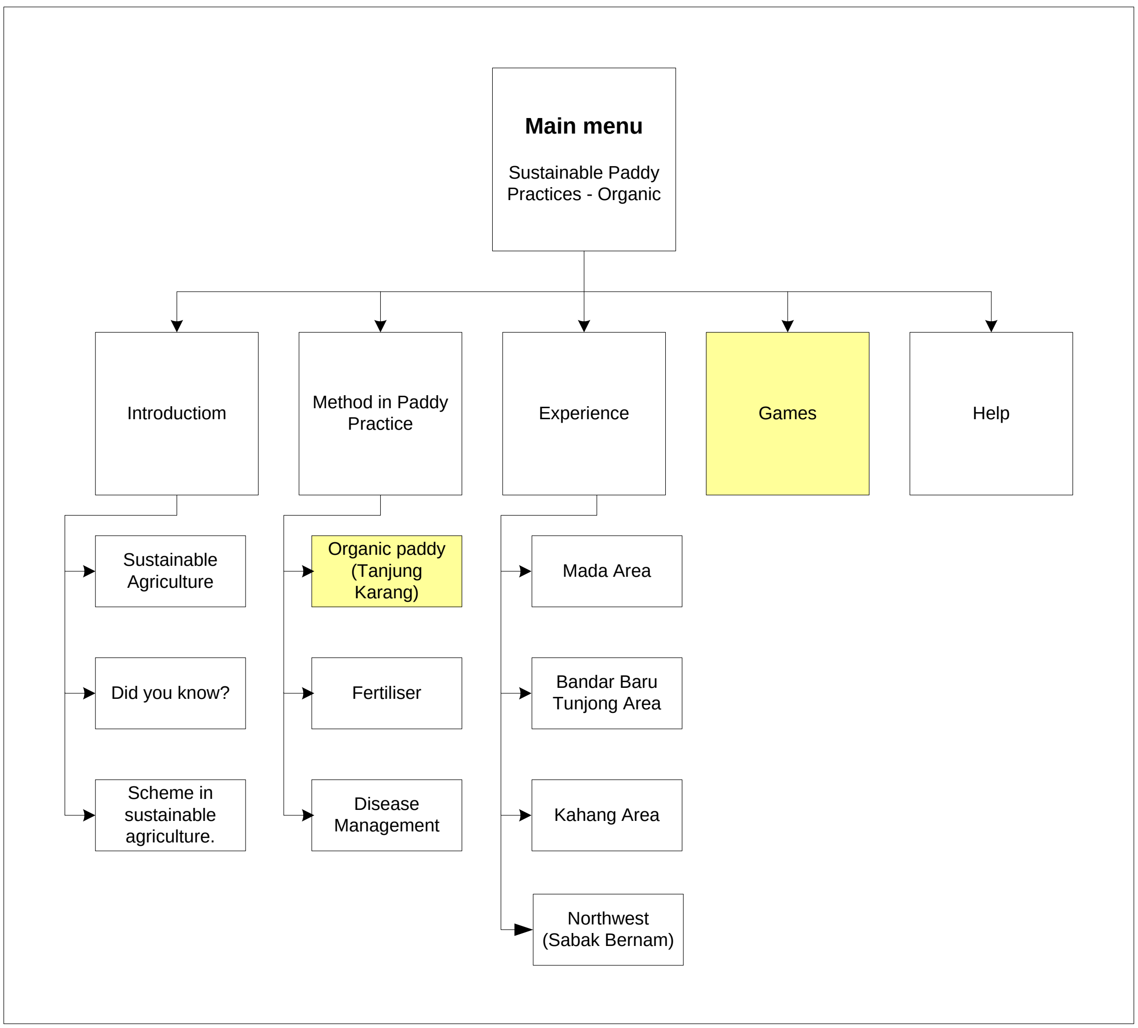


Figure 5.7: The Organisation of Prototype, Main Menu

The storyboard consists of a series of screen sketches of how to organize a story and a list of its contents. They are used by the designer to visualize their ideas and obtain feedback. The draft of the storyboard is illustrated in Figure 5.8. There are examples of the storyboard in Appendix I.

5.4.3 Preparation of Scripts

The scripts are for the speech and video. The speech in the game is based on the storyboard and the script in video is for the interview sessions.

5.4.4 Preparing the Prototype

Prototyping is a powerful tool for both brainstorming and communicating ideas. It is a mock-up of the programme that portrays the look and feel, the methodology and the metaphor to be used. A prototype, even if it does not work smoothly, makes the actual operation more obvious (Alessi & Trollip, 2001).

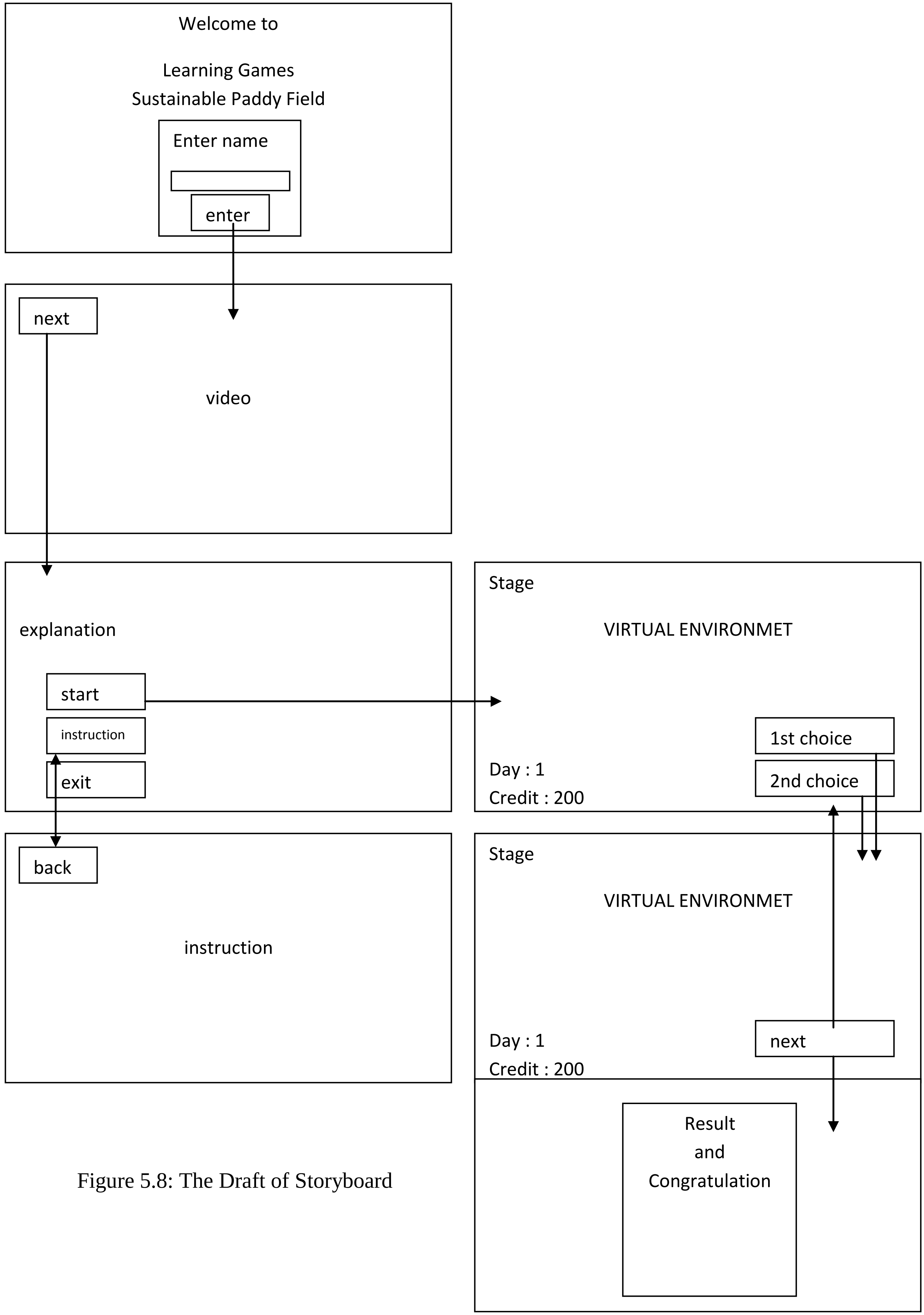


Figure 5.8: The Draft of Storyboard

5.5 Development

This phase is the implementation of the prototype's design which includes the development process as suggested by Alessi and Trollip (2001) model and a non-immersive VR desktop (Kalawsky, 2000). There are eight steps involved in the development phase: preparing the text, graphics, audio and video, developing virtual environment, assembling all the pieces, preparing the support materials, doing an alpha test, doing revision and doing the beta test (Alessi & Trollip, 2001). Figure 5.9 illustrates the implementation phase, including the steps involved.

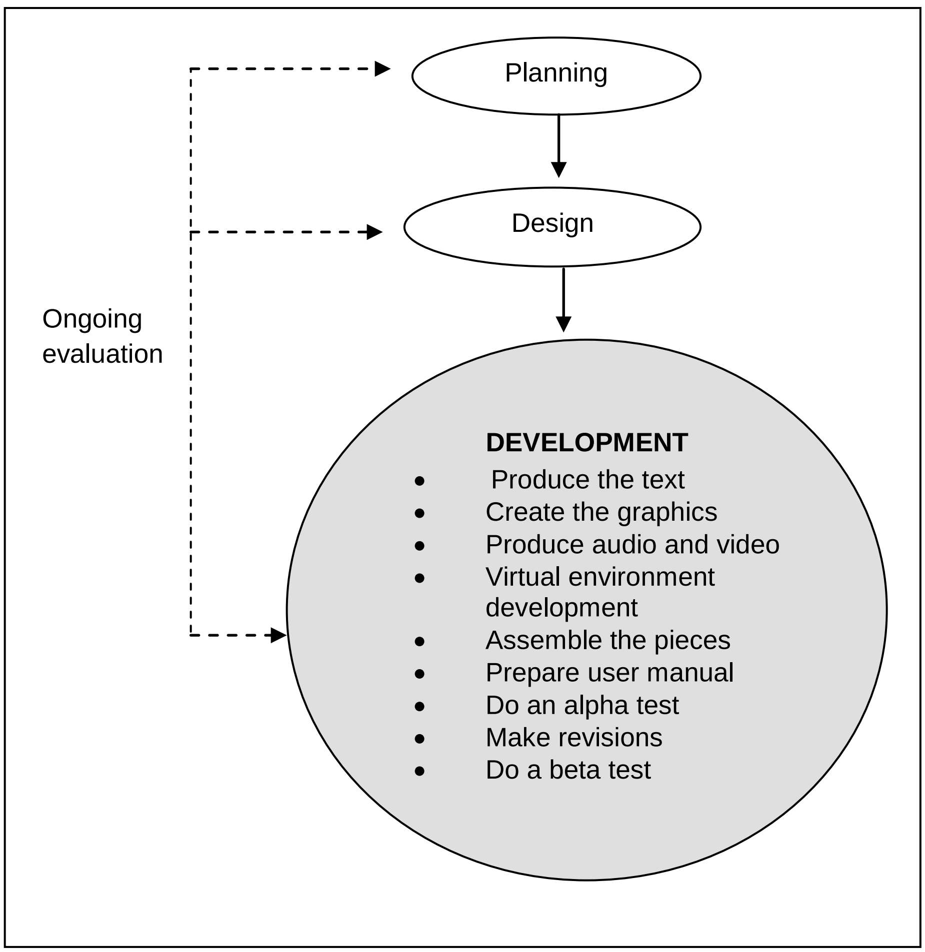


Figure 5.9: Development Phase and the Steps Involved

5.5.1 Preparing the Text

In this prototype, text materials were produced in a word processor. This allows the developer to make changes easily. After that the text was transferred to *Flash*. The format of the text was Arial font type and the size used was twelve. The text format is illustrated in Appendix J.

5.5.2 Creating the Graphics

For the graphics, real pictures were collected through field work visit. The images were produced from photography images using Canon digital camera with 1200 x 1600 pixel resolution. These images were then edited in Adobe Photoshop CS2 and saved in Joint Photographic Experts Group (JPEG) format.

5.5.3 Production of Audio and Video

Video is a powerful tool for learning and instruction. This prototype created a short video clip of a selected paddy area to get the feel of actual paddy farming in Malaysia. For video production, a Sony video camera was used and the video editing software used was *Windows Movie Maker.*

Audio as voice over was also produced in the prototype. Audio recording involved a male character as instructor in the paddy farming game. This process took a lot of time and was repeated several times because it involved an inexperienced person and it was quite difficult to get a better voice over that can be well spoken as needed. The equipment used for audio recording was headphone with a microphone, speaker and Sound Forge 5 was used as audio editing software.

5.5.4 Virtual Environment Development

There are two parts in *SiPadi* which involved the development of virtual environment. They are the step by step organic paddy practice and the paddy farming game.

The prototype development began by gathering information. The steps involved in creating a virtual environment were adapted from Kalawsky (2000) and was modified by the researcher to suit the requirement (Othman & Muhammad, 2010).

5.5.4.1 Gathering Information

The design process began with studying the object and environment involved. In this stage, general and important information and pictures about the object and environment in the four selected paddy growing areas was collected.

5.5.4.2 Scene Definitions

Next, the scene definition includes a few processes, such as 3D object definition, texture definition, scene lighting description, definition of environment effects and definition of interaction between individual objects.

a) 3D Object definition

3D objects for virtual environment of *SiPadi* can be divided into five categories:

i. Paddy field environment which includes water, trees, land, hut, a straw man, and water path.

ii. Character objects such as farmer, rats, birds and paddy.

iii. Texts.

iv. Tools in paddy farming like weeder, tractor, spray tub and fertilizer tub.

v. *Avatar* an object to represent user navigation.

b) Definition of Textures

Texturing is a technique performed in the rasterizing stage of graphics pipeline in order to modify the object model's surface properties such as color, specular reflection or pixel normal (Burdea & Coiffet, 2003).

c) Scene Lighting Description and Definition of Environment Effects.

From the observation, the researcher decided that the suitable paddy field environment is bright, quiet and calm. However, there were sounds of birds singing, burning straw, traditional song, cheering voice, and booing voice. All of the audio used is in a *wav*. format file.

d) Definition of Interaction between Individual Objects

Users are free to walkthrough and explore in the virtual paddy field. In some cases, the user needs to choose the play button in games to interaction. After the scene was definite, 3D modeling objects were developed.

5.5.4.3 Three Dimensional (3D) Object Modeling

The 3D object was developed starting with land surface, cloud, paddy field land and objects in the paddy field. 3D models are needed to create the virtual environment. The 3D models are created using *3D Studio Max* 8, and *3D Studio Max* 2009. The modeling technique for this courseware is not the same with modeling for photorealistic or animation because the 3D models are used for virtual environment where the number of polygon count is matter.

Polygons are used in computer graphics to compose images that are three-dimensional in appearance. Usually triangular, polygons arise when an object's surface is modeled, vertices are selected, and the object is rendered in a wire frame model. This is quicker to display than a shaded model; thus the polygons are a stage in computer animation. The polygon count refers to the number of polygons being rendered per frame.

Because the virtual environment uses real-time rendering, so to avoid too much rendering time, the models need to create with as low as possible polygon which affect the quality of models (not too smooth or not too realistic). The polygon reduction for 3D model was done at *3D Studio Max* through *Polychop* command.

After finishing the 3D modeling, the texture mapping and material process needed to complete the object as a realistic view.

Texture mapping is a process in which textures in real world was applied on 3D object surfaces to enable it to look as realistic as in the actual environment. This texture channel in Quest3D is able to load an image from others format and use it as texture channel group (Figure 5.10).

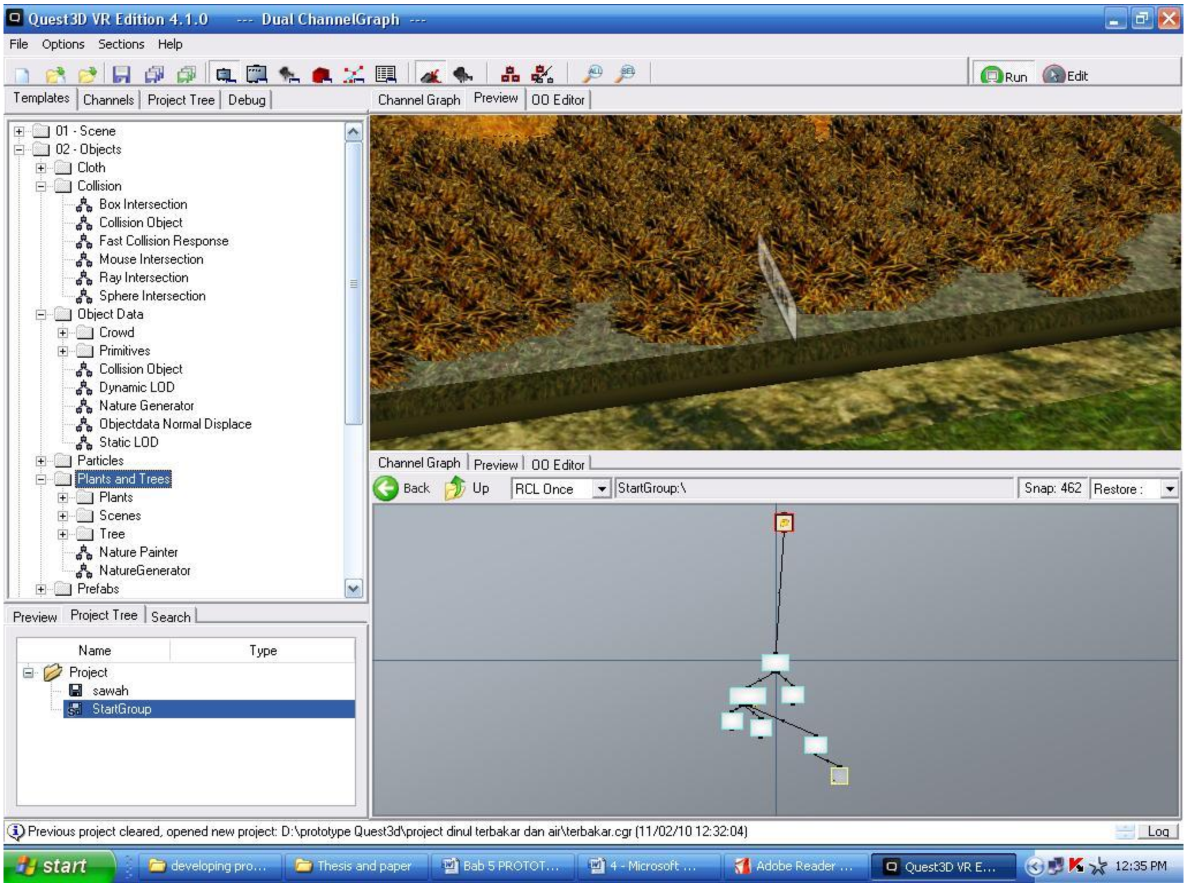


Figure 5.10: The Texture Process

5.5.4.4 Optional Database Conversion

3D objects that were exported in 3DS file format will be imported in Quest3D. Imported objects will then be displayed in the channel graph as shown in Figure 5.11 as a tree channel with parents above, followed by children.

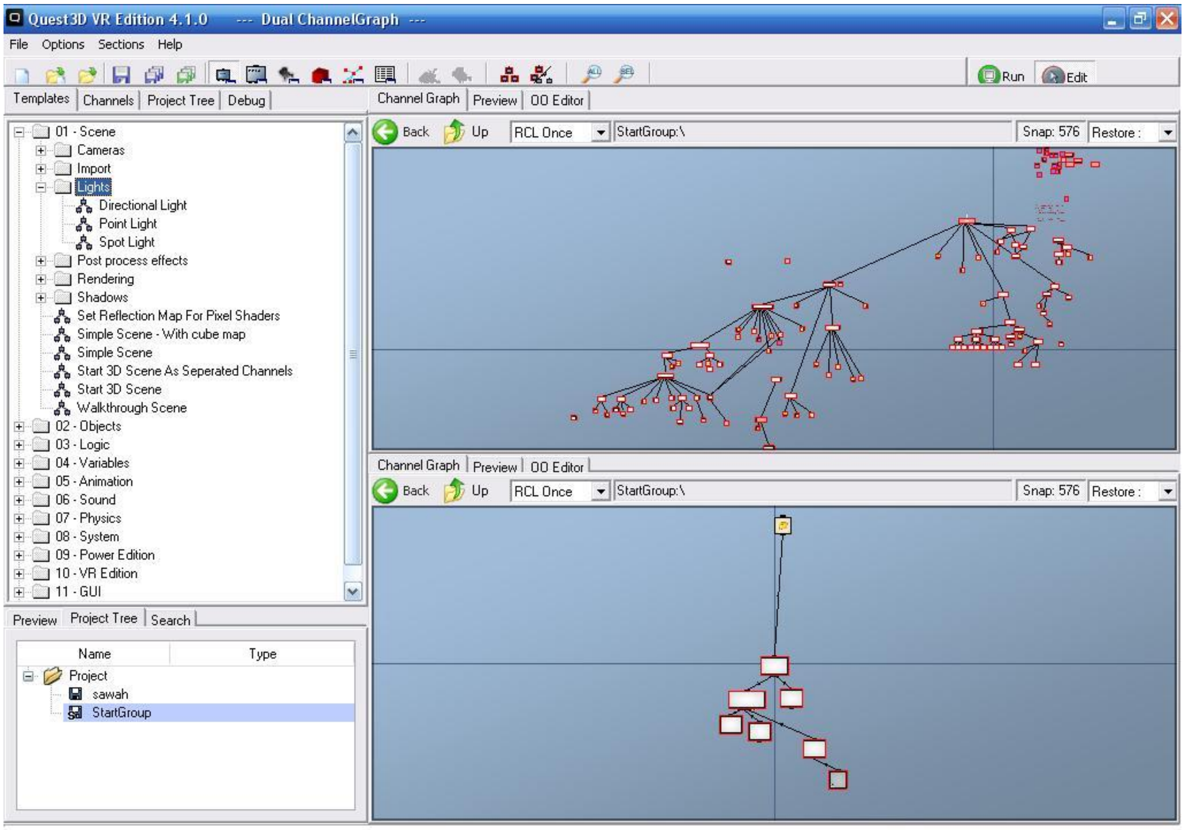


Figure 5.11: Channel Graph

5.5.4.5 Virtual Environment Authoring

The first thing to develop is the user interface using head-up display camera. Heads-up displays are elements of the graphical user interface in personal computing systems. They allow for the transmission of information concerning the current task in a running desktop application in a separate window that is designed so as to not to distract from the current task.

The second part is user control because virtual environment must be controlled by its user or else the view will be static. For *SiPadi* virtual environment users can use the mouse and keyboard.

The scoring technique is proceed directly when a user makes the choice from user interface for the next scene condition and looped until all of the stages are finished. The 3D environments are prepared for some conditions, but the environment that will be displayed is the one that the user chooses. For each stage, two virtual environments are prepared.

In authoring, there are several simulations and animations involved. The programming script, involve controlling user scores. Several animations were developed in 3D max, for example, a farmer engaged in farming such as weeding, paddy planting and spraying fertilizer. Some animations like burning straw and water condition was done in *Quest 3D*.

After the development system was completed, this virtual environment needs to be tested for its performance, optimization and user interface.

5.5.5 Assembly of the Pieces

When all the pieces of a programme have been produced, they must be assembled. In this prototype, the integration process of all the pieces was developed using *Adobe Flash MX*. Perhaps the most important aspect of this process is keeping track of versions of the various assets. The version control is extremely important. Typically, this includes making sure that computer files were renamed and date stamped whenever it was changed.

5.5.6 Prepare User Manual (support material)

A user manual in this study was described at the back cover of the CD-ROM containing the persuasive multimedia learning environment. This user manual is a resource to ascertain what users, will be doing and to determine if the prototype is appropriate for the user.

Components of the user manual are title page, important warnings, a brief introduction, and equipment needed to install the prototype. The title page clearly identifies the name, authors and other credits, copyright, and copyright date. Warnings included comments on compact disc care and actions to avoid that can disrupt the prototype. An introductory section included a short statement of the purpose and objectives of the prototype and what user will be doing, all of which was described.

5.5.7 Doing an Alpha Test

In addition to ongoing evaluation activities, this study includes alpha tests. The alpha test is the major test of the programme by the design and development team. The beta test is done by the clients (Alessi & Trollip, 2001). In the alpha test, the content expert, user interface experts and potential target user were asked to go through the prototype to evaluate the content, observe the flow of content through the material provided, the look and feel, navigation and satisfaction aspect. The purpose is to identify and then eliminate as many problems as possible. The alpha test process has been described in detail in the research methodology section previously.

5.5.8 Make Revisions

The revisions were based on the feedback or comments from the content expert, user interface expert and potential target users. As changes are done, the updated documentation was also made. After the revisions, the final step was to conduct a beta test.

5.5.9 Doing a Beta Test

A beta test is a full test of the final product by the target users, who are the university students. The beta test is a formal process with clear procedures about what to do and what to observe. In this study, the beta test was referred to as an experimental study. There are seven steps recommended by Alessi and Trollip (2001). The steps involve (1) selecting the learners, (2) explaining the procedure to them, (3) finding out how much of the subject matter they know already, (4) observing them going through the prototype, (5) validating the prototype, (6) interviewing them afterwards to get their reactions and, (7) analyzing the data. The detailed process has been described in sub section 3.6.2.

5.6 Summary

This chapter describes the overall process of designing and developing *SiPadi* including the persuasive principle, macro and micro strategy and utilising software such as *Quest3d*, *Macromedia Director*, *Adobe Photoshop SC*, *Sound Forge*, *Macromedia Flash* and *Movie Maker*. The three phases involved in the design and development of the prototype is discussed in detail in this chapter. The discussion of finding and evaluation of *SiPadi* is the topic for the next Chapter.

CHAPTER 6

FINDINGS AND DISCUSSION

6.1 Introduction

The chapter discusses the findings of the field work study and prototype evaluation. The research produces two major outcomes: the identification of sustainable paddy farming practices based on organic farming in selected areas in West Malaysia; and the design strategy and the instructional development model that guided the design and development of *SiPadi* prototype. The evaluation of the prototype *SiPadi* is divided into two parts namely, the finding of Lab Experiment 1 and Lab Experiment 2. The following subsections discuss these two main findings.

6.2 Identification of Sustainable Paddy Farming Practices

Data related to paddy farming from the four locations were compared and analysed based on the principles in SOM. There are several similarities and differences in the practice of paddy farming in the four selected locations. The paddy farming practices Tanjung Karang, Bandar Baru Tunjong and Kahang can be categorised as the sustainable practice.

Figure 6.1 depicts sustainable paddy farming in this study. It can be divided in to characteristics of sustainable practices characteristics, sustainable paddy farming practices and the challenges.

Figure 6.1: Model of Sustainable Paddy Farming Practices

6.2.1 Sustainability Characteristic

The characteristics of sustainability in practical paddy farming as observed in Tanjung Karang, Kahang and Bandar Baru Tunjong are (1) balancing the ecosystem; (2) input from sustainable resources; (3) no chemical or synthetic fertiliser and pesticide used and (4) natural control of pests, diseases and weeds.

The first is balancing the farm ecosystem, Tanjung Karang, Kahang and Bandar Baru Tunjong farmers agree that the farms should observe a natural control to create balance in the ecosystem. This is evident in the statements from Farmer 4 and 5 as recorded in the interview session:

> *"organic crops without using pesticides and chemical. Currently, there are about 50 large eels. How about the harvest in several months later? Probably more animals breed, more worms, small fish, ecosystem at the farm complete, will add a more population, rapidly.*"
>
> (Farmer 4, personal communication, July 23, 2009)
> Original text at Appendix H, Part A

" the ecosystem is complete, let's look at this farm, we see it complete. There are living things. There is an eel ... There must be life life. Then there is growth…and the paddy will grow well",

(Farmer 5, personal communication, July 23, 2009)
Original text at Appendix H, Part A

This feature is also evident in the availability of living creatures such as fish, eels and shrimp in the paddy fields as shown in Figure 6.2.

.


Figure 6.2: Shrimp and Eels at Bandar Baru Tunjong Farm

6.2.2 Sustainable Paddy Farming Practices

Overall, there are eight major steps in sustainable paddy farming practices at the locations of this study.They are:

a) Land Preparation

Tanjung Karang, Bandar Baru Tunjong and Kahang farms recycle the rice straws by incorporating them into the soil during the preparation of the land. They apply one or two rounds of dry plouging and two times wet ploughing by tractors. However, they prefer less or no tilling of land.

In MADA and Sabak Bernam the farmers use chemical fertilizers and compost made from burning the straw from the previous harvest. They apply two rounds of dry rotary and one or two rounds of wet rotary tilling.

b) Seeds

Paddy is planted from seeds. The farmers plant paddy twice a year, once in the main season and once in the off season. All the farmers in the four selected study areas use high quality seeds obtained from the MARDI. Tanjung Karang and Bandar Baru Tunjong farmers use the SRI method in which, the seedlings are widely spaced (25 times 25 cm), while Kahang, MADA and Sabak Bernam apply the direct seeding method.

c) Water Management

The efficiency of irrigation is necessary for high yields (Cunningham & Cunningham, 2009). However, the organic method (SRI) uses less water compared to the conventional farming method. The farm in Kahang obtains its supply of water from the nearby river, whereas the other areas obtain water from Department of Irrigation and Drainage system. They use reticulation system, telemetric system, recycled water, rainfall onto the rice fields, water from surrounding rivers and dams.

For example under the Muda Irrigation Scheme, a drainage and irrigation system was prepared in the plains of West Kedah and Perlis to enable the planting of two crops of rice per year. The sources of water are rainfall onto the rice fields, the water from the surrounding rivers and water stored in the Muda and Pedu Reservoirs. These sources of water are integrated into one system to fulfill the requirements of crops in both seasons (MADA, 2008).

However, in Sabak Bernam the ‘Palong’ technique (Figure 6.3) is derived from Korean technology is employed. This technique provides a good irrigation system because farmers can control the quantity of water for their paddy fields.

Figure 6.3: ‘Palong’

d) Fertilisers

Currently the Tanjung Karang, Bandar Baru Tunjong and Kahang farmers apply only compost, organic fertilizers and natural minerals. The Sabak Bernam and MADA farmers use chemical fertilisers such as urea and planting tonic. They apply chemical fertilisers four times or more by top dressing.

e) Weed Control

Basically, the Tanjung Karang, Bandar Baru Tunjong and Kahang farmers control the weeds manually and by rotary weeding, while the Sabak Bernam and MADA farmers use chemical sprays such as rethilachlor, thiobencarb + propanil and, 2 and 4-D butyl ester for weeds. The control of weedy rice needs to be carried out directly right after the harvesting season.

f) Pest and Disease Control.

Tanjung Karang, Bandar Baru Tunjong and Kahang farmers adopt an ecological system with conservation of natural predators, and IPM practices to control pests and diseases. The IPM practices include biological pest control, proper cultivation methods, effective application of pesticides and mechanical traps. Some of the biological practices implemented by the Department include integrated fish rearing, integrated Muscovy duck rearing, and rat controlled by *Tyto Alba* bird, a type of owl.

Agriculture Department Officer 1 from Sabak Bernam and farmers at the MADA area stated that the IPM method, especially the biological pest control method, is not as effective as the conventional methods. The pest population overcomes the biological predators, thus limiting the effectiveness of this method. Furthermore, it requires more time and effort from the farmers. Therefore, the farmers have little interest in adopting the IPM practices.

g) Harvest

Paddy is ready for harvesting in 105 to 125 days, and all the farmers in the four selected areas of this study use the harvester machine for harvesting.

In summary, there are several similarities and differences in the practice of paddy farming in the locations studied. The comparison between organic and conventional rice is illustrated in Table 6.1. The paddy farming practices in Bandar Baru Tunjong, Kahang and Tanjung Karang can be categorised as sustainable. This is illustrated in Table 6.2.

Basically, in MADA and Sabak Bernam, the same technique is used in paddy field management. However, there are several differences between the two locations such as in terms of the management of water resources and information technology acceptance (refer Table 6.3).

Table 6.1 Comparison Chart between Organic Rice and Conventional Rice Planting, Processing Processes and their Impacts on Health, Environment, Ecology and Biodiversity

Item	Organic Rice		Conventional Rice (non-organic)	
	Planting Process	Impact on health, environment, ecology and biodiversity	Planting Process	Impact on health, environment, ecology and biodiversity
Land preparation	Straw incorporated into the soil by 1-2 ploughing (dry rotaty tilling) and 2 wet ploughing tractors. Preferably towards less or no tilling of land.	Less or no tilling will conserve fossil fuel and is environmental friendly.	Burning of straw from last harvest. 2 round of dry rotary and 1-2 round of wet rotary tilling.	Pollute the environment by burning the straw. Reduce soil organic matter and bio-diversity.
Seed	More than 8 generations oforganically grown seeds. No genetically modified seeds allowed.	No agro-chemical residues in seeds, protects the soil, workers, aquatic fauna and environment.	Agro-chemically treated conventional seed. Genetically modified seed is allowed.	Agro-chemical residues in seed, pollute the water, the soil & environment, threaten wild life consuming the seed.
Nursery Preparation	No agro-chemical treatment on rice seeding. Use compost & organic fertilizer.	Protect nursery bed fauna, ecology balance and its surroundings.	Use 2-3 sprays of agro-chemical to control pests and diseases and apply chemical fertilizer	Damage nursery bed fauna and its surroundings. Pollute the water, the soil of nursery bed.
Fertilizer Application	Recycle rice straw by incorporating it in the soil during land preparation. Apply only compost, organic fertilizer and natural minerals. Releasing duck and	Enhance soil organic matter. No chemical residue in rice. Enhance soil texture & do not acidify the soil. No leaching of fertilizer into the ground water and river system.	Apply chemical fertilizer 4-5 times of by top dressing.	Acidify and solidify the soil, damage the root development. Chemical fertilizers easily leach into ground water and river systems damage the surrounding ecology system.

	culturing azolla (nitrogen fixing aquatic plants) in the rice field.			
Weed control	Weeding by hand, farm tools, machine, crop rotation methods and stocking of fish, livestock.	No herbicide/weedicide residues in rice, water & soil. Protect flora and fauna of rice wetland ecology system. Conserve host plants for predators during fallow period. Conserve bio-diversity.	Use 4 sprays of weedcide/herbicides with 2 sprays after planting	Chemical herbicides destroy soil and surrounding environment flora and fauna inducing unbalanced ecology system and reducing bio-diversity. Herbicide residues in rice, water and soil.
Pest control	Adopt ecological system with conservation of host plants for natural predator. Release duck, culturing fish in the rice field to control pests.	No agro-chemical residue in rice, water and soil. Protect environment, preserve rice field and its surroundings ecology system and bio-diversity. Protect worker's health.	5-6 sprays of cocktail insecticides to control insect pests. 3-4 types of insecticides are frequently mixed together for each spray on rice plant.	Pollute the rice, water, soil and surroundings. Killing of predators, fishes, aquatic organisms, etc. Upset ecology balance and reduce bio-diversity of rice field and its surroundings. This leads to heavy dosage insecticides in order to control secondary pests. Destroy the rice field and its surrounding. Insecticide residues in rice and soil.
Disease control	Use resistant rice or varieties, low density planting and crop rotation to prevent dense canopy of disease infection and outbreak.	No fungicide application. No fungicidesresidue in rice, water and soil. Preserve ecology balance with beneficial microbes to reduce crop losses.	Use different fungicides 3-4, at early, mid and late stage to control rice diseases.	Fungicides will destroy beneficial microbes. Fungicide residues in rice and soil. Risk to workers' and consumers' health.

Production cost	Use intensive labour to control weeds, pests, rearing ducks, fish, etc. Production cost above RM 2,000 per acre.	Adopt highly mechanized farming methode, use large quantity of agro-chemical, synthetic chemical fertilizer. Production cost is about RM 1,000 per acre, 50% less than organic farming.
Yield	Adopt low density farming method to reduce pests and disease losses. Use only organic fertilizer inputs. Yield is usually 50% less than conventional.	Adopt high density planting method and water-soluble chemical fertilizer. Yield is usually 100% higher than organic rice.
Nutritional Content	Harvest at almost 100% maturity with high content of natural enzyme in the grain that accelerate breaking down of grain nutrient that readily absorbed by digestive system.	Usually harvested at 80% maturity mainly for milled/polished to reduce field losses, and high percentage of broken rice.

Note: 1. Chemicals, Agro-chemicals mean synthetic chemicals, which are artificially produced and not occurring naturally.
2. Organic rice farming is twice costlier and yet twice as low the yield of conventional farming. Hence the price of organic rice (without price subsidy) should be 4 times higher than conventional (with subsidy) to justify the cost and risk.
3. Yet, organic brown rice is sold twice the price of conventional brown rice

Source: (Farmer 2, personal communication, January 11, 2009).

Table 6.2: Sustainable Practices in the Management of Paddy Farming

ITEMS	Sabak Bernam and MADA		Tanjung Karang, Kahang and Bandar Baru Tunjong	
	Management Techniques	**Sustainable practice**	**Management Techniques**	**Sustainable practice**
Land Preparation	- Chemical fertilizers. - Burning of straw from last harvest. 2 plouging (dry) and 1-2 rounds of wet plouging.	No	- No chemical fertilizers - Straw incorporated into the soil by 1-2 rounds of plouging (dry) and 2 times plouging (wet) by tractors.	Yes
Seeds	- Use a high quality variety of paddy seeds from MARDI.	Yes	- Use a high quality variety of paddy seeds from MARDI.	Yes
Water management (irrigation)	- Good water management. - Use reticulation system, telemetric system, recycled water, rainfall onto the rice fields, water flowing from surrounding rivers and dams.	Yes	- Good water management. - Use reticulation system, telemetric system, recycled water, rainfall onto the rice fields, and water flowing from Madek river (Kahang). SRI uses much less water than conventional methods of rice cultivation.	Yes
Fertilizer Application	- Uses chemical fertilizers such as urea. - Apply chemical fertilizers 3 times or more by top dressing.	No	- Recycle rice straw by incorporating it in the soil during land preparation. Apply only compost, organic fertilizer and natural minerals.	Yes
Weed control	- Uses chemical sprays such as rethilachlor, thiobencarb + propanil and, 2 and 4-D butyl ester.	No	- Farmers use manual weeding by hand and rotary weeding.	Yes
Pest control (insect)	- Uses chemical pesticide - Uses paddy seeds of high quality variety. - 3 sprays or more of cocktail insecticides to control insects pests. 3 types or more of insecticides are frequently mixed together for each spray onto the rice plant.	No	- Adopt an ecological system with conservation of natural predators. Release duck, cultured fish in the rice fields to control pests.	Yes
Disease control	- Use 3 times or more of different fungicides at early, mid and late stages to control rice disease.	No	- Use resistant rice cultivars or varieties, low density planting and crop rotation to prevent dense canopy of disease infection and outbreak.	Yes
Harvesting	- Use harvesting machines.	Yes	- Use harvesting machines.	Yes

Sources: (Othman & Muhammad, 2008)

Table 6.3: The Difference in Paddy Field Management in Sabak Bernam and MADA

	Sabak Bernam Agriculture Department	**MADA**
Water management (irrigation)	- Modern irrigation system - 'Palong' technique since 1982 - Drainage system at paddy field - Rain water	- Recycled water - Rain water - Water flowing from surrounding rivers - Dams
Information technology acceptance	Medium	Low

According to Agriculture Department Officer 2, information technology acceptance in MADA can be considered as low because majority of MADA farmer do not have formal education in ICT and their average age is around 60 years old. This is in contrast with farmers under the jurisdiction of Sabak Bernam Agriculture Department, where by majority of the farmers are young and have formal education in ICT.

6.2.3 Challenges of Sustainable Farming

The study also shows that there are three challenges in implementing sustainable paddy farming. They are awareness and early education in sustainable paddy farming, management transition, and high work commitment.

6.2.3.1 Awareness and Education

Awareness and early education of sustainable paddy farming is vital. It is hoped that innovations through ICT would provide meaningful contributions.

During this study, it was found that most paddy farmers were lacking in awareness and education regarding organic farming practices. Therefore it is pertinent that farmers and youth be educated on the immense benefits of sustainable practices in paddy farming.

According to Mustapha and Mohd Jani (1995, p. 25), agriculture projects must prioritize social interest and long-term economic goals rather than short-term interests by implementing programmes that minimize the destruction of resource. Nevertheless, any attempt to make the society aware requires the intervention from the government because of two factors. Firstly, policy formulation which supports sustainable agricultural development and secondly, government intervention in implementing laws relating to the maintenance and control of agriculture resource utilization. Therefore a government policy which supports agricultural development that takes into account sustainability factors is the prerequisite that determines the success or failure of a sustainable agricultural development programme.

6.2.3.2 Management Transition

The next challenge is management transition from conventional farming to organic farming. In reality, there are several challenges in the current implementation of rice management, among them are:

i. Unsatisfactory outcome

Most farmers are categorized as low income. A study conducted in 1990 showed that 60 percent of the household or rice field employees were either poor or extremely poor. After 10 years, however research showed farmer's poverty rate had reduced to 40 percent.

The income of rice farmers is low due to the uneconomical size of the fields which is mainly unprofitable. The majority of farmers acquired the fields through inheritance, and poverty forces most farmers to find other jobs to increase their income. Thus, according to Ahmad (2008) most small scale rice farmers with low income make paddy farming as their part time jobs.

This opinion is supported by MADA (2005) whereby many low income rice farmers face financial difficulty and need loans to support the family. Unfortunately, loans become a burden and three quarter of MADA farmers are classified as debtors.

ii. Demand exceeds production

Rice production in Malaysia is insufficient to cater to the country's needs, and around 30% of rice is imported from Thailand and Vietnam. On average, paddy production yield in Malaysia is 4.2 tonnes per hectare a season (MADA, 2009), which is considered low. Thus, would not meet the country rice need as a whole.

iii. High production cost

Production cost of rice in Malaysia is high and this has compelled the government to intervene by offering incentives. Accordingly if the various types of input given by the government in the form of subsidies, such as seed, fertilizer and price subsidies, were to be taken away, it would be difficult to attract a person to venture into rice agriculture.

iv. Labor shortage

The rice farming sector in Malaysia faces a problem of labor shortage. The youth are more keen to migrate to the cities and work in the manufacturing and other sectors than growing rice. Therefore, the present Malaysian rice farmers' average age has actually exceeded retirement age. Due to old age and low income, they work on their rice fields just to fulfill their basic daily needs.

v. Incomplete infrastructure, water shortage

Lack of infrastructure and weak irrigation system are also the main problems faced by many rice farmers in Malaysia, including MADA (Abdul Hamid, 2008) and Tumpat, Kelantan (Rahim, 2011).

6.2.3.3 High Work Commitment

Organic paddy farming requires a high commitment from farmers. This is supported by information extracted from an interview with an organic farmer who believes that farming organically require sacrifice and patience.

> "*To ensure that this (pointing to his paddy field) is good, more sacrifice is required. It requires wisdom. By doing this, the outcome is better.*
>
> (Farmer 4, personal communication, July 23, 2009)
> Original text at Appendix H, Part A.

Farmers who consider organic rice cultivation as a part-time job will not be able to run it effectively. This is because waste from agricultural products need to be recycled, for example it should be turned into compost. Apart from that, pest, disease and weed control should be done naturally. This will be difficult if the farm environment is damaged or polluted. According to organic farmers in Bandar Baru Tunjong, they face environmental problems and an inbalanced ecosystem because of long term usage of chemical fertilizer.

Ismail (2006 p. 35) also agrees that the transition from conventional to organic farming requires a high level of commitment. According to him, this conversion is a difficult move because the positive impact, if there is any, can only be gained in the long term.

6.3 Prototype Evaluation

The goal of evaluating the prototype (*SiPadi*) is to investigate the use of learning system as a persuasive tool in promoting awareness of sustainable paddy farming practice.

For evaluation purposes, it can be divided into two parts, the Lab Experiment 1 and Lab Experiment 2. The lab experiment results can be divided into awareness and user interface satisfaction.

6.3.1 Respondent Profile of Lab Experiment 1

This part describes the background of respondents, which consists of information about gender, age, major area of study, experience in computer education package, experience with VR games application, and lastly experience in paddy farming.

A total of 56 students from the Department of Biological and Agricultural Engineering, Faculty of Engineering were selected randomly to answer the usability and awareness (knowledge and understanding) questionnaire. Out of the 56 responses received, six questionnaires were discarded because of missing and invalid answers. The experiment was conducted on the 8th of April 2010. Table 6.4 presents the demographic information of Lab Experiment 1 respondents.

Table 6.4 shows that 58% of respondents were female while 42% were male. The age range was from 21 to 25 years. Item 1.3 (Table 6.4) indicates the majority (78%) have used a computer education package, and Item 1.4 shows that the majority of respondents (84%) have experience in playing virtual reality computer games. As for personal experience in paddy farming, the vast majority (86%) indicated that they have no experienced in paddy farming.

Table 6.4: Demographic Information of Lab Experiment 1 Respondents

	Percents (%) (Respondents = 50)
1.1: Gender	
Male	42% (21)
Female	58% (29)
1.2: Age	
21	6%(3)
22	62%(31)
23	18%(9)
24	6%(3)
25	8%(4)
1.3: Have you ever used a computer education package?	
Yes	78% (39)
No	22% (11)
1.4: Have you ever played virtual reality computer games?	
Yes	84% (42)
No	14% (7)
No answer	2% (1)
1.5: Have you ever been involved in or worked as a paddy farmer?	
Yes	14% (7)
No	86 % (43)

6.3.2 Respondent Profile of Lab Experiment 2

For lab experiment 2, 13 respondents were selected from the Department of Biological and Agricultural Engineering, on the 5th of October 2010 to evaluate the prototype. The demographic information of Lab Experiment 2 respondents is summarized at Table 6.5.

Table 6.5: Demographic Information of Lab Experiment 2 Respondents

Topic	**Percents (%) (Respondents = 13)**
1.1: Gender Male Female	 53.8% (7) 46.2% (6)
1.2: Age 22 23 25 28	 30.8%(4) 7.7% (1) 53.8%(7) 7.7% (1)
1.3: Have you ever used a computer education package? Yes	 100% (13)
1.4 Have you ever played virtual reality computer games? Yes	 100% (13)
1.5 Have you ever been involved in or worked as a paddy farmer? Yes No	 30.8% (4) 69.2% (9)

Table 6.5 shows that 53.8% of respondents were male while 46.2% were female. It shows that all respondents were young with their ages ranging from 22 to 28 years. The result also shows that all respondent have used a computer education package and they have experience in playing virtual reality computer games. It also shows that the majority (69.2%) have no experience in paddy farming.

The focus group strategy was used in Lab Experiment 2, and the respondents (Figure 6.4) were interviewed in detail for their opinions and comments on the *SiPadi* system. The discussion sessions were carried out for two hours from 4:40 pm to 6:40 pm with a five-minute break. It can be divided into two parts, namely (1) pre test session and (2) post test session. The pre test session is the discussion held before using the prototype, while, the post test session was held after using the system. Upon completion of each session, respondents were asked to fill in the answers on the questionnaires. Questions raised during the discussion were the same questions in the questionnaires. The aim was to verify the respondent answers.

Figure 6.4: Respondents at Lab Experiment 2

6.3.3 Awareness Result

The first question was about the meaning of sustainable agriculture. The result shows 90% respondents in Lab Experiment 1 agree ‘that sustainable agriculture is the capability of a farm to sustain the production of its plantation while conserving the environment continuously’. During the post test session, 94% respondents agreed with that statement.

The second question 'Is the organic agriculture system a sustainable agricultural practice?' To this question, it was found that 32% of the respondents were not aware of organic practices as being part and parcel of sustainable agriculture. However, after the respondents had used this prototype (post test session), 90% of them agreed that organic practices are a part of sustainable agriculture. Similarly, information from respondents in Lab Experiment 2, only one respondent was not sure about organic practices after using the system. In conclusion, *SiPadi* has proven to be a learning tool to provide information and concepts of sustainable and organic farming.

As for their knowledge on the local environment and their awareness, the results show that 38% of the respondents from Lab Experiment 1, knew about sustainable programme in Malaysia before using the prototype (*SiPadi*). After *SiPadi* is used, their knowledge increased up to 64%. Similarly, Lab Experiment 2 result shows that only 23.1% of respondents knew about sustainable programme in Malaysia before using the system (*SiPadi*), and after using *SiPadi,* their knowledge increased up to 46.2%, therefore, the percentage of knowledge on local environment for example SOM and SLAM was not high and their awareness is not high.

Figure 6.5 shows the opinion of respondents in Lab Experiment 1 relating to the reasons why paddy farmers did not practice sustainable agriculture. The results are quite similar to the result of at Lab Experiment 2 as shown at Figure 6.6. In summary, using persuasive technology and VR technology in learning application can increase awareness among respondents. The result of prototype evaluation in this study is indicated in a similar study by Gustafsson, Katzeff and Bang (2009) and Sobihatun Nur (2010).

Figure 6.5: The Opinion of Respondents in Lab Experiment 1 Relating the Reason Why Paddy Farmer did not Practice Sustainable Farming

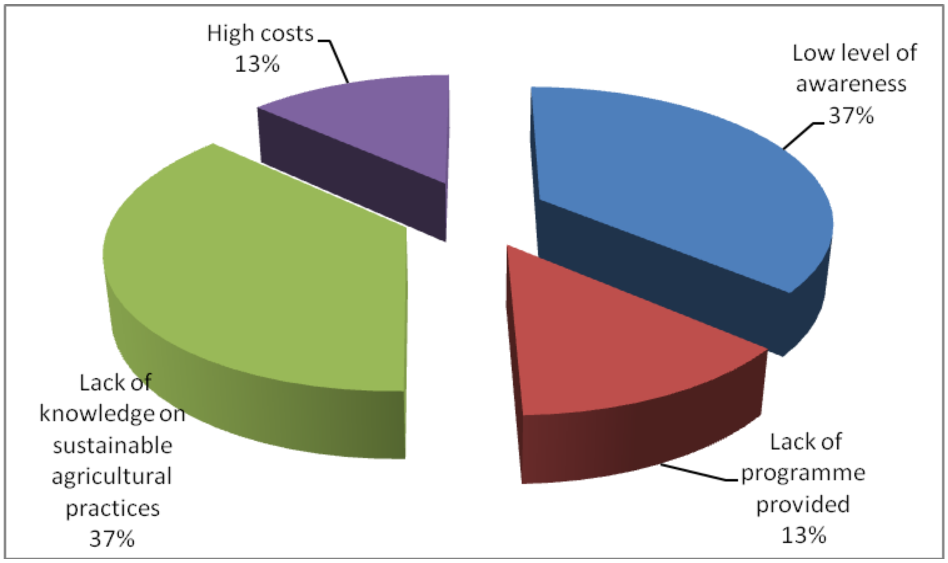
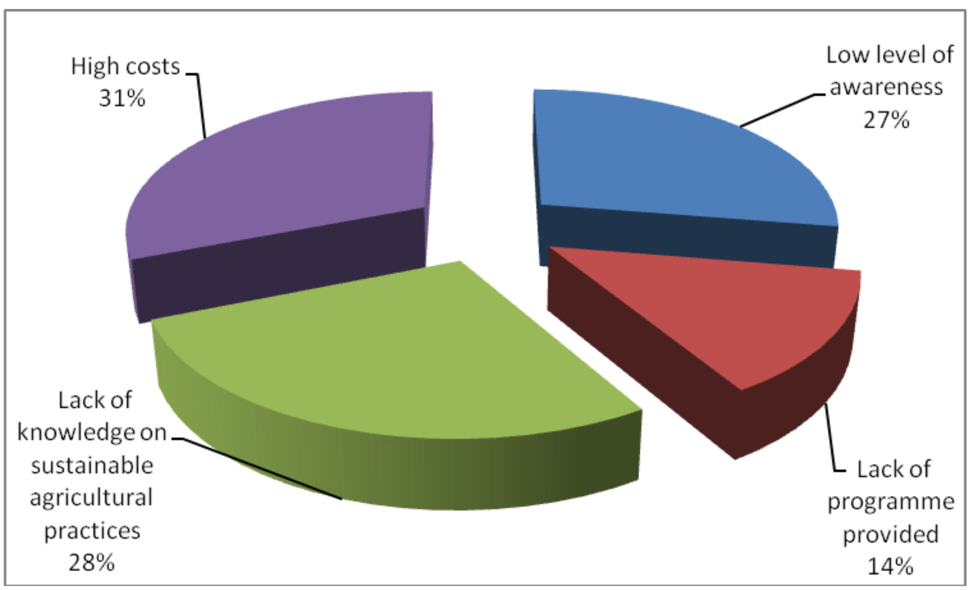


Figure 6.6: The Opinion of Respondents in Lab Experiment 2 Relating to the Reasons Why Paddy Farmers did not Practice Sustainable Farming



6.3.4 Post Test Discussion

This part reports on the interview to the respondents in Lab Experiment 2. During the interview, Respondent 13 stated that government campaign is a major influence in creating awareness among the public. Besides that, Respondent 12 stated that the cost factor must also be taken into consideration since changes from the conventional to the new practices involves cost and time.

In addition, the study also shows that the Lab Experiment 2 respondents agreed that the factors of demand from buyers and agriculture officer affecting farmers to change to plant organic crops. Besides that, Respondent 13 said that awareness should be there on the buyer. Another suggestion from Respondent 7 was that the government should set up model farm to educate the farmers.

Respondent 5 and Respondent 10 stated that the *SiPadi* system is appropriate for all ages so as to obtain general information about sustainable paddy farming. Respondent 13 said that the *SiPadi* design method is suitable for other sectors such as palm oil and others. Respondent 7 was of the view that '*SiPadi* suitable for the education sectors'.

The results show, more than 90% Lab Experiment 1 respondents understand the information in *SiPadi.* This is supported by Lab Experiment 2 respondents result.

6.3.5 User Interfaces Satisfaction

Table 6.6 and 6.7 show the analysis for the User Interface Satisfaction for Lab Experiment 1 and Lab Experiment 2 respectively.

Table 6.6: Mean of User Interface Satisfaction (Lab Experiment 1)

Dimension	**Mean (Scale 5)**
Overall Reaction to the Software	4.15
Screen	4.35
Terminology and Sytem Information	4.30
Learning	4.25
System Capabilites	4.21

The results show the highest score is for screen with mean of 4.35, and the lowest mean is for the overall reaction to the system. The mean value is 3.92. The result shows the average mean in Lab Experiment 1 and Lab Experiment 2. The result of summary of satisfaction Lab Experiment 2 user as follows:

Table 6.7: Mean of User Interface Satisfaction (Lab Experiment 2)

Dimension	**Mean (Scale 5)**
Overall Reaction to the Software	4.35
Screen	4.44
Terminology and Sytem Information	4.23
Learning	4.44
System Capabilites	4.10

The Lab Experiment 2 results show two items with the same mean (4.44). There are screen and learning. The lowest mean is system capabilities with the mean value is 4.10.

6.4 Respondents' Comments

Figure 6.7 lists the respondents' comments in Lab Experiment 1. Translation text from original document is in italic text. 75% of the respondents gave positive comments.

1. Alert signal should be more visualize. Refer game data, high graphic requirement.
2. *Well done and congratulations for the satisfactory work, hopefully everything you do succeeds well.*
3. Repair/upgrade the sistem.
4. Best.
5. First time and *impressive.*
6. Good and interesting.
7. *Explanation should be concise so easily understood by all levels of society.*
8. *The label on the main page too much. Should be further simplified. In the game, I only focus on the people (what I should do). After all this while I realize that left top screen shows what is happening. The positioning of the message is inappropriate.*
9. Ok.
10. *Amazing software but can farmers use them?*
11. *It needs to be improved.*
12. *Fun games.*
13. *I hope this system could be explained to farmers, so that practice sustainable agriculture could be implemented. Sustainable agricultural practices can reduce pollution.*
14. *Overall the system is very interesting and helpful to learn more but it takes time to upload.*
15. *Some users experienced dizziness when using the game.*

16. *This system is good.*

17. *This system is satisfactory and attractive.*

18. *This system should be exposed to not only university students but also to the public.*

19. *The system is interesting, to attract specific groups. Should be adjusted according to those who participate in or use the system.*

20. The system is a very good effort that can increase the knowledge among the farmer to apply the sustainable farming the future. I really believe one day the farming system in Malaysia will change.Good luck!

Figure 6.7: Respondents’ Comment (See Original Text at Appendix H, Part C)

6.5 Summary

In summary, usability results revealed that the learning prototype *SiPadi* has the potential to be a communication tool, particularly to be used in promoting sustainability and enhancing the level of awareness pertaining to its benefits. The result of identification study has been adapted in second research phase. It means, the actual practices in sustainable paddy farming has been used to design an education prototype (*SiPadi*) using multimedia and virtual reality software. Overall, *SiPadi* system provides useful information. This was reinforced by responses to the question of overall satisfaction with a mean of more than 4 out of 5. This indicates that this system could be used to provide new information to increase the awareness in terms of maintaining the environment.

CHAPTER 7

RECOMMENDATIONS AND CONCLUSION

7.1 Overview

This chapter presents a summary of the research findings. It will also examine the limitations of the study and make recommendations for future studies.

The purpose of this study was to design and develop an alternative solution to promote sustainability awareness, particularly sustainable paddy farming through ICT innovation. The study is organized into seven main chapters. The first chapter discussed the issue of sustainable agriculture and the objective of this research. In the second chapter, the literature review discussed issues related to sustainable agriculture focusing on organic, paddy and rice industry in Malaysia, sustainable agriculture in other countries, innovation and ICT application in learning about and promoting sustainability. The third chapter presented the methodology, while the fourth chapter discussed sustainability in paddy farming. This included the identification of organic practices. In chapter five, the discussion was on the design of the educational prototype and its evaluation. In chapter six, the evaluation finding was discussed. In this final chapter, a summary and conclusion of this study is presented, together with the limitations of the present work and the recommendations for future investigations.

7.2 Major Outcomes

The research has produced two major outcomes; (1) the identification of sustainable paddy farming practices in Malaysia; and (2) the design strategy and the instructional development model that lead to the development of sustainable paddy farming prototype. The following subsections discuss these two main outcomes.

7.2.1 Identification of Sustainability Paddy Farming Practices

The results indicate that sustainable agriculture in paddy farming is practiced in four locations, in phases of the management of paddy farming as shown in Table 6.2 previously.

7.2.2 Design Strategy of Prototype (*SiPadi*)

The successful development and the proven satisfaction performance of *SiPadi* in increasing sustainable agriculture awareness (in this case paddy farming) indicates the feasibility and appropriateness in this prototype. It can thus be used as a guideline in the design of other learning environments. The design strategy incorporated both the macro and micro strategy as illustrated in Figure 7.1.

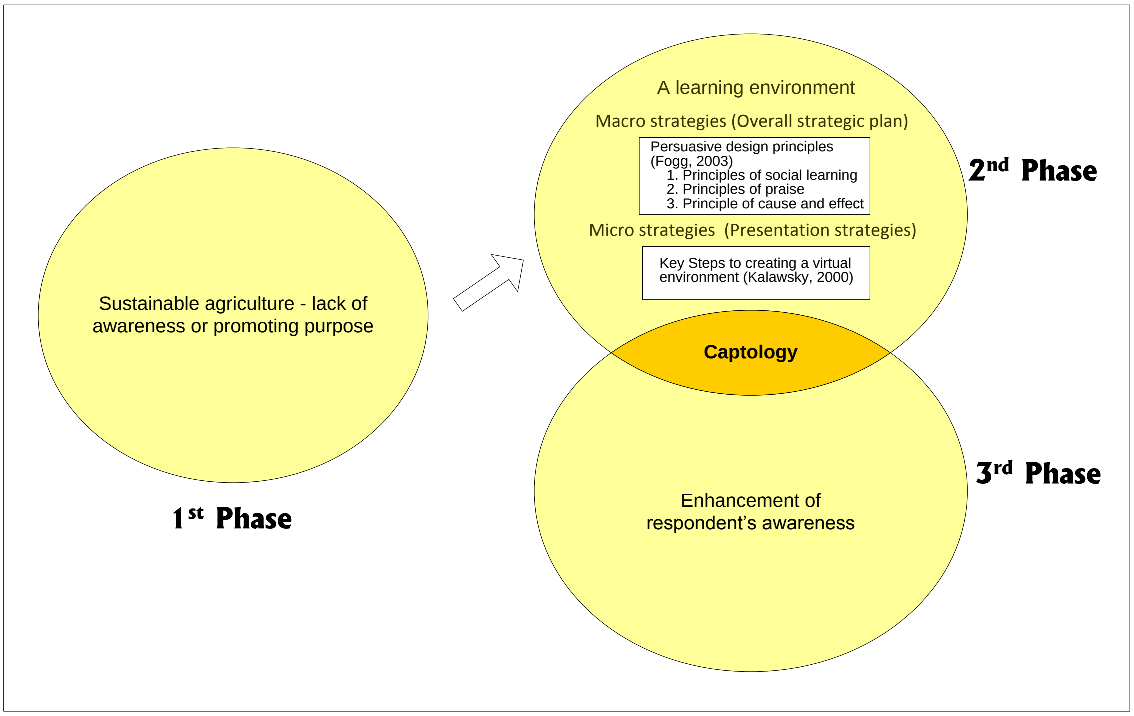


Figure 7.1: Design Strategy

7.2.3 Prototype Development

The completion of the design and development of the *SiPadi* proves the practicality of the Alessi and Trollip (2001) model; and of the steps involved in creating a virtual environment as proposed by Kalawsky (2000), to guide the instructional design process. There are three components in the Alessi and Trollip (2001) model: planning, designing, and development. Altogether, there are five steps to create a virtual environment, which are scene definition, object modeling, optional database conversion, virtual environment authoring and testing.

7.2.4 Evaluation of *SiPadi*

The usability results reveal that the prototype *SiPadi* has the potential to be a learning innovation, particularly to be used in promoting awareness regarding sustainable farming issues. At the beginning of the survey, it was found that 32% of the Lab Experiment 1 respondents were not aware of organic practices as being part and parcel of sustainable agriculture. However, after the respondents had used this prototype, 90% of them agreed that organic practice is a part of sustainable agriculture. The results of Lab Experiment 1 also indicated that 94% of the respondents agreed that this system (*SiPadi*) provided better understanding of organic paddy farming and 96% also stated the prototype has been successful in creating awareness among them. The feedback from Lab Experiment 2 was also similar to those obtained in Lab Experiment 1. For the descriptive user interface satisfaction analysis, the combination of Lab Experiment 1 and Lab Experiment 2 results as shown in table 7.1 reveal that the highest item scores at a mean of 4.40 and the lowest mean is overall system capabilities.

Table 7.1: Mean of User Interface Satisfaction

Dimension	**Mean (Scale 5)**
Overall Reaction to the Software	4.25
Screen	4.40
Terminology and System Information	4.27
Learning	4.35
System Capabilites	4.16

7.3 Implications of the Study

The five implications of this study are discussed below:

7.3.1 *SiPadi*: An ICT innovation in Enhancing Sustainability Awareness

This study has been successfully evaluated and experimented in University Putra Malaysia, and the results obtained has proven that *SiPadi* is a viable mechanism in helping university students to enhance their sustainability awareness. Besides that, *SiPadi* should be proposed in the future as a promotional tool to the Department of Agriculture, Malaysia to promote organic farming. It also can be used as a tool by the Department of Environment and the Ministry of Energy, Green Technology and Water for their sustainability promotion in the country.

SiPadi has also proven to be a successful ICT innovation in enhancing sustainability awareness through its recognition at the Malaysia Technology Expo (MTE) 2009; *SiPadi* was awarded a bronze medal (see Appendix K) and is being promoted to the public in the prestigious exhibition.

7.3.2 Sustainability

Organic agricultural practices aim at preserving nature. There are many reasons why sustainability practices ought to be encouraged. Research has proven that sustainable agriculture has many advantages such as cost effectiveness in reducing water consumption, balancing the ecosystem and being environmental friendly. It increases the resistance towards crop diseases and protects the soil and diversity of the organism. In addition, organic farming provides better quality food which tastes better, is safer and healthier.

This study made a significant contribution on the agricultural sector, in line with the objective of AgroMakanan Policies (2011-2020) which is to guarantee adequate and safe suplly of food for consumption (Kementerian Pertanian dan Industri Asas Tani, 2011).

7.3.3 Persuasive Technology: Feasible Design Strategy of *SiPadi*

SiPadi is a persuasive technology learning innovation presented via VR. It is a novel way to educate and promote the practice of sustainable agriculture. In this context, it was designed to be a persuasive learning tool in virtual paddy farming to promote sustainable paddy farming in Malaysia. Three persuasive principles were applied in this study, namely, principle of cause and effect, principle of praise, and principle of social learning.

7.3.4 Virtual Environment as a Design Strategy

Numerous researchers have discovered that VR learning offers many benefits that support a more authentic learning process. Futhermore, it is easier to use, understand and remember; provides greater flexibility and resourceful information; and more attractive and interesting**.** The study also used the most basic multimedia computer or laptop specification, 2D mouse and keyboard to play and navigate environment.

7.3.5 Value for Society, Environment and Economy

Learning applications such as *SiPadi* are powerful mediums which can generate and disseminate sustainability-related knowledge and practice aimed at creating awareness in environmental preservation, social justice, and economic prosperity.

7.4 Limitation of the Study

There were limitations in this research. Below are the limitations that were faced during this research.

Firstly, there are four locations visited in this study; only, the sustainable practice at Tanjung Karang was adapted for the virtual environment of this prototype. Sustainable practice in Tanjung Karang is quite similar in practices in Bandar Baru Tunjong. The study of other areas which practice organic farming enabled the researcher to understand the phenomena of real practice in paddy farming in Malaysia. Tanjung Karang was chosen because they are using SRI technique that has been proven to be greatly satisfactory in many countries. In addition, the team of SRI researchers from UKM also has good networking with the SRI pioneer, Professor Norman Uphoff from the Cornell International Institute for Food, Agriculture and Development.

Secondly, the prototype design only focused on SRI organic practices at Tanjung Karang. This includes the virtual environment and games development. Due to time limitation, and since the design and development of the prototype was time consuming, the services of an assistant was used for the development of the 3D modeling and animation.

This research is limited in its measure of the descriptive level of awareness of sustainable agriculture and usability satisfaction of prototype. Thus, the sample of the evaluation study was limited to students from the Department of Biological and Agricultural Engineering, Faculty of Engineering, University Putra Malaysia. In addition, the researcher has difficulty in providing lab and computer equipment suitable for evalution a prototype *SiPadi*, especially to farmer. Therefore, university students had to be used as respondents as they will graduate in the agriculture and technology sector.

The sample of the evaluation study was limited to the three sessions, with different students. Apart from that, a pilot test, Lab Experiment 1 and Lab Experiment 2 were conducted. In Lab Experiment 2, the session was conducted as a focus group. The discussion was conducted to support Lab Experiment 1. All respondents were open to ask questions or give suggestions without time limitation.

7.5 Recommendations for Future Investigation

This study has raised several interesting issues that warrant further research. Firstly, there should be more of design and development of various types of persuasive technology integrated with VR learning environment based on the proposal model. Early responses to the *SiPadi* prototype revealed that it is promising in creating sustainability awareness among various stakeholders in paddy farming which later on can be extended to other agricultural sectors such as palm oil, rubber, and cocoa.

Second, this study is limited to measuring the descriptive level of awareness and usability satisfactory of students. For a longitudinal study, an alternative research design might be applied to enhance the measurement of the awareness and acceptance of sustainable paddy farming. This includes technology transfer and technology adoption research.

Thirdly, the sample of the study was limited to Department of Biological and Agricultural Engineering students, Faculty of Engineering, University Putra Malaysia. Hence, it is recommended that future investigations should consider the primary and secondary school students in order to establish the advantage of using *SiPadi* in enhancement awareness in sustainable agriculture in an early age.

This study has shown that ICT innovation in the learning environment prototype can be used to educate the public about sustainability practices. However, other factors such as good perceptions (Bagheri *et al.*, 2008); interactive and cooperation between farmers; government, research institution; and the role of the policy-maker are important factors in achieving sustainable agriculture (Murad *et al.*, 2008; Sharghi *et al.*, 2010). As such, further research could generalize the results to a larger sample. For future work, more research regarding sustainability awareness to promote clean and green sustainability issues can be carried out.

7.6 Conclusion

In summary, three general conclusions can be drawn from the present study. First, sustainability in paddy farming, secondly the design and development of prototype and lastly, using the learning prototype to support the awareness process.

The focus of the study was to promote sustainability awareness through ICT innovation. The finding also shows that paddy farmers in the four selected locations have employed sustainable paddy farming in certain stages. The SRI organic was chosen and the real life practices of sustainable farming were adapted in the design of the prototype. For evaluation purpose, the usability results revealed that the learning prototype has the potential to be an education tool, particularly to be used in promoting sustainable issues and enhancing the level of awareness in sustainability. For the descriptive user interface satisfaction analysis, the lab experiment results shows all major item stands at a mean of above 4 of 5.

Besides that, this study proves that ICT innovation has developed to the point that it can be used as medium of simulation which generates and disseminates sustainable agricultural knowledge for environmental, social and economic sustainability. Sustainable agriculture has an important role to play in improving the quality of human lives and the environment. Hence, technology should be used to facilitate sustainable practices in farming activities. This study can be deemed as a tangible benefit which and education purpose to enhancement sustainability awareness. Moreover, the study has proven that ICT innovation can be used as alternative strategy to educate and promote sustainability practices to the public.