Interface Design in Interactive Science Courseware for the Malaysian Smart School Project

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Abstract

With the goal of improving the academic performance of primary and secondary students in Malaysia by 2020, the Malaysian Ministry of Education has made a significant investment in developing a Smart School Project. The aim of this project is to introduce interactive courseware into primary and secondary schools across Malaysia. As has been the case around the world, interactive courseware is regarded as a tool to motivate students to learn meaningfully and enhance learning experiences. Through an initial pilot phase, the Malaysian government has commissioned the development of interactive courseware by a number of developers and has rolled this courseware out to selected schools over the past 12 years. However, Ministry reports and several independent researchers have concluded that its uptake has been limited, and that much of the courseware has not been used effectively in schools. This has been attributed to weaknesses in the interface design of the courseware, which, it has been argued, fails to accommodate the needs of students and teachers.

Taking the Smart School Project’s science courseware as a sample, this research project has investigated the extent, nature, and reasons for the problems that have arisen. In particular, it has focused on examining the quality and effectivity of the interface design in facilitating interaction and supporting learning experiences. The analysis has been conducted empirically, by first comparing the interface design principles, characteristics and components of the existing courseware against best practice, as described in the international literature, as well as against the government guidelines provided to the developers. An ethnographic study was then undertaken to observe how the courseware is used and received in the classroom, and to investigate the stakeholders’ (school principal, teachers and students’) perceptions of its usability and effectivity. Finally, to understand how issues may have arisen, a review of the development process has been undertaken and it has been compared to development methods recommended in the literature, as well as the guidelines provided to the developers.

The outcomes of the project include an empirical evaluation of the quality of the interface design of the Smart School Project’s science courseware; the identification of other issues that have affected its uptake; an evaluation of the development process and, out of this, an extended set of principles to guide the design and development of future Smart School Project courseware to ensure that it accommodates the various stakeholders’ needs.
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Dila Kamaruddin,
BRISBANE
I would like to dedicate my research thesis to my two little boys:

**AMIR and AIRELL**

And hope that this would inspire them to greater heights in their lives.

“The journey of a thousand miles begins with the first step”
Statement of Original Authorship

I declare that this thesis entitled “Interface Design in Interactive Science Courseware for the Malaysian Smart School Project” is the result of my own research except as cited in the references.

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution.

To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

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1. Introduction to the research project

During the past two decades, Information and Communication Technology (ICT) and multimedia-based learning have begun to play an important role in classrooms. The benefits of this technology have been noted by scholars who acknowledge that computer software and the Internet provide a great potential to make learning processes more accessible (Segers, 2002), more engaging (Beuschel, Gaiser & Draheim, 2003) and more interesting (Cawkell, 1996; Flew, 2002; Gauss & Urbas, 2003; Harry & Khan, 2000). In line with this, interactive courseware has been adopted as an effective learning tool to motivate students to become active participants in the teaching and learning process (Burgess, 2003) and to improve students’ learning performance (Raisinghani, 2003). To take advantage of the potential that ICTs offer, many educators, including those in developing countries, have chosen to use interactive courseware in various levels of education (primary, secondary and tertiary).

Inspired by this understanding that computer technology and multimedia-based learning can improve the performance of teachers and offer pedagogical benefits by improving students’ learning abilities, attitudes and achievements, the Malaysian Government has also incorporated ICTs into the Malaysian education system. 1998 saw the launch of the Smart School Project (locally known as the Sekolah Bestari), with 89 schools involved in a pilot program across the country (Malaysian Ministry of Education, 2004; 2006b). The explicit goal of this program is to provide interactive teaching and learning materials to enhance teaching performance and improve students’ learning outcomes (Malaysian Ministry of Education, 2006). The eventual goal is to transform a further 10,000 primary and secondary normal schools in Malaysia into Smart School status by the year 2020 (Malaysia Ministry of Education, 2004).

Under the Smart School Project, there are three different types of Smart School. Schools are categorised as a new Smart School, a state Smart School, or a remote Smart School. Categories are depends on the school’s background, facilities and infrastructure. A new Smart School is provided with a high level of technology and equipment, a state Smart School is provided with a medium level of
technology and equipment, and a remote Smart School is provided with a minimal level technology and limited equipment. That is, students at a new Smart School receive a mini laptop per person, while remote Smart Schools are supplied with a handful of shared computers in a computer lab. The government also supplies a laptop to all teachers involved in the pilot project, to provide an incentive for them to implement computer technology in their teaching and learning and thereby ensure that project delivers benefits to Malaysian education (Malaysian Ministry of Education, 2008; Multimedia Development Corporation, 2007; Rohana, 2006).

Various types of interactive learning materials have been introduced into primary and secondary education classes in Malaysia as part of the Smart School Project. This includes stand-alone interactive courseware such as CD-ROMs; browser-based teaching and learning materials, such as online tutorials provided through a web portal called BestariEd; and a joint program in collaboration with overseas schools called My School Net (Azizah & Rohani 2005; Malaysian Ministry of Education, 2006). In line with this, many private companies in Malaysia have invested in collaborating with the government (through the Malaysian Ministry of Education) to produce stand-alone interactive courseware. Out of this collaboration, 1494 titles have been developed so far. Involving key learning domains, namely Bahasa Melayu (Malay language), Mathematics, Science and English, they have been distributed across the Smart School Project in Malaysia (Malaysian Ministry of Education, 2006, 2008; Multimedia Development Corporation, 2007).

To date, the interactive courseware has had the greatest uptake in Smart Schools in Malaysia (Malaysian Ministry of Education, 2008) because of its capacity to present educational content (Rohana, 2006) and because it is believed to be a suitable tool for presenting rich media environments to allow students and teachers to work collaboratively (Malaysian Ministry of Education, 2004; 2006; 2008). For this reason, the courseware is the focus of this study.

1 BestariEd is a web portal that was developed by the Malaysian Education Ministry in cooperation with private companies. This portal contains learning aids and materials and can only be accessed by selected schools.

2 MySchoolNet is a website set up by the Malaysian Education Ministry to provide links to educational information worldwide. The key feature in this website is the provision of interactive communication between Malaysian school children and students from other countries.
1.1 Background to the research problem

After several years of producing interactive courseware, and implementing it through the *Smart School Project*, evaluations of the level of uptake and utilisation were conducted between 2003 and 2008. Unfortunately, this research indicates that the courseware is under-utilised. Research by the Education Technology Division of the Malaysian Ministry of Education in 2006 found that 60 percent of the 86 *Smart Schools* surveyed do not fully utilise the interactive courseware that has been provided to them (Malaysian Ministry of Education, 2006). This finding is also supported by research conducted by Zaitun (2006) and Shiong et al. (2008), who have similarly found that much of the courseware is rarely used in teaching, and that the frequency of courseware usage overall is limited.

Several studies that have primarily focused on the effectiveness of the interactive courseware have also noted similar patterns of uptake and usage (Malaysian Ministry of Education, 2008; Multimedia Development Corporation, 2007; Shiong et al., 2008). These studies have evaluated teacher preferences, and the needs of students in the *Smart School Project* in Malaysia. The results indicate that a range of factors have impacted negatively on courseware uptake and use. This not only includes a lack of available technology (Jowati, 2005) but also includes the attitudes of students and teachers, based on the perceived quality of the interactive courseware (Malaysian Ministry of Education, 2006; 2008; Multimedia Development Corporation, 2007). Indeed, a study by Zaitun (2006), which focused on the perceptions of teachers, concluded that some of the lessons in the courseware do not adequately meet the needs of end-users, especially teachers.

These studies have largely conclude that the limited uptake of the courseware can be attributed to deficiencies in the interface design in accommodating the needs of students and teachers and that problems with the interface design have resulted in poor interactivity (Habsah et al., 2006; Kamariah, 2006; Zaitun, 2006; Malaysian Ministry of Education, 2006; Multimedia Development Corporation, 2007; Shiong et al., 2008).
Specific interface design issues have been highlighted by some researchers. For example, Baharuddin et al. (2006) have indicated that the interfaces in current courseware do not encourage students to use the courseware, or to stay long in front of it. Habsah et al. (2006) and Shiong et al. (2008), both have argued that this is because the current interfaces have limited interactive features and fail to attract the attention of students. Others have argued that interface design issues cause poor user interaction and fail to encourage students’ participation and engagement with the courseware (Lee, 2000; Malaysian Ministry of Education, 2006; Multimedia Development Corporation, 2007). The most recent review of the interactive courseware in 2009 concluded that some of the content is too long or too short and that some content includes no multimedia components (Goi & Ng, 2009).

These issues are particularly notable in the courseware for science subjects that are delivered in the Malaysian Smart School Project. In particular, a report by the Multimedia Development Corporation in 2007 stated that it does not provide enough instructional information for the students to understand and use it (Multimedia Development Corporation, 2007). And a comprehensive study on the interactive science courseware conducted by Kamariah (2006) concluded that some of the simulations in the courseware do not reflect real lab scenarios, such as safety drills. Two reports by the Ministry of Education suggest that such issues affect students’ learning outcomes and academic achievement, particularly in primary school (Malaysian Ministry of Education, 2006; 2008).

The broad international literature on interactive courseware explains that an effective learning experience is achieved when students are engaged and involved in the learning activities (Biggs, 2003; Sambrook, 2003) and that interactive courseware should therefore motivate students to learn by encouraging them to actively participate (Mayer, 2001). That is, it should enhance the learning experience by facilitating users’ interaction and experience.

While it has been argued that the level of engagement and courseware use depends on teachers’ and students’ attitudes towards the interactive courseware and its implementation (Malaysian Ministry of Education, 2004; 2006; Puteh &
Hussin, 2007), it can be concluded from the above that the end-users of the existing interactive courseware (both teachers and students) are not completely satisfied with the interface design of the current interactive courseware available in Malaysia and this contributes to the formation of such attitudes. It can therefore be said that much of the interactive courseware that has so far been developed for the Smart School Project in Malaysia has been developed without properly considering key factors relating to the various interactions between students and the courseware, the students and teachers, and between students.

While most international researchers recognise the value of interactive courseware in educational settings, there has been ongoing debate about aspects of its effectiveness in improving the quality of learning experiences in primary education. For example, various studies have been conducted to compare its value relative to traditional media in educational settings (Beuschel, Gaiser, & Draheim, 2003); the advantages and disadvantages of using interactive courseware (Beuschel et al., 2003; Burgess, 2003; Cawkell, 1996; Flew, 2002; Harry & Khan, 2000; Keegan, 2000; Loeding, 2002; Radford, 1997; Raisinghani, 2003); its overall effectiveness (Loeding, 2002); its effects (Eveland, 2003); the relationship between the use of interactive courseware and academic performance (Kubey, Lavin & Barrows, 2001); and the needs of students in using interactive courseware (Beuschel et al., 2003).

It has been established that various factors influence its effectiveness, which range from the availability of the necessary technology (Cantoni, Cellario & Porta, 2004; Council for Higher Education Accreditation, 2002; Kubey, Lavin & Barrows, 2001), accessibility (Baharuddin et al., 2006); interaction design (Clark, 2001; Fresen, 2005; Wagner & Kozma, 2005); and interface design (Meyer, 2002). In particular however, the uptake and effectiveness of the interactive courseware depends on aspects of interface design and the extent to which it accommodates students’ needs (Thurmond, Wambach, Connors & Frey, 2002), encourages students’ interaction (Yang & Cornelius, 2004) and contributes to an effective interactive learning experience (Kubey, Lavin & Barrows, 2001). And, it is broadly accepted that poor interface design and interactivity affect user interaction and can diminish the learning experiences of users.
The international literature has therefore established that the design of interfaces for interactive courseware needs a systematic process and must be executed by a skilled development team (Buzhardt, Abbott, Greenwood, & Tapia, 2005; Galitz, 2002; Nielsen, 2000) and that it must above all involve consideration of the end-user needs (Hinostroza & Mellar, 2001; Norman, 2002) to ensure the uptake and effectiveness of the interactive courseware. In particular, when developing interactive courseware, developers must consider the following factors: the interface design must support interactivity and individualised learning among users; the layout and display of the interface must be suitable and appropriate for the end-users; and the instructions must strategically facilitate learning.

However, a study by Thang et al. (2009) in Malaysia, points to the fact that while the Malaysian Ministry of Education provides guidelines that can be related to those established in the international literature, some of the courseware developers have not properly followed the design guidelines and instructional design strategies that were provided to them.

### 1.2 Research problem

The results of the above-mentioned studies and the latest survey results by the Malaysian Ministry of Education suggest that the interactive courseware that has been developed for the Smart School Project in Malaysia often fails as a tool for teaching and learning. This failure is largely attributed to poor interface design. However, no study has yet been published that contains an empirical analysis that clearly explains the claims made about the deficiencies of the interface design, and details the reasons for them arising.

Because the problems with the courseware have been largely attributed to deficiencies in the interface design, this research project has focused on that aspect of the courseware. It has sought to investigate the validity of claims surrounding the deficiencies in the interface design of the interactive courseware that has been developed for the Malaysian Smart School Project and to understand the reasons for them. It has involved a content analysis to compare the interactive courseware against a range of interface design principles established in the
international literature, as well as against the Malaysian government development guidelines. It has evaluated the reception of the interactive courseware through empirical analysis of the level of uptake, engagement, effectiveness, and barriers of use for the end-users by observing and evaluating the use of the courseware in the context of the classroom and by interviewing school principals, teachers and students. The perspectives of the courseware developers have also been considered through a series of interviews.

Following these steps, this study has sought to clarify the extent and specific nature of issues surrounding the courseware, as well as reasons for any identified failures of the interface design in facilitating the process of interaction between end-users (teachers and students), and accommodating their needs in the teaching and learning process.

1.3 Research aims and objectives

While the main aim of this research project has been to critically investigate the extent, nature and reasons for problems in the interface design within the existing interactive courseware in the Malaysian Smart School Project, the objective of the research has been to establish a revised set of effective interface design principles and practical guidelines for future courseware development. Both the resulting principles and practical guidelines will be made available to the Malaysian Ministry of Education and courseware developers for consideration in future development of interactive courseware in Malaysia. It is anticipated that, by addressing the needs of all stakeholders (the Ministry, courseware developers and the end-users), these outcomes will serve to improve the interface design of future courseware and so enhance students’ interaction and overall learning experiences in Malaysian classrooms.

1.4 The scope of study

This research project focuses on the interface design of interactive courseware in the Malaysian Smart School Project. Although other multimedia software products are used in teaching and learning at schools in Malaysia currently, this study has focused specifically on the interactive courseware. Interactive
courseware is defined as academic software available via stand-alone CD-ROM, which contains structured lessons and exercises and combines text, sound, video, and images to achieve particular learning outcomes. Other types of e-learning materials available via the Internet are not included in the scope of this study.

Because recent reports by the Malaysian Ministry of Education have established that the highest level of user dissatisfaction in the Malaysian Smart School Project is with the interactive Science courseware (Malaysian Ministry of Education, 2008), this study has focused specifically on this interactive courseware as a sample.

The study provides an analysis of the courseware itself, as well as how the courseware is actually used in classrooms, and how it was developed. To do this, several schools have been involved in the study as a representative sample of the Malaysian Smart School Project. Other types of school populations that exist in Malaysia were not included because they are not involved in the pilot Smart School Project and differ in several regards, such as school facilities, infrastructure and access to the courseware. A number of courseware developers have also been involved in the project as a limited, representative sample.

While the interactive courseware that is the focus of this study is used in educational settings and its interface design affects learning experiences, this study has focused on examining the interface design against established interface design theories rather than educational theories. It approaches interface design as a medium of communication in delivering content, encouraging user interaction and enhancing user learning experiences. That is, the perspective of the study focuses on the effectiveness of the interface design principles and characteristics in terms of accommodating, facilitating and enhancing students and teachers needs and experiences. Thus, the evaluation has not focused another educational issue such as differences in learning styles or individual differences in learning activities, which are beyond the scope of this study.
1.5 Research questions and sub-questions

The main research question of this study is:

**To what extent does the interface design in the current interactive Science courseware that has been developed for the Malaysian Smart School Project accommodate user needs and facilitate user interaction and so support the overall learning experience; and how it might be improved?**

This leads to four specific sub-questions. They are:

**Research Question 1:** What interface design principles established in the international literature are echoed in the Malaysian government guidelines, and are they evident in the current interactive Science courseware?

*Investigative questions:*

1) What principles and characteristics for effective interface design are recommended in the international literature?

2) Are the principles, characteristics and components suggested in the international literature evident in the Malaysian government guidelines? And are the government guidelines comprehensive or overly broad?

3) Are the principles, characteristics and components outlined in the Malaysian government guidelines evident in the sample of interactive Science courseware?

**Research Question 2:** How do the users (school principals, teachers and students) of interactive Science courseware for the Malaysian Smart School Project interact with the courseware and how do they perceive it?

*Investigative questions:*

1) How frequently is the courseware used in schools, and are there any barriers such as infrastructure, staff skills and so on?

2) How do the school principals and teachers perceive the courseware? Do school principals encourage the use of the courseware in their schools? How do they and the teachers compare its value against traditional teaching and learning methods?
3) How easily do the students and teachers interact with the interactive Science courseware and are any obstacles to engagement encountered through the interface design?

4) Do the interface design components in the existing interactive Science courseware effectively facilitate students and teachers interaction? If so, how does this happen? If not, what obstacles are encountered?

**Research Question 3:** How has the interface design of the existing interactive Science courseware been developed and has this contributed to the quality of the interface design?

*Investigative questions:*

1. What methods and processes are recommended in the international literature for interface design production and software development?

2. What are the processes recommended in the Malaysian government guidelines and how do they compare to the international literature?

3. Do the courseware developers follow the Government guidelines and/or the international literature?

4. What relationships exist between the main stakeholders - the ministry, the developers and the schools?

This leads to the question relating to the objective of the study, namely:

**Research Question 4:**

Drawing on the review of the international literature, the Malaysian government guidelines, and a content analysis of the current interactive Science courseware, as well as the observed and reported experiences of end-users (students and teachers) within this research study; what principles, characteristics and development guidelines can be recommended for future interactive Science courseware in Malaysian education?

*Investigative questions:*

1. Are there any aspects of the design process in the current framework that can be changed to benefit the various stakeholders including the end users?
In response to these research questions, this PhD project consists of an exploratory research study into the strengths and weaknesses of the interface design of interactive courseware developed for the Malaysian Smart School Project. In response to claims made by previous researchers in Malaysia (for example, Baharuddin et al., 2006; Shiong et al., 2008) and a report by the Ministry of Education (2008), which state that interface design of the current interactive courseware has failed to adequately accommodate the needs of students and teachers, this investigation has examined the quality of the design of the existing interactive courseware, with particular emphasis on the interface design and the experience of the courseware by end users. It has then gone on to investigate why issues may have arisen by investigating the development process against recommended guidelines and international approaches to software development.

1.6 Overview of the thesis

This thesis is divided into eight chapters, namely: (1) Introduction to the research project, (2) Theoretical Background, (3) Approaches to the research: Methodology and methods, (4) A comparison of the Malaysian Smart School Project courseware with international interface design principles and government guidelines, (5) Evaluating the courseware in use: Outcomes of the fieldwork, (6) Understanding the design of the interface as part of the software development process, (7) Proposed framework for the Malaysian software development processes and extension of the current guidelines and finally, (8) Conclusion and recommendations for future work.

In brief, Chapter 1, Introduction has provided an overview of the context and background of the research project, as well as the project’s rationale. It has outlined the research problem and questions and identifies the purpose and objectives of the research project. It has also defined the scope of the study.

The context of the project is discussed in detail in Chapter 2. It provides an overview of educational learning systems and the use of interactive courseware in
the learning process through reference to international studies and the Malaysian context. Then, the complexities associated with the interface design of interactive courseware are discussed, including how interface design impacts upon user interaction, influences the learning process, and affects learning experiences. The context of the current research project is outlined at the end of this chapter.

Chapter 3 explains the methodology used, and the rationale for the use of methods drawn from ethnography is provided. Both the strengths and weaknesses of each method are described in detail. This chapter then elaborates on how the research project was planned and conducted. It describes the research design by explaining the research sampling and the research settings that were involved in this research project, the types of qualitative methods used for data collection and the analysis procedure. Finally, some ethical issues are considered.

Chapter 4 presents the data collected through the multi-method approach. It is divided into four main sections. After presenting the rationale for the data collection, the second section provides an explanation and comparative analysis of the data collected through analysis of interface design principles gathered from the literature and the guidelines set by the Malaysian government. The third section presents the data gathered through a content analysis of the interactive Science courseware. The fourth section describes a comparative analysis of the courseware against Ministry guidelines and the international literature. A summary of the data and the relationships identified between the data sets is provided at the end of this chapter. This provides the basis for a comparative analysis of the interface design principles, characteristics and components identified in the international literature, the Ministry guidelines and the existing courseware. The outcomes of comparative analysis are then discussed in terms of the strengths and deficiencies of the interface design within the courseware.

Chapter 5 focuses on the findings of the fieldwork and provides an analysis of the interface design in use. It presents the data collected through surveys and field studies, which focus on how the courseware is currently being used in classrooms, and the perceptions of school principals, students and teachers as end-users. A rationale for the fieldwork within real contexts is provided, as well as details of
the participants involved. A discussion on the interviews with school principals and teachers establishes the frequency of courseware use in the classroom and reasons for the level of uptake. Then, the data gathered through classroom observations is presented and discussed, followed by data gathered through focus group discussions with students and interviews with science teachers. This leads to conclusions on how the interface design affects the level of students’ interaction and the overall learning experiences.

The investigation into why issues have arisen in the development process in Malaysia is reported in Chapter 6. A comparative analysis of the software development process that is recommended in the international literature against the Ministry guidelines provided to Malaysian developers is presented. This is followed by a comparison with the actual development processes, based on information obtained from face-to-face interviews with the courseware developers, school principals and teachers. This chapter also discusses how the current development practices affect the quality of interface design and it outlines some alternative models of software development and design.

Based on these findings, a new framework for the software development process and supplementary guidelines for interface design production in the Malaysian context are proposed in Chapter 7. These are based on the needs, concerns and recommendations of the three main stakeholders; namely the Ministry, developers, teachers and students. The resources provided are designed to be used by the Ministry and courseware developers for future courseware development in Malaysia.

The final section of this thesis (Chapter 8) provides conclusions. It consists of a summary of findings from the different data sources, then all the findings are brought together to summarise the overall research findings and the conclusions drawn from this research study. This chapter also elaborates on the limitations of the study and its theoretical and practical implications. Finally, this chapter discusses recommendations for further research by articulating potentially beneficial lines of enquiry.
2. Theoretical Background

2.1 Introduction

As outlined in the Introduction, this project consists of an exploratory research study into the strengths and weaknesses of the interface design of interactive courseware in the Malaysian Smart School Project. In response to claims made by previous researchers in Malaysia (see for example, Baharuddin et al., 2006; Shiong et al., 2008) and a report by the Ministry of Education (2008), which state that the interface design of the current interactive courseware has somewhat failed to accommodate the needs of students and teachers (as end users) and encourage interaction, this investigation examines the quality of the existing interactive courseware, with particular emphasis on the interface design and the experience of the courseware by end users.

There is a growing body of literature in the field of computer-based learning, e-learning and multimedia-based learning. There is also a large and established body of literature on interface design and interaction design. There is also a body of literature (albeit a much smaller one) that focuses on these issues in relation to the quality of learning experiences in the Malaysian context. This chapter will ground the current study by providing an overview of the broad literature on interface design and its importance in interactive courseware. This will provide a critical perspective on the importance of interface design for ensuring the effectiveness of users’ interactions and overall learning experiences in interactive courseware. Following this broad overview, a review of the literature in the context of Malaysia will narrow the focus to a local context.

2.2 E-Learning and interactive courseware

E-learning is commonly defined as an approach to teaching and learning that includes the use of electronic or computer technology to access and interact with learning materials (Davis, 2001). Some theorists, such as Fry, (2000) are more specific, defining it as a form of training or education that incorporates
interactivity with various electronic media. Other scholars have defined it more narrowly, as a process of teaching and learning that is specifically related to the Internet and World Wide Web (Bates, 2005; Clark & Mayer, 2003; Colvin & Mayer 2008; Roffe, 2002; Sambrook, 2003, Schank, 2003; Tsai & Machado, 2002). However for the purposes of this study, it is defined by the common use of the term as the use of various interactive media to achieve learning goals. It includes various technologies and ranges from providing classroom access to information via the Internet, to context specific electronic learning materials delivered via standalone CD-ROMs installed in computers at schools.

The later is the focus of this study. It is generally referred to as interactive courseware (Clark & Mayer, 2003; Lee & Sullivan, 1996; Mayer, 2001), which can be described as computer software that incorporates educational material intended as kits for teachers or as tutorials for students. It is comprised of combinations of multimedia components such as animation, sound and graphic images that provide learning materials and can accommodate students with different learning styles (Shamsiah, 2004).

Advances in both online and stand-alone software technologies have enabled courseware developers around the world to deliver innovative educational programs to students, and the uptake of E-learning has expanded substantially over the past decade. By 2002, it was estimated that 55% of education programs worldwide included some form of computer technology (Elearnframe, 2002). Since then, many more students and teachers have adopted the use of computer technology in educational settings (Akar, Öztürk, Tunçer & Wiethoff, 2004; Githens, 2007; Repetto & Trentin, 2008).

These new approaches to education have altered the way it is being delivered. The benefits of interactive learning have been long established. As far back as the early 1990’s Funkhouser (1993) and Henderson (1992) argued that the use of interactive courseware in teaching and learning can help students understand principles and concepts more effectively and Khoo and Lou (1995) suggested that the use of interactive multimedia products in teaching and learning can strengthen the learning process and improve students’ performance. Many claims have since
been made about the effectiveness of interactive courseware to help students gain more knowledge (Alessi & Trollip, 2011; Hoon, Chong & Binti Ngah, 2010), to motivate students to learn meaningfully by engaging them more in their learning process (Mayer & Moreno, 2002), to enable students to learn more in a shorter time (Weiss, 1993), to improve students’ learning outcomes and performance (Clark & Mayer, 2003; Gauss & Urbas, 2003; Jonassen et al., 2003; Sambrook, 2003), to enhance students’ commitment (Balinsky, 2006; Rashthy, 2003), and to help students build new knowledge and skills related to learning goals.

Other studies on the acceptance of interactive courseware in education have found that it can help to motivate students to participate more in the learning process (Bradler, 1999; Hunt & Ivergard, 2005; Wan Ng & Gunstone, 2003; Nugent, Soh, Samal & Lang, 2006). Most importantly, Lee (2000) has argued, students become more responsible and spend extra time in their learning activities through the use of interactive courseware. Others have concluded that participation in a technology-rich environment has a positive impact on students’ performance in all subject areas (Khalili & Shashaani, 1994; Perez-Prado & Thirunarayanan, 2002). In line with this, measurements have been made to evaluate what Schank (2003) describes as ‘learning gains’, which evaluate student performance and the effectiveness of interactive courseware and E-learning systems more broadly.

Some scholars have focused on specific reasons for such accomplishments. For example, Koory (2003) has argued that interactivity with learning content helps to improve users’ understanding. Wu, Tennyson and Hsia (2010) have argued that the learning process can become more lively and fun for teachers and students when computers are used in the process of teaching in classroom. And a study by Mason and Rennie (2004) has argued that effective interactivity through interactive courseware in E-learning helps users to gain more a in-depth understanding of the content. Others have argued that the personalized feedback and consistent messages provided with computer-based materials assists students in the learning process and some argue that they allow a student to set his or her own pace of learning. As such, a student that is a fast learner can forge ahead at a pace that an average student would not be able to manage. Thus, combining
traditional classroom training with E-learning tools can produce a powerful combination for long-term success (Sambrook, 2003).

On the other hand, some scholars have differed and have argued that there is not necessarily a significant difference in performance between students who are supported by computer technology and those who learn through conventional classroom methods (Abraham, 2002; Dykman & Davis, 2008; Piccoli, Ahmad, & Ives, 2001). White and Weight (2000) have claimed that learning by using interactive courseware cannot replace the traditional teaching and students’ learning style in the classroom. Clearly, interactive courseware itself can never completely replace teachers because teachers are necessary to assist students in the learning process (Schwier & Misanchuk, 1993). It should be noted however, that the basic objective of interactive courseware is not to replace the teacher, but it does change the teacher’s role. Stolterman (2008) indicates that the effectiveness of interactive courseware in the classroom is not guaranteed if teachers use it simply as a support tool. Teachers, he argues, need a solid understanding of the nature of interactive courseware itself, and to understand and embrace its potential. He further highlights that when the teacher uses the interactive courseware to teach their students in the classroom, it is important for them to have some knowledge about how interactive courseware, particularly the interface design of interactive courseware helps students to learn better (Beuschel, Gaiser & Draheim, 2003).

Because E-learning necessitates a new style of teaching and learning, a large number of studies have investigated the problems associated with making it part of the teaching process. This includes the need for teachers to assume different teaching methods to those used in traditional teaching (Bonk, Wisher, & Lee, 2004). Thus, while most studies on the level of teachers’ acceptance of courseware found that it has a positive impact on their decision to use computers in the classroom (Smerdon et al., 2000; Yuen & Ma, 2002), this may lead to resistance among teaching staff (Pegler, 2005). Teachers’ and students' attitudes toward interactive courseware, as well as the effective integration of learning materials into the curriculum, are therefore identifiable sub-factors that influence its effectiveness (Baylor & Ritchie, 2002).
We must also endeavour to understand other potential obstacles such as access to technology (both software and hardware) due to the cost and logistics (Weller, 2004) as well as the availability of support resources (Fabry & Higgs, 1997). In addition, Willging and Johnson (2004) have found that the ability of students to use computers is a primary factor in successful implementation and Homan and Macpherson (2005) and Litto (2002) have found that teachers’ and students’ attitudes towards computers can present a potential barrier.

Bates (2005) suggests that interactive courseware must be fully interactive to encourage and motivate students to be involved actively if it is to be effective. The presentation of content alone is clearly not enough to engage students in learning. Studies on the implementation of interactive courseware have confirmed that highly interactive courseware can make the teaching and learning process easier and help students understand and remember better (Bates, 2005; Raisinghani, 2003). In addition, interfaces must allow students to tailor the learning experience to their own individual needs.

One of the biggest challenges for teachers in using interactive courseware is to meet the different needs of students (Lin, 2002), especially their different learning styles. Yet different courseware packages offer varying degrees of individualisation. Because of such factors, not all interactive courseware is equally effective and productive, and choosing suitable interactive courseware for a particular E-learning community is an important and somewhat complex decision (Ghaoui, 2003).

Evaluation research on interactive courseware proceeds from two main perspectives. Some draws on instructional design theories to evaluate the pedagogical value of courseware systems while other research focuses on broader interface design and interaction design theories. For example, while Reeves (1992) focuses on pedagogical dimensions and uses learning theory to establish criteria for evaluating different forms of Computer Based Training, Nielsen uses heuristic evaluations to assess usability. That is, interactive courseware is primarily intended to achieve educational goals and is designed for various educational uses (such as reference material, instructional tools, or supporting
exercises or explorations in the classroom environment for students to do on their own or in groups) and must contain specific learning objectives (Alessi, & Trollip, 2001). Therefore, interactive courseware must support, and be informed by, educational theory and the courseware developer must understand how interactive courseware meets these needs. However, it is equally important to gauge the effectiveness of interactive courseware through the level of user interaction, which is then related to the level of users’ understanding of the content (Appana, 2008; Oakley, 2004; Rovai & Jordan, 2004). As Mayes & Fowler (1999) and Hannay & Newvine (2006) argue, to achieve better results through E-learning, we should not only focus on learning outcomes, we must also look at the learning process and interaction with the teaching materials (in this case interactive courseware).

Andrewartha and Wilmot (2001) and Ladyshewsky (2004) have established that the level of participation and satisfaction with interactive learning materials by both students and teachers make the most significant impact on academic outcomes. The literature establishes that the quality of interactive courseware can be measured by a usability test, which looks at the level of engagement by the end-users and their satisfaction with the interactive courseware.

Evidently, user satisfaction with the courseware depends largely on the quality of the interface design (Cavalier & Klein, 1998; Balinsky, 2006; Nastasi, Clements & Battista, 1990, Schoenfeld-Tacher, McConnell & Graham, 2001). It has been noted that it is not easy to design interfaces that effectively meet the needs of users (Homan & Macpherson, 2005). But an understanding of interface design is imperative to the development process in order to create effective interactive courseware. Along with an in-depth understanding of the theory of interface design, it is also necessary to establish user needs and requirements to ensure ease of access to, and understanding of, content (Galitz, 1997; Nielsen, 2000).

And finally, the use of interactive courseware in the classroom necessarily involves interaction between teachers, students and the courseware itself. Since the early 1990s, numerous researchers across the world have focused on the ‘engagement’ of users with interactive courseware and how it affects these
relationships. Notably, Rhee, Moon and Choe (2006) have reported that poor interface design performance can reduce the interactivity between the courseware and users, and further, it can diminish interactive learning experiences among users (Stone, Jarrett, Woodroffe & Shailey, 2005). This indicates that interface design not only plays an important role in supporting users’ access to the content of courseware, it is imperative in providing individual and shared user satisfaction in the learning process.

For these reasons, the interface design of interactive courseware must be carefully designed by courseware developers to ensure that it meets all of the intended users’ needs, provides user satisfaction and enhances quality learning experiences (Galitz, 1997; Manovich, 2001; Nielsen, 2000). Besides the materials and pedagogical approach, the effectiveness of interactive courseware used in classroom is highly dependent on two main factors: (1) the quality of interactive courseware, including the effectiveness of interface design performance and (2) user interaction, including user participation and collaboration in learning experiences. Both are contingent on a strong software development process.

2.3 Interactive courseware: The Malaysian experience

While various aspects of E-learning have been discussed in the international literature, most of the research it focuses on has been conducted in first world countries such as the United States, the United Kingdom and Continental Europe. The empirical data and information about E-learning in developing countries such as Malaysia is limited. Nonetheless it is possible to draw on local reports and a small body of literature to establish the current context of E-learning in Malaysia.

Because of a strong belief that computer technology will improve learning outcomes, Malaysia constantly invests in computer technology for education and has implement an E-learning strategy. In Malaysia, e-learning has been developed under the umbrella of educational technology programs offered by the government through the Malaysian Ministry of Education. E-learning programs actively began with a pilot called the Smart Schools Project in 1998, when teachers in selected Smart Schools were given the opportunity to use interactive
courseware to teach Malay language, English, Mathematics and Science subjects in the classroom (Goi & Ng, 2009; Jowati, 2005; Malaysia Ministry of Education, 2004, 2008; Rohana, 2006). In addition, the Malaysian government has provided a laptop to each teacher to ensure that the supplied interactive courseware can be utilised successfully (Hajar, 2005; Malaysia Ministry of Education, 2006b, 2008). These initiatives were designed to provide an incentive to the schools to use computer technology in their teaching and learning activities (Atan, Azli, Rahman, & Idrus, 2002).

Since 1998, E-learning has taken shape and gained widespread popularity in Malaysia. However, only a small number of studies have been conducted into the effectiveness of E-learning, its implementation and its outcomes in the local context. This includes work by Azizah et al. (2005); Baharuddin et al. (2006); Hajar (2005); Jowati (2005); Kamariah (2006); Lee (2007); Puteh (2006); and Multimedia Development Corporation (2007).

These studies have largely focused on the interactive courseware that is available for the Smart School Project. Most have concluded that the E-learning system in Malaysia does not provide significant impact. Some studies relate this to teachers’ and students’ attitude and perceptions, and argue that these must be improved for it to be effective. However most conclude that the interactive courseware itself presents two major issues. Firstly, not all subjects can be taught effectively using an interactive multimedia approach (Baharuddin et al., 2006; Jowati, 2005; Multimedia Development Corporation, 2007; Malaysian Ministry of Education, 2004, 2008; Muda & Mohamed, 2006). In particular, Kamariah (2006) notes that some subjects – such as Science – need to be presented in the form of the real thing because learning through simulations in Science can mislead students and impact negatively on their understanding. A second issue that has been identified is that the current interactive courseware has not been tailored to the needs and abilities of students (Azizah & Hanita, 2005; Mokhtar et al., 2005).

Muda and Mohamed (2006) have gone further to claim that much of the interactive courseware in Malaysia fails in terms of instructional design and interface design and go on to explain that the courseware does not accommodate
the end-users’ interests, preferences and needs. They conclude that it is for these reasons that teachers have returned to the use of printed textbooks for teaching and learning sessions. Similarly, Jowati (2005) has argued that the courseware has been used as a forum to showcase the advances of computer technology, rather than prioritising the facilitation of content writers, graphic designers and instructional designers who are working towards the needs of students and teachers to produce a tool to enhance teaching and learning.

The main challenge faced in Malaysia is to ensure that teachers and students can use interactive courseware effectively and creatively (Goi & Ng, 2009; Thang, Murugaiah, Hall & Hazita, 2009). While positive conclusions have been reached in previous research about teachers’ willingness to embrace interactive courseware use in classroom, a general misunderstanding that often occurs is that interactive courseware is simply used to establish topics and present content (Bismillah Khatoon, 2008; Hoon, Chong, & Binti Ngah, 2010; Thang, Murugaiah, Krishnasamy, Azizah & Hazita, 2009; Zain et al., 2006). According to Bismillah Khatoon (2008), teachers commonly project the interactive courseware to a big screen located in front of the class and students simply watch it with limited guidance by the teachers. At the other extreme, some teachers have claimed that teaching with the interactive courseware requires more preparation work. Hence, the interactive courseware is likely to remain in the box.

Clearly interactive courseware should not be expected to replace teachers’ roles in delivering knowledge to students but must be seen as a tool for engaging students in curriculum and must do so in an engaging way that involves both teachers and students interacting with the courseware. The literature on the Malaysian experience makes it clear that, in order to ensure the successful adoption of interactive courseware in Malaysian classrooms, the most important considerations are the quality of interface and instructional design, as these design factors provide the basis for access and engagement. And, as the broad literature establishes, the development of interactive courseware should be based on theoretical understandings of the learning process because the main goal should be to help students gain knowledge. Understanding of the processes through
which this happens effectively is therefore crucial. That is, in Malaysia, as is the case internationally, the effectiveness of interactive courseware is related to the quality of its instructional and interface design.

Therefore, in the following sections, the ecology of interface design and how interface design theory relates to other aspects of interactive courseware such as interaction design, learning processes and learning experiences are discussed in detail. This discussion covers the way in which the interface of an interactive learning product not only affects user interaction but the learning process and learning experiences, and it explains why a lack of attention to interface design in the development process can lead to limited uptake of interactive courseware in the classroom as well as a failure to enhance the learning experiences of students.

**2.4 Interface design**

Put simply, interface design is defined in the literature as the aspect of software that allows humans to interact with a machine. As Soren (2005) describes it, interface design bridges the gap between users and machines, so that data is arranged in a systematic way to make it easier for users to navigate, access information efficiently, and understand the product. Interface design may be regarded as the ‘front-end’ of the product, which enables the users to interact, communicate and have conversations with the machine while code and data from the ‘back-end’ (Galitz, 2002; Shneiderman, 1998). In information communication technologies (ITCs) interface design refers to the overall screen-presentation of the application, which allows the user to access and understand the information required or sought.

Borchers (2001) argues that interface design does not just pertain to aesthetic values, or the look and feel that is produced by the design elements such as colour, font size, images and layout (i.e. the positioning of title, menus, keys etc.) but that it is a communication tool that mediates between users and computer systems. From the perspective of interaction design, interface design is defined as a specific approach to component arrangement, in which the designer facilitates access to content, activities, collaborations and so on. Preece, Rogers and Sharp
(2002) believe that the interface design of an application determines how users feel about the communication process, and Cooper and Reimann (2003) similarly suggest that interface design is the primary aspect that determines users’ satisfaction. Thus, to ensure that users of computer systems are satisfied and access to the content is maximised, a designer of an interactive system must create an appropriate and effective interface.

In 1993, Weiss mapped the inter-related components of the interface which, he argued, consists of four main categories with separate features. These can be summarised as follows:

- **a)** *Presentation interface*, which impacts on the way the user feels about information and is produced through the elements of screen design, such as graphics, menu, layout, colour and so on.

- **b)** *Conversation interface*, which controls how the system communicates with the user of the system and mediates between the user and the system (as a form of communication).

- **c)** *Navigation interface*, which controls the way in which the user can move from one piece of information to search for other information (for example, in movement from one page to another page).

- **d)** *Explanation interface*, which controls the way in which the system supports the user’s different activities by providing guidance and explanation (through, for example, text and visual cues such as icons, bread crumb trails etc.).

That is, interface design should not only be appealing and establish a look and feel that users will respond to positively, it must also help users to find and remember information, and support them in the tasks that they need to perform. Interface design is therefore an important aspect of interaction design.

### 2.5 Interfaces form part of interaction design

As the context through which users control different activities, interfaces serve as an explanation for interaction. For example, interface design should mediate tasks by providing direction for interaction through text, images or icons, they should
link between activities, and they should enable the provision of appropriate feedback as an encouragement to the user to continue using the software. That is, an interface produces tangible effects in facilitating and encouraging interaction between users and systems. As Nielsen (2000) argues, an effective interface design gives users control over the interactive courseware. Moreover, key authors in the field have established that graphical presentations through interface design can provide users with the confidence that they can find what they want without wasting their time, (Norman, 2002, Nielsen, 2000) and can support end-users in the tasks they must perform. As explained by Galitz (2002), if the interface is well designed, users will not only perform well, but their experience will be enriched. On the other hand, poor interface design can lead to stress (Balinsky, 2006). From a users’ point of view then, effective interface design is a major factor that contributes to the degree of pleasure and agency of interaction. And this has a flow on impact on the enjoyment and effectiveness of learning experiences.

Besides these broad functions and principles, it is also important to note that interfaces must accommodate the varying contexts and needs of users. Norman (2002) has argued that, because user experience is the key to the quality of the end product, the development of interface design should therefore begin with an understanding of the user and the reasons they are using the product. Therefore, the process of interface design should first include an investigation of the target demographic, needs and the level of experience with technology. However, designing an interface may involve a complex creative process that accommodates several target end-users with different needs, levels of experience and so on. As Nielsen (2000) argues, an effective interface design blends user experiences and needs.

As Spohrer (1996) and Galitz (2002) have pointed out, interface design that is developed without a clear understanding of the software’s target users and the context of use, may not be usable, effective or pleasurable. This is not to say that all interface design for computer software must be designed to accommodate all user’s needs, but that it must be designed for the needs and abilities of the users for whom it is intended.
Interface design must therefore be understood as a key factor in interacting with a software system in a meaningful way. Therefore, any evaluation of the effectiveness and appropriateness of the interface design of an application should include observing user interactions with it to establish access, usability and engagement.

2.6 The relationship of interface design to information and interaction design

The use of technology alone does not automatically translate into effective learning experiences. There are a number of inter-connected factors that are important to ensure this. Savery and Duffy (1995) argued early on that learning is optimised when the process of learning is active and many education specialists have since gone on to argue that effective learning requires a degree of participation and involvement in the learning environment (Boud & Prosser, 2001; Preece, Rogers & Sharp 2002). Oliver and Herrington (2003) extend this argument by suggesting that it is a combination of the nature of the interactive learning material, the level of learner engagement, and the forms of learning support offered that is required to provide quality of learning experiences. Biggs (2003) and Sambrook (2003) concur but frame these three factors differently as: effective learning material presentation, effective engagement with tasks, and effective engagement with content.

These three types of effectivity can be facilitated through three design elements: interaction design, information design, and interface design. Numerous researchers have established the importance of these three components of interactive courseware. For example, Ben-Ari (1998) argues that interaction is one of the key factors in effective learning, and that different kinds of interaction promote different degrees of learning. Van Duyne, Landay and Hong (2003) claim that learning experiences are influenced more by interface performance and instructional design strategies associated with the learning materials than by the type of technology used to deliver the instruction. And Thurmond, Wambach and Conners (2002) propose that the mode of content delivery influences user
interaction, while interface design can enhance the active participation of the user. Yang and Cornelius (2004) also affirm that in order to produce quality learning experiences, effective user interaction and interface design are essential. In addition, Paluch (2006) and Shedroff (1994) establish that it is the combination of interaction, information and interface design that is the key to effective user experience design. This interconnected relationship is shown in Figure 2.1.

![Figure 2.1: Relationship of design approaches for creating effective learning experiences](image)

What can be drawn from this diagram is that it is necessary to consider the three elements (interaction design, information design and interface design) as inter-related factors in any research on students' learning experiences and the potential learning outcomes that can be gained from interactive courseware. And, to improve students’ learning experiences and outcomes, these three elements must to be understood in concert.

However, there is a case for focusing on interface design performance in an analysis of the effectivity of interactive courseware. This position is strongly

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3 Some may argue that navigation design and usability should be included in the key components, but they are relatively results-driven functions rather than cause-driven, and navigation design is a subset of interaction design.
supported by Raskin (2000) who argues that interface design is the essential factor in the quality of learning experiences, because an interface must inherently cater to learners’ possible and expected interactions. Furthermore, Shedroff (2001) argues that interface design is the primary factor that affects users’ understanding – and whether the user misunderstands or misinterprets the material presented. While interaction design is an important structural factor that impacts on engagement, it is interface design that acts as a filter of information (Johnson, 1997), as it determines the information that users can access, what they can do with the content, how they perceive tasks and how they interpret information. In addition, interface design contributes to the motivation of the learner to continue using the application. And, as Balinsky (2006) asserts, a well-designed interface can excite user interest, demonstrate concepts clearly with interactive examples, and allow learners to manipulate, play with, and develop ownership of concepts.

From a pedagogical perspective, this is particularly important as it relates to access, as well as to the interpretation and value of incorporated learning material. In addition, for the user to become actively involved in the learning process through interactive courseware, the interface design must not only respond appropriately and meaningfully to user actions, it must enable the user to control his/her own pace and mode of learning. That is, interface design is an integral part of an entire product, and it determines experience and enhances interaction. It therefore impacts the most on the use of interactive courseware in the learning process as well as its effectiveness.

2.7 Interface design in the development process

What becomes evident from the discussions in the literature is that developers must understand users’ needs. In the case of educational software, this includes expertise on how students learn and how technology can be meaningfully integrated into that learning process. To create appropriate courseware for educational contexts, developers must therefore apply learning theories as they focus on interface design as a fundamental aspect of the design process.
Because the design of an effective user interface arises from a careful analysis of the proposed user’s tasks and environment, it requires an understanding of at least three things: (1) the users who will interact with it, (2) the capacity of the computer systems and software, and (3) the interactions between users and the computer systems (Galitz, 2002). To further the understanding of these three elements, a variety of methodologies, guidelines and principles have been established. Early on, Shneiderman (1998) suggested three pillars for successful user-interface development from the perspective of HCI (human-computer interaction). They are: (1) guidelines and process (using both theory and a model), (2) user interface software tools (arising from a prototype), and (3) usability testing and expert review (conducted with a representative user group). These pillars are illustrated in Figure 2.2.

**Figure 2.2:** The three pillars of successful user-interface development
(Source: Shneiderman, 1998)

With regards to the first pillar, Shneiderman (1998) differentiates between principles and guidelines. Whereas principles are broad and general, and should be interpreted before being applied to a specific system, guidelines are specific to a project and are contextual and quite detailed. A well-designed interface is therefore based on design principles but guidelines and recommendations also provide designers with specific requirements for designing the interfaces of a particular project. While Smith (1986) explains that guidelines should be offered to designers as a potential resource, to complement a designer’s experience, rather than a requirement, guidelines help to ensure an effective interface design and a
developer who is left unguided may produce poor interfaces that fail to establish a context-specific relationship between users and a purpose-designed product.

With regards to the second pillar, Shneiderman (1998) explains that prototyping increases interface design quality. Prototyping is used to generate a trial version of the interface for users to evaluate, and it forms part of the analysis phase of the systems development life cycle. A prototype model may vary between a low fidelity (paper) prototype to an high fidelity interactive prototype of overall interface design, at different phases of the design process. It includes features, functions, and look and feel of the potential screen of the computer system. Often one or more prototypes are made in a process of incremental development as part of an iterative process, where each prototype builds on feedback on previous designs. In this way problem or deficiencies in interface design can be identified and corrected at the initial stages. Therefore, the likelihood of success in the resulting interactive courseware in terms of appropriateness to the target user, and optimisation of intended use within an anticipated context is increased. Thus, when prototypes of interfaces are used in the system development process, there is an improvement in interface design quality.

In terms of the third pillar, which involves gauging the quality of the interface design, Shneiderman (1998) suggests that the quality of interface design should be evaluated through usability testing and expert review. Shields and Kukulska-Hulme (2006) argue however that interface design performance should be measured by the level of courseware usage, while Preece, Rogers and Sharp (2002) argue that it should be measured from both the users’ and the developers’ perspective. Whatever the process involved, it is clear that usability testing is highly recommended in the international literature to ensure that the interface design is optimal before releasing the product to users.

2.8 The context of this research project

As discussed in the Introduction to this thesis, surveys carried out in Malaysia (Goi & Ng, 2009; Malaysian Ministry of Education, 2006; 2008) have shown that the uptake and extent of use of locally developed interactive courseware in the
classrooms is not very encouraging. The reasons reported include a range of factors, but most commonly relate to the interface design and the attitudes of users. As this literature review has established, interface design is a crucial aspect of interactive courseware because it facilitates ease of access to content, active user engagement, perceived relevant of the courseware to the target group and the overall perception of the interactive courseware. Perhaps not surprisingly then, reviews that have been conducted on the interactive courseware developed for the Malaysian Smart School Project point to failures in the interface design and its impact on the courseware’s capacity to meet the needs of teachers and students for effective learning experiences.

The international literature makes clear that understanding user needs and the involvement of stakeholders in usability analysis through prototype testing are key factors in the development process and are crucial for the development of effective interaction and interface design in educational courseware. From this, we might conclude that if the interactive courseware was developed with a deep understanding of the users’ needs and requirements through their involvement in aspects of the design process, along with the application of pedagogical knowledge identified in the literature, and adherence to a clear and comprehensive set of government guidelines, and rigorous user testing, then the interactive courseware that has been developed for the Smart School Project would not face barriers to adoption in classrooms.

Within the Malaysian context, the interface design of the interactive courseware is clearly an issue that needs to be examined in greater detail. While International theorists have long explained that the production of effective interface design is dependent on courseware developers adhering to established design principles, and the execution of context and project specific guidelines, and while previous studies conducted in Malaysia have established that interface design is a key factor contributing to the under-use of the purpose designed courseware, as yet there is a lack of empirical analysis of the exact nature of the issues arising in the interface design and how this relates to established principles and the guidelines that have been provided to the developers by the Malaysian government.
This gap in the literature on the local problem of interface design in educational courseware has motivated this research project to critically explore the specifics of the problems with the interface design from the perspective of the end users as well as the people involved in the design process – the courseware developers. The project proceeds from the premise that, in order to establish a deeper understanding of the issues and deficiencies in the interface design of the interactive courseware in Malaysian *Smart School Project*, it is important to establish a comprehensive understanding of both perspectives: the end-users and the courseware developers. The following chapter, which outlines the design of the study, explains how this intention to establish a dual perspective has been incorporated into the project’s approaches to data collection.
3. Approaches to the research: Methodology and methods

The Introduction and the Literature Review, which preceed this chapter, have introduced the reader to the research problem of this thesis and how it relates to the broader established field. In particular, they have provided an overview of the international and local Malaysian literature on interactive courseware, as well as a current understanding of interface design and its importance in interactive courseware for ensuring the effectiveness of users’ navigation, access to content, and engagement through interaction. This chapter will now discuss the research methodology utilised by the researcher to establish empirical evidence as a foundation for understanding the issues surrounding the interface design of interactive courseware in Malaysia.

3.1 Qualitative ethnographic approaches

Because this research project set out to first investigated the validity of claims surrounding deficiencies in the interface design of interactive courseware for the Malaysian Smart School Project before establishing reasons for any identified problems, it was necessary to gain a broad understanding of the level of uptake and use of the courseware, as well as a detailed insight into the ease of use, levels of engagement and perceptions of end users. This has required forming an understanding the context and practices of use of the courseware, before ascertaining the reasons for any problems encountered through an analysis of the practices relating to the development process. Specifically, it has proved necessary to understand the practices and attitudes of the participants involved in the use of the interactive courseware then the practices and attitudes of those involved in its production and implementation. The participants in this project have therefore included a range of stakeholders including the community that comprises the schools in the Smart School Project (the school principals, teachers and students), the government (Malaysian Ministry of Education), and the courseware developers.
To gain the necessary insights, this research project has employed qualitative approaches that can be related to an ethnographic research methodology. Ethnography is a research strategy developed by anthropologists and sociologists, which is used to identify the social and cultural values, beliefs, practices and meaning of experiences and activities of certain groups of people (Gobo, 2008; Goetz & LeCompte, 1984). This approach can be related to this research project because the main research problem involves an empirical study of the views and real experiences of communities of students and teachers interacting with Malaysian Smart School Project courseware in their natural settings.

However, this research project is not an extensive ethnographic study. Firstly, it does not involve an intensive investigation into the holistic cultural and social practices of a community. Secondly, when used in educational research settings, ethnographic studies tend to focus on a single research setting and concentrate on recording detailed aspects of a single phenomenon over a period of time (Goldman et al., 2007). However, in this research project, the researcher did not spend extensive periods of time in the field as an anthropologist would, but short intensive periods of time in the physical location of selected schools involved in the Smart School Project, which proved sufficient to gather the data necessary for the focal study. Thus, it can be said that the project has utilised ethnographic approaches to data collection rather than it being a full-blown ethnographic study.

According to Gobo (2008), conducting any form of ethnographic research is complex because there are at least three approaches that must be merged: participant observations, fieldwork and case studies. Chapman and McNeill (2005) argue that these three approaches are highly recommended for ethnographic researchers in educational settings and Irwin (2008) also argues that this can lead to a deeper understanding. Moreover, using these different methods helps to alleviate the shortfalls of each single research method (Plano Clark et al., 2008; Creswell, 2003; Lapan, 2004). Thus, this research project has employed a range of ethnographic techniques: watching what happens, listening to what participants say, and recording the information given by the participants by taking field notes. This combination of methods has provided richer insights and ensured that more meaningful information has been collected.
Besides ethnographic methods, this project has also incorporated other research methods including contextual analysis, content analysis, comparative analysis and the triangulation of data and findings. In summary, this research project commenced by identifying what types of data are relevant to the research problem, through a formal contextual analysis of the international literature and the Malaysian-specific literature. Then, a content analysis of the interactive courseware was conducted. Following that, the researcher entered the field to examine and document what was occurring in the real situation. This is where ethnographic techniques were employed to gather empirical data, including face-to-face interviews with school principals and teachers, non-participant observations with the teachers and students in context (the classroom), followed by focus group discussions with them. This was followed by interviews with Malaysian courseware developers. Finally, the researcher conducted a comprehensive comparative analysis on the different data gathered to provide answers to the research questions that have been outlined in the Introduction to this thesis (and summarised below). The process concluded with report writing to outline the findings and recommendations. The overall research design is explained in the following section.

3.2 Research design

As noted by Lang and Heiss (1998), a design for conducting research helps the researcher to plan the process for finding answers by focusing on the research questions. This research project has similarly been guided by the main research questions, sub-questions, aims and objectives, and the research design has involved the following research methods set out against the objectives, as summarised in Table 3.1.
<table>
<thead>
<tr>
<th>Research Questions (RQ)</th>
<th>Study</th>
<th>Objectives</th>
<th>Research Methods</th>
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</thead>
<tbody>
<tr>
<td><strong>RQ1</strong> What interface design principles, including those established in the literature, and those outlined in the Malaysian government guidelines are evident in the interactive science courseware?</td>
<td>Part 1</td>
<td>Ascertain the principles, characteristics and components that have been established in the literature; are provided in the government guidelines; and are evident in the courseware.</td>
<td><strong>Formal contextual analysis:</strong> Collecting, reviewing and analysing the international literature and the current Ministry guidelines. <strong>Content analysis:</strong> Collecting, reviewing and analysing the interactive courseware. <strong>Comparative analysis:</strong> Comparing principles used in the courseware against the international literature and the Ministry guidelines.</td>
</tr>
<tr>
<td><strong>RQ2</strong> How do the users (school principals, teachers and students) of interactive Science courseware for the Malaysian Smart School Project interact with the courseware and how do they perceive it?</td>
<td>Part 2</td>
<td>Determine how school principals and teachers perceive the courseware. Evaluate users’ interaction with the interface design components in the courseware. Determine the strengths and weaknesses of interface design principles, and characteristics in the courseware.</td>
<td><strong>Ethnographic Study</strong>  ● Face-to-face interviews with the school principals  ● Non participant classroom observation of students and teachers  ● Focus group discussions with students accompanied by their teachers.  ● In-depth interviews with the teachers.</td>
</tr>
<tr>
<td><strong>RQ3</strong> How has the interface design of the existing courseware been developed, and has this contributed to the quality of the interface design?</td>
<td>Part 3</td>
<td>Determine the current development process. Compare this process with the guidelines. Identify the current relationships among all stakeholders.</td>
<td><strong>Ethnographic Study</strong>  ● Face-to-face interviews with the courseware developers  <strong>Comparative analysis:</strong> Comparison of the development process with Ministry guidelines.</td>
</tr>
<tr>
<td><strong>RQ4</strong> Drawing from the above: What principles, characteristics and development guidelines can be recommended to benefit stakeholders in the Malaysian education context?</td>
<td>Part 4</td>
<td>Classification and provision of a revised set of effective design principles and practical guidelines.</td>
<td><strong>Comparative analysis</strong> Collate and compare the data gained from the above investigations. <strong>Conclusion</strong> Extract effective principles and guidelines and make recommendations.</td>
</tr>
</tbody>
</table>

Table 3.1: Research design
As summarised in Table 3.1, this research project has followed three general stages of research design, as proposed by Noble and Bestley (2005). They are investigation, information gathering and transformation of information. As per these recommendations, the researcher arranged this research project by dividing it into three stages relating to one main research question and four sub-questions. The stages include the process of reviewing the established literature (Stage 1), data gathering process by conducting content analyses and field visits (Stage 2) and transformation of information by transforming all the information gathered into new findings by report writing (Stage 3). These phases are visualised in the following diagram (Figure 3.1).
Identify the interface design characteristics and principles that have been established, endorsed and used.

Evaluation of effectiveness by the different stakeholders.

A new set of effective interface design principles characteristics and components.

Comparative analysis.

Practical guidelines and recommendations for the courseware development process.

**Key**

- Research Problem
- Research Method
- Object of Investigation
- Research Outcome

**Figure 3.1:** Overall research plan
3.2.1 Stage 1: Research Investigation: Reviewing established literature

Noble and Bestley (2005) point out that determining the research questions is the most important aspect of any research project, and that such questions are determined by reviewing the literature relating to the topic. Therefore, the initial stage of the research process for this project involved reviewing the appropriate literature to help define the research problem and identify the research questions.

The preliminary literature review involved three disciplines, namely interface design, interaction design, and interactive learning experiences, and it included both international literature and focal literature on the Malaysia context. Investigations of recent reports from the Malaysian Ministry of Education were also used as a primary source to establish the research context and determine the gap in knowledge and the emergent research problem. Out of this preliminary literature review, a research problem was established, and research questions were formulated. It also helped to establish the context and scope of the project, its conceptual frameworks and the project design, including the research methods and instruments appropriate for the research problem and research questions.

3.2.2 Stage 2: Data Gathering Process

After identifying the research problem, questions and appropriate research methods, the second stage involved the process of primary and secondary data collection in order to answer the research questions. This involved gathering information from various sources, through six different methods. The methods of data collection are explained in detail in Sections 3.3 and 3.4 below but first a summary of the unfolding of data collection may be useful.

The process of data collection first involved a contextual document analysis which included the following steps: (1) collection and analysis of established interface design principles and guidelines from the international literature, (2) collection and analysis of focal literature on Malaysian courseware, (3) review and analysis of reports from the Malaysian Ministry of Education on the extent of courseware uptake in the Malaysian Smart School Project, (4) collecting,
reviewing and analysing the model of software development recommended in the international literature, and (5) collection and review of the guidelines provided to the courseware developers by the Malaysian Ministry of Education.

Secondly, the data process involved a content analysis of the interactive Science courseware that has been developed for primary schools in the Malaysian Smart School Project by the Ministry. Thirdly, data was gathered through field visits to several primary schools involved in the Malaysian Smart School Project. This involved: (1) face-to-face interviews with the school principals to determine information including the current quantity and frequency of uptake of the interactive courseware at the schools, which packages are used most in the classroom, and any specific difficulties experienced by the school in implementing the courseware, (2) classroom observations to gauge users’ engagement with the interactive courseware and any difficulties they encounter, (3) focus group discussions to gather details on users’ perceptions of the interface design of the interactive Science courseware, and (4) in-depth face-to-face interviews with teachers to established their perceptions of the educational effectiveness of the courseware through detailed feedback.

Finally, face-to-face interviews were held with the courseware developers of the courseware. This was important to help form an understanding of how the current courseware has been designed and whether it is the cause of any problems that have arisen. This involved ascertaining whether established international development processes have been followed, the degree of implementation of the Ministry guidelines, the common processes that have been adopted, and the level of involvement of the various stakeholders in the current production and development process.

3.2.3 Stage 3: Transformation of information
All of the information collected during Stage 2 was then compiled systematically and analysed thoroughly in the transformation of information stage, which involved analysing the data to evaluate, create meaningful comparisons and draw
conclusions from the data gathered. All the sources, processes and outcomes from data gathering are summarised in Figure 3.2.

**Figure 3.2:** Stage 3 – Transformation of information

In particular, a comparative analysis was conducted of the information gathered on established interface design principles from the formal contextual analysis of the international literature against those outlined in the guidelines provided to developers by the Ministry as well as against those evident in the content analysis of the current courseware. Contextual document analysis has also helped to provide a comparison of the software development models established in the international literature with the Ministry guidelines that are provided to the developers and the current practices.
The data gathered from school principals’ and teachers’ interviews provided a deeper understanding of the extent of courseware uptake and any difficulties experienced by the school in implementing the interactive courseware, while classroom observations and focus group discussions with teachers and students who use the courseware helped the researcher to clarify how interface design components affect users’ interaction and overall learning experiences. These outcomes then helped to establish what principles, characteristics, and components should be recommended for the developers of future interactive science courseware.

Subsequently, the data from face-to-face interviews with the courseware developers helped the researcher to explain the developers’ attitudes towards the role of interface design in interactive courseware, as well as the strengths and weaknesses of the Ministry guidelines, and hence to establish the reasons behind problems arising in the interface design.

In summary, at this final stage, the data collected from Stages one and two was compared and analysed in order to establish the extent, precise nature and reasons for issues with the interface design of the interactive courseware. From this, two major outcomes could be established: a new set of interface design principles, characteristics and components that can serve to increase uptake and the effectivity of future Malaysian interactive Science courseware and practical guidelines for future software development, including recommendations around workflow, processes and stakeholder involvement.

### 3.3 Research setting, population and sampling

In this research project, two research setting were involved. The primary research setting can be described as the place where the interactive courseware is delivered and used, namely *Malaysian Smart Schools*, while the secondary research setting can be described as the place where the interactive courseware is developed, which is the developer’s offices. Observations and interviews were conducted in site in these contexts because, as Chapman and McNeill (2005) have argued, familiarity of the environment to informants is important because it can affect the
way participants behave or feel and how they respond to questions and also because it allows the researcher to observe the full context in which the informants work.

Overall, four groups of participants were involved in this study. They consist of a representative sample of the school principals, teachers and school students involved in the Smart School Project, and a representative sample of ten courseware developers. The purpose of including these four groups of participants was to gain a better understanding of any differences in perception regarding specific aspects of the interface design and its effectivity.

3.3.1 Primary research setting, population and sampling

Smart Schools in Malaysia were the primary research setting for this project. The focus of the study was on primary schools because, according to the literature, the most problematic interface design within the interactive courseware occurs in courseware used at primary school level (Ministry of Education, 2006). Twenty primary schools have been involved in the Smart School Project in Malaysia (Ministry of Education, 2004). Within this cluster, there are three different types of Smart School: a new primary Smart School, a state primary Smart School, and a remote primary Smart School. In this research project, six schools were selected as a representative sample, including two of each type of Smart School.

Permission to conduct the study in Malaysia and involve the schools was sought from the Malaysian Ministry of Education by writing to the chairperson, and it was granted prior to contact with the participants. (The letter is included in Appendix 1.) Along with the approval by the Ministry, a list of six primary school names was provided (refer to the list of primary schools in Appendix 2). Based on this list, the principal of each school was approached to gain approval for the school to participate. The principals were informed of the intention to interview them at the schools and agreement was obtained from these participants. (A sample copy of a principal consent form is attached as Appendix 3.) The teachers and students were also contacted prior to the study to gain their agreement to
participate in this study and a letter of consent was received from each in line with the ethical clearance processes outlined below.

### 3.3.2 Secondary research setting, population and sampling

The interactive courseware used within the *Smart School Project* has been developed by the Malaysian Ministry of Education in conjunction with hundreds of private courseware developers. The courseware developers must go through a tender process by submitting an application with a sample of their past work and a financial plan to the Ministry. The Ministry then appoints them on a case by case basis. Because this research project focuses specifically on the interactive Science courseware for primary schools, only courseware developers who have been involved in developing it were included in the sample. To contact them, a list of courseware developers was obtained from the Ministry, which provided the contact details of twenty courseware developers. All twenty were contacted through email and telephone, seeking an interview. Ten developers agreed to participate and were included in the study. (A sample copy of their consent is attached as Appendix 5.)

### 3.4 Ethical issues and other considerations

Ethical considerations are associated with this research project, since the process of inquiry has involved interviewing and observing human beings. Great care has been taken to avoid any harm to the participants. A number of aspects were considered, as set out in this section. In this regard, a comprehensive QUT Ethical Clearance application was submitted on 16\textsuperscript{th} January 2009 and approval was gained on 27 January 2009 (refer to Human Ethic Approval certificate in Appendix 6).

#### 3.4.1 Informed consent, confidentiality and anonymity

Consent is the protection and respect of self-determination (Cohen & Manion, 1995, p.350). It is the procedure through which individuals choose whether to participate or not after being informed of the facts that would be likely to influence their decisions.
This information was provided to potential participants including the school principals, teachers, parents, and students of primary schools in the Malaysian Smart School Project as well as courseware developers, in a letter outlining the purpose of the study, data collection methods and the extent, nature and duration of participation required of the respondents. A letter guaranteeing confidentiality was also sent to all participants. It assured participants that the information they provided would be treated as anonymous through the de-identification of all responses in the data collection. They were advised that although a research report would be published, it would only contain figures, percentages and facts obtained from analysing and interpreting the responses from the completed data. The respondents were also informed in writing that their participation was voluntary and they could withdraw from the study without fear of being penalised by the researcher or, in the case of the students, teachers and parents, by the school. Written consent was requested from each participant. Each participant signed a consent letter, placed it in a separate envelope and returned it to the researcher prior to being involved in the data collection. A sample of the information letter sent to the school principals is attached as Appendix 7 and that sent to developers as Appendix 8.

3.5 Methods of data collection

To achieve the aims and objectives of this project, as explained in the Introduction under Section 1.3, and summarised above in Table 3.1, a multi-method approach has been adopted. A method is a technique for gathering data (Punch, 2004; Wadsworth, 1997) and each research method carries underlying assumptions (based on an epistemology), as well as approaches and strategies, which provide “a context for the process involved and a basis for its logic and its criteria” (Crotty, 1998, p.66). As Irwin (2008) points out, “multiple methods may provide different lenses of perception of some particular state of affairs” (Irwin, 2008; p.415) and, as he goes on to establish, this approach can contribute to the trustworthiness of the data collected. Various theorists have established that using different methods helps to mitigate the shortfalls of each individual research method (Plano Clark et al., 2008; Creswell, 2033; Lapan, 2004) as well as different methodologies (Plano Clark et al., 2008). Therefore, as Painter and Rigsby (2005) point out, the use of
various methods increases confidence in the research findings and provides a clearer understanding of the problem.

Employing a combination of different methods in one research project can also be referred to as a triangulation of data sources, which strengthen a study (Cowger & Menon, 2001; Irwin, 2008; Creswell, 2033; Lapan, 2004). This triangulation metaphor was used in this research project because data has been derived from six different methods of data collection, which have been adopted to provide a greater degree of understanding and to ensure that meaningful information was obtained. These methods, including a contextual analysis, content analysis, face to face interviews, non-participant classroom observations, focus group discussions and in-depth interviews are explained in detail below.

3.5.1 Contextual analysis

A contextual analysis is a method that involves analysing a text to assess the meaning of a word or concept from the surrounding context and an assessment of similarity and difference in the qualities that characterize it within the content of texts (Manning & Schütze, 2002). The process of contextual analysis in this research project focused on retrieving the principles, characteristics, components, guidelines that are most often recommended for effective interface design from international books and journal articles as well as articles that have been written in the context of Malaysia. It also focused on reviewing the literature to establish the model of development process that is most frequently recommended. The current guidelines that are provided by the Ministry to developers were also analysed to determine the correlation between the principles established by international scholars and those provided in the Ministry guidelines. In addition, reports on the uptake of the interactive courseware that have been compiled by the Ministry were also reviewed to determine the current level of courseware usage. From these various contextual references, a comprehensive comparative analysis of the documents was produced.
3.5.2 Content analysis

Content analysis is a technique used for determining content, including consistency and differences between multiple variables within documents or artefacts (West, 2001). It can be conducted manually or by computer to determine patterns and generalities within a sample. According to Neuendorf (2002), to minimise the risk of research bias, most content analysis involves the establishment of various pertinent categories and is usually undertaken through a coding system.

A significant part of the research material in this project was gathered through a content analysis of the interactive courseware for Science subjects in the Malaysian Smart School Project. As the aim of the research project was to measure the quality of interface design in the interactive Science courseware by comparing it against the interface design principles established in the international literature, as well as Ministry guidelines, this was an appropriate method of data gathering. It not only allowed the researcher to analyse the strengths and weaknesses of the interface design principles, characteristics and components in the sample courseware through comparison of its characteristic with established principles, it also helped to establish whether the Ministry guidelines have been followed by the developers.

In order to ensure the validity of the data, a coding system was first developed by the researcher to determine themes and categories. Through this systematic thematic coding and categorising, the researcher determined the similarity and differences between the principles in the literature, those in the Ministry guidelines and those evident in the courseware.

3.5.3 Face-to-face interviews

Face-to-face interviews can be effective in gathering information about people’s actions, beliefs, thoughts and perceptions (DeMarrais & Lapan, 2004). An interview is a process through which respondents are asked questions by a researcher and their responses are recorded (Vockell & Asher, 1995). Johnson (2008) has suggested that an interview can be conducted through a printed
questionnaire (completed by mail, or email), by telephone or face-to-face, however, to reduce interviewer bias, the researcher usually interacts with the respondents directly so that they can observe non-verbal expressions, which would not be observed otherwise. Face-to-face interviews can be semi-structured or unstructured, with closed format or open-ended questions. Common techniques used for documenting the interview include note taking, video recording and audio-taping (Johnson, 2005).

This method is recommended by many social science researchers, especially when conducting research related to education (McMillan & Schumacher, 2001). As Johnson (2005) has established, face-to-face interviews are useful for establishing comparative data, which allows the researcher to compare attitudes and opinions, as well as to reduce bias.

This research project therefore used face-to-face interviews with open-ended questions as a method of gathering in-depth information on attitudes, experiences and the wider perspectives of the stakeholders. The interviews were conducted in the respondents’ natural settings. In essence, interviews were conducted at school principals’ and teachers’ offices, as well as developers’ offices through the use of standardised procedures, where every participant in a sample group was asked the same questions in the same way. A videotape and audio recorder were used to record all the interview sessions.

1. **Face-to-face interviews with the school principals**

The purpose of face-to-face interviews with the school principals was to seek a broad view of the issues faced by the schools in the uptake of the courseware. Six school principals were approached by way of a letter, after gaining a list of relevant candidates from the Ministry. Before the interviews, the school principals were assured that their identity would remain private through the de-identification of their responses and they were advised that they had the opportunity to withdraw from the interview at anytime. After gaining the school principals’ agreement to be research participants, and receiving a signed statement of informed consent, a list of the questions to be asked of them was mailed in advance.
The individual interviews then took place at a time convenient to the principals, in their school offices. The language used in the interviews was primarily Malay, while the guiding questions were asked in English.

At the conclusion of each interview, the researcher recapped all the key points in the information provided and sought corrections or clarifications. The interviews were then transcribed from audio tape in Malay and the National Institute of Translation Malaysia translated it into English. All of the transcripts were then analysed by categorising the answers into several themes, which are detailed in Chapter Five.

2. Face-to-face interviews with the courseware developers
The main purpose of face-to-face interviews with the courseware developers was to determine their current development processes and practices of interface design, as well as their understanding of the role of interfaces as well as the extent of their adherence to the Ministry guidelines and any issues that arise from them. In total, twenty developers were approached by email and telephone and only ten developers (n=10) confirmed their willingness to participate in the interviews.

Prior to the interviews, the same processes were conducted as for the school principals. It was explained that any comments would be de-identified as an anonymous response and that they had the opportunity to withdraw from the interview at anytime; then the developers were asked for signed consent. The interviews took place at a time convenient to the developers and were conducted in their offices. The same interview techniques and recording procedures described above in relation to the school principals were followed.

3.5.4 Non-participant classroom observations
Observation is one of the most straightforward ways to gather information and verify what is happening in a particular context. As Montgomery (2002) suggests, it is particularly useful during the exploratory phase of an investigation, and can help to generate insights into what is happening and why. The term observation is open to a wide range of interpretation, but this study takes the definition offered
by Jorgensen (1989), who defines it as a method to gather data in two inter-related settings: the physical setting (i.e. the actual physical environment and its organisation), and the human setting, (the organisation of people, as groups or individuals).

A common definition of observation as it is used in educational settings is ‘watching’ and ‘listening’ to the subject, with subsequent specific analysis and interpretation (Goetz & LeCompte, 1984). Tilstone (1998) expands that observational approaches can be divided into two major kinds: non-participant observation, where the researcher is not involved in the group activities but is present as a passive observer who records the participants’ activities and draws conclusions; and participant observations, in which the researcher is involved in the group’s activities. Both are associated with ethnographic, qualitative research and are commonly used in the field of education (in, for example, Goetz & LeCompte, 1984; Montgomery, 2002; Croll, 1986).

In this research project, non-participant observation was employed as a method for three reasons. Firstly, as suggested by Fraenkel and Wallen (2003), observations provide information about what people actually do, so it is appealing as a means to gather “live” data from “live” situations. Non-participant observation, where the researcher does not interact with the participant who is being observed, allows the researcher time to take field notes and reflect on the observations and issues raised. And, as recommended by Montgomery (2002), the researcher is relatively less obtrusive, so their impact on the data collected is minimized.

Classrooms at primary schools in the Smart School Project have provided the physical setting for non-participant classroom observations in this research project. The researcher visited the schools and observed the students and teachers using the interactive courseware in class. They were limited to short-term commitments of two weeks for each of the six classrooms. Teachers and students were observed during the periods when they used the interactive courseware in teaching and learning activities. To ensure that students and teachers did not feel distracted or
uncomfortable during the observations, the researchers watched and listened from a distance without interacting or participating in classroom activities.

Two periods of observation were conducted for each class. In the first observation period, the researcher was in the classroom and observed the students and teacher using the interactive courseware from the back of the room while simply taking field notes. This session helped to make the participants feel comfortable and familiar with the researcher being in their classroom. In the second observation period, the researcher recorded observational notes and recorded activity with a video camera. The video recording equipment was placed at the back of the class and at a selected computer monitor. The observational notes were taken on the spot as an in-tandem resource for the video observational data.

This method was applied to gather data on several factors including: which aspects and components support and encourage students’ and teachers’ interaction, participation and engagement with courseware interfaces; to what extent does interface design affect the level of students’ concentration and access; are any obstacles encountered; and which components present most difficulties for the participants. In line with this, the length and level of engagement with the interactive courseware by the students and teachers was measured. The researcher also observed how particular interface design components identified during the content analysis of the interactive courseware facilitate students’ interactions (both positively and negatively), and how they accommodate, assist or inhibit the teachers in using the courseware.

In conducting observations, each page of the observational notes was divided into two columns: the left column documented what was done, seen and heard and the right column documented preliminary interpretations of the observations. These recorded notes and videotapes allowed access to both verbal and non-verbal elements of the data in subsequent analysis and so facilitated a better insight and more robust analysis of the students’ interactions as they engaged with the courseware, as well as the directions, approaches and levels of enthusiasm of the teacher.
3.5.5 Focus group discussions

Focus group discussions allow a researcher to interview more than one person at a time (usually between 6-12 people depending on the objectives of the research study). They provide a key tool for exploring stakeholder needs through an open-ended approach, as well as allowing a researcher to clarify issues raised through other techniques such as observations by asking participants very specific follow-up questions (Krueger, 1988; Krueger and Casey, 2000; Stewart & Shamdasani, 1990). Focus groups elicit perceptions, beliefs, attitudes and experiences from multiple points of view and, compared to individual interviews, provide a deep insight into complex situations (Vaughn, Schumm & Sinagub, 1996). Moreover, in individual interviews, the respondent may give the answers that he or she thinks the interviewer wants to hear, while in a focus group discussion, the participants feel more in control and greater insights can be gained as they debate their views with others.

Focus group discussions with students were conducted as part of this project to provide a deeper understanding of the extent to which the interface design of interactive courseware for the Smart School Project affects students’ interaction and engagement. The groups were comprised of 5 to 6 students and sessions were limited to 15 minutes. This was because numerous educational ethnographic researchers (for example, Edmunds, 1999 and Goetz & LeCompte, 1984) have established that students may feel uncomfortable in a large group and aren’t engaged longer than this in the discussion. To reduce any anxiety of the students, the sessions included their teachers in the discussion as a moderator.

In total, six focus group discussions were conducted with 30 students. The researcher began all the focus group discussions by briefing the students on the purpose of the discussion and giving clear guidelines on the length and limit of their involvement. The students were asked open-ended questions, with the researcher taking notes on all answers provided through the discussion. Each session was also recorded on audio and videotape with permission from the participants. Like recording interviews and observations, recording focus group discussions is useful since it can limit the need to write during the discussion,
which may distract the participants from the conversation (Lang & Heiss, 1998, p.103). These focus group discussions provided clarification on students’ responses to the interactive courseware during the observations. The outcomes are discussed in detail in Chapter Five.

3.5.6 Follow-up in-depth interviews

Follow-up in-depth interviews were also employed as a research method of information gathering in conjunction with observations and focus group discussions. This method provides a way to explore more deeply participants’ actions and also provides opportunities for the participants to explain their perspectives on what the researcher has observed. Sekaran (2000) suggests that in-depth, one on one follow up interviews are a way of discovering perceptions, feelings, opinions, thoughts and interpretations that people give to their experiences.

According to Silverman (2004), there are two types of in-depth interviews: full in-depth interviews (lasting from 45 minutes to an hour) and mini-in-depth interviews (lasting 15 minutes to half an hour respectively). In both, the researcher can ask open-ended questions and freely use prompts such as “tell me more” or “could you give me an example?” to investigate and clarify a topic. Frequently, in-depth interviews involve audio or videotape recordings, but they also require the researcher to be a good listener so that answers can be teased out (Kvale, 1996).

In this research project, the researcher carried out mini in-depth interviews with the Science teachers after the classroom observations and focus group discussions. In all, six Science teachers were interviewed. The interviews used semi-structured and open-ended investigative questions that were designed to gain a better understanding of the teachers’ experiences, degree of satisfaction and difficulties with the use and interface design of the interactive courseware. All the in-depth interviews were recorded via digital voice recorder with the permission of the interviewees.
The aim of the follow-up in-depth interviews was to enrich the researcher’s understanding from the teachers’ perspectives. In combination with the other methods that have been described, the objective was to help the researcher to clarify the strengths and weaknesses of the interfaces and any elements that cause interaction or engagement problems and, ultimately, to identify specific principles, characteristics and components of interface design that contribute to the user’s engagement and enriched learning outcomes, as well as what obstacles obstruct these goals.

3.6 Data analysis

Because multiple methods have been used in this research project, different types of complementary data was gathered, including quantitative data (for example, to ascertain which courseware titles are most often used and the frequency of courseware use at schools) and qualitative data (such as the words used by principals, students and teachers to express their perceptions). It has therefore been necessary to merge them for the analysis process. As established by Plano Clark et al. (2008), drawing on both quantitative and qualitative data can result in a better understanding of the problem at hand. For example, investigating the international literature, the Ministry guidelines and reports, and the interactive science courseware, has allowed the researcher to discover and compare the various interface design principles embedded throughout the data, while the perceptions of students’, teachers’ and developers’ of interface design and stories about their experiences with the interactive courseware provide a rich empirical understanding of the principles in use.

Various analysis techniques have been employed. As Cohen, Manion & Morrison have noted, “the choice of data analysis techniques must be appropriate for the kinds of data gathered” (2000, p.82) and, as Neuman elaborates, data analysis techniques are employed in different ways for qualitative and quantitative data (2006). For quantitative data, the data analysis process involves entering the raw data into a computer software package such as SPSS, which can create tables, graphs and statistics. The output of the quantitative data gathered from surveys for example can provide useful information which can be interpreted in an attempt to
answer a research question. With qualitative data, the researcher must look for “patterns, themes, categories and regularities” in the data gathered from the participants (Cohen, Manion & Morrison, 2000) to explain the respondents’ experiences, and so provide a better understand the phenomenon studied.

As suggested by Vallance & Lee (2005) and Plano Clark et al. (2008), the analysis process was continuously undertaken throughout this research project rather than being undertaken at the end of the data collection. The results were therefore emergent and led to subsequent investigations. A thematic process was applied to incrementally sort the information gathered and responses received from principals, developers and teachers interviews. A (MSWord®) Excel spreadsheet was used to categorise the data into small clusters around themes related to the interview questions. Data sets were clustered thematically using a system called “coding schemes” as defined by Frankfort-Nachmias and Nachmias (1992). This involved the process of creating a data index, labelling the source, and sorting the content into meaningful categories according to a pre-determined list of themes. As recommended by Silverman (2004), the purpose of such coding schemes is to categorise the data into smaller clusters of similar content to allow simple analysis of the data.

In this study, information extracted from the international literature, the Ministry guidelines and reports was clustered around particular interface design principles. Similar words that were consistently repeated were used to group the primary data output, while less frequent words were used as a supporting data output. Words that overlap in meaning or duplicate one another were combined in this process.

The process of coding information gathered from the interviews was more complex. First, the tapes of the interviews were transcribed one by one. Then, the transcriptions were coded according to the occurrence of keywords in participant’s responses to the interview questions. After completion of the process of coding and organising, frequent keywords were sorted into several categories and themes with the relevant statements clustered around them. Then the researcher identified potentially useful categories and themes to be included in the report. Because the interviews with the school principals, teachers and courseware
developers involved a small number of participants, the researcher performed this analysis manually.

The process of analysing data gathered through non-participant classroom observation and field notes involved transcribing and formatting the data from the tape recordings of what the students were doing or saying into a narrative. Then, the transcripts of the field notes were sorted into categories by looking for the patterns in the data such as particular behaviours and levels of focus and engagement with tasks at different points during the software use. A summary for each category was then written. A qualitative data analysis computer programme (NVIVO) was used throughout the analysis process. The outcomes from the analysis helped to ascertain strengths and weaknesses of the interface design in the courseware as they were experienced by real users.

Similarly, the information collected from the focus group discussions was treated as raw data. A full transcript was first prepared to provide a complete record of the discussions. Then, the content of the transcripts was analysed by gauging the frequency of the words used in the answers and comments, with similar terms clustered together. The aim of this process was, as before, to look for patterns that reappeared within the focus group discussions and collate the content of each comment thematically.

Finally, all of the data drawn from the contextual document analysis, content analysis of the interactive courseware, interviews with developers, principals and teachers, classroom observations and focus group discussions was compared. Persistent and relevant points relating to each research question were collated, based on the identified themes. This subsequent analysis led to a classification set of effective principles and practical guidelines for the development process. The outcomes of this analysis resulted in the conclusions of the research project.
3.7 Conclusion

This chapter has provided the reasons for selecting the chosen methodology and has outlined how this methodology has unfolded in the research project. In summary, while this project was not approached as a full ethnographic study, some ethnographic methods were used in this research project because of their capacity to ascertain the perceptions and experiences of the teachers and students in terms of the reception of the interface design of the *Smart School* interactive courseware and the courseware developers in terms of the development process.

The data was collected from numerous sources using several complementary methods including contextual document analysis, content analysis of the courseware, interviewing courseware developers, school principals and teachers, and conducting classroom observations and focus group discussions in schools. The resulting data was analysed inductively by interpreting the meaning of participants’ perceptions as they arose.

In the following chapter, the data gathered from the contextual document analysis and content analysis of the interactive courseware will be presented in detail. The results from different data sources will also be discussed in relation to the research questions and objectives.
4. A comparison of Malaysian Smart School Project courseware with international interface design principles and government guidelines

4.1 Introduction

Because a primary goal of this research project has been to identify the strengths and weaknesses of the interface design within the existing interactive Science courseware of the Malaysian Smart School Project, the first process of data collection and analysis was guided by the question: Do the principles for effective interface design that have been established in the international literature appear in the Ministry guidelines that have been provided to courseware developers and have they been applied in the interactive courseware developed for the Smart School Project.

To establish an answer to this question, the established principles and characteristics of effective interface design in the international literature were first identified, then the existing guidelines of the Malaysian Ministry of Education (hereafter referred as the ‘Malaysian government guidelines’) were reviewed. These two sources therefore were compared in order to identify in-common principles and any omissions. Following that, a content analysis was conducted on a sample of existing interactive Science courseware to determine whether the principles and characteristics established in the literature and outlined in the Ministry guidelines were evident.

4.2 Contextual document review and analysis

The process of reviewing and analysing established interface design principles in the literature first involved with compiling a substantial collection of respected and frequently cited books, journals and online resources on interface and interaction design. At the local level (in Malaysia), documents relating to the
Malaysian *Smart School Project* were also collected from the Malaysian Ministry of Education, including guidelines for the design and production of interactive courseware that are provided to developers who have been successful in the tender process for the Malaysian *Smart School Project*.

With these documents in hand, procedures for a contextual document analysis were applied. First, the literature of international scholars was read and reread, and the general principles and characteristics that are recommended were identified. These were refined through a sorting activity process. As discussed in the methodology chapter, previous researchers have suggested that sorting activities are much more manageable if being conducted through a coding system that uses categories and keywords (Neuendorf, 2002).

Therefore, the general principles and characteristics were sorted by using specific keywords that were encountered in the sources or, where similar concepts are expressed through multiple terms, a generalised keyword were adopted to consolidate the various terms. Through a sorting activity process, these keywords were then grouped and, based on frequency of occurrence of the keywords; a list of the most common principles and characteristics that are established and cited in the international literature was derived. The outcomes are explained in the following section.

**4.2.1 Interface design principles in the international literature**

Throughout the literature, many scholars propose and promote principles, guidelines and characteristics to make interface design more effective and to encourage and accommodate end-users’ interaction. For this research project, the broad literature was narrowed down to six key texts for the purpose of a comprehensive review and the extraction of principles into a manageable data set. The selection was based on the following criteria:

1. The book and/or article that list clear principles for the effective design of interfaces for educational courseware.
2. The book and/or article is cited as the genesis for guidelines by multiple authors, and
3. The book and/or article gives a clear rationale for the guidelines and principles presented.

The texts that were included on these grounds are include the book by Donald Norman’s - “Psychology of Everyday Things” (1998); the book by Ben Shneiderman's - “Designing the User Interface: Strategies for Effective Human-Computer Interaction” (1987), Jakob Nielsen’s book -“ Designing User Interfaces for International Use” (1990); Deborah J. Mayhew’s book- “Principles and Guidelines in Software User Interface Design” (1992); Wilbert O. Galitz’s book - “The Essential Guide to User Interface Design: An Introduction to GUI Design Principles and Techniques” (2002); and the book by Jenny Preece’s - “Interaction Design: Beyond Human-Computer Interaction” (1994). They are discussed below through a brief overview of each:

Norman argues that principles are needed to guide the design process and he simply suggesting to designers that products should be intuitive is not enough. He also argues that it is very important for courseware developers to understand the needs of end-users and advocates that listening to intended users as a basic strategy for creating effective interface designs. This process of ‘User-centred design’ should be accompanied by a number of characteristics that draw on knowledge, needs and abilities of the users who will use the software, to ensure the usability and understand-ability of products can be improved.

Norman’s principles are based on the concept of a “user mental model”, which is can be described in brief as the user’s perception of the interface design, which determines the relationship between the user and the software. Out of this, Norman establishes seven general principles for effective interface design. By keywords, they include ‘visualisation’ (i.e. a clear visual explanation of how the application actually works), effective feedback (sending information back to the user about on actions taken and what has occurred through image, sound or animation or combinations of these), user constraints and freedoms, natural mappings (onto existing user knowledge and experience), consistency (the use of
similar elements, rules and operations throughout), flexibility, and a conceptual model.


Motivated to improve the usability of applications, Shniederman articulates a set of principles for effective interface design that are derived from heuristic evaluations of users’ experience. In which, Shniederman argues is a quick, cheap, and easy method for evaluating interface design. However, he also emphasises that designing interfaces is a complex and highly creative process that blends experience and careful consideration of numerous technical issues.

Moreover, Shniederman’s principles are focused on the productivity of users, the usability of the product, and are intended to help and facilitate rapid learning and performance, and a high degree of user satisfaction. Like Norman, he emphasises the role and experience of end-users in the principles he espouses. The primary eight principles, which are referred to as the “golden rules for effective interface design”, reflect this. They are (by keywords): consistency, sequences, (sequences that require the same thing in similar situations), familiarity (similar terminology and comparable commands in prompts, menus, help screens; and consistent colour), an efficient feedback (the interface should offer informative, immediate feedback from the system), simplicity, reversibility, constraints, and reduced short-term memory load. However, Shniederman principles are not only intended to help to create effective interface design but also to enhance interaction design.

3. Jakob Nielsen’s (1990)“Designing User Interfaces for International Use”

Also concerned with the importance of end-users in creating effective interface design, Nielsen believes that users spend most of their time focusing on the interface design of an interactive application when using it. He has therefore also adopted and popularised heuristic evaluation to improve the usability of interface design which, from Nielsen’s point of view, entails judging software against a small set of evaluators of usability and compliance with usability principles.
Nielsen argues that the ability of the user to learn to use the application is the most basic principle, because the first experience many people have with a new system is that of learning how to use it and they may invest a great deal of money or time on learning how to use a system. And, the more easily users control the system, the more they will value the application.

Out of this, the ten general principles suggested by Nielsen (by keywords) are the principles of visualisation (the use of accepted forms of visual explanations), familiarity, user constraints and freedoms, consistency, error prevention, recognition, flexibility (capacity to accommodate different levels of competence in end-users), aesthetic design (a look and feel that is appropriate to the target audience and product), efficient feedback (within reasonable time) and user tasks.


Mayhew similarly proposes that interface design should be developed with the goal of being clear and easily understood. She also highlights the importance of users’ interests in the principles she proposes. Compared with the text summarised above, Mayhew’s principles cover a wide range of aspects of interface design. Primarily however, Mayhew argues that developers should create a clear and easily accessed interface and, to this end, should accommodate variations in user skill and preferences.

Although her principles are very similar to other three scholars reviewed above, and share the aim that an interface design must be clear and easy to understand, Mayhew indirectly indicates that the users’ needs and experience should be harnessed. She argues that often the intended user of a new system is already a user of other systems. Thus, the across-product compatibility is important since it allows the user to adapt to a new system quickly.

Based on extensive research in the field of Human-Computer Interaction, the eight principles she proposes (by keywords) are compatibility (concepts, terminology, and spatial arrangements that the user is already familiar with, should be incorporated into the interface as this allows people to reason by analogy and
predicts how to do things they have never done before), consistency (similarities within a product, rather than across products), familiarity, simplicity and invisible technology (an interface should be relatively simple to understand by the user who need not be concerned with ‘back end’ processes), flexibility, efficient feedback, and responsiveness.

Galitz also identifies principles in common with the other scholars discussed above. Indeed, Galitz believes that interface is the system for most users, and his principles are based on User-centred design, where the needs of the user are of foremost importance and users are involved in the design process. His principles for creating effective interface design therefore emanate from the perspective of the end-user and emphasise that interfaces should be organized purposefully in meaningful and useful way.

The principles he suggested can be described (by keywords) as aesthetics, clarity (clear elements that are recognizable to users), compatibility, efficient feedback, consistency, familiarity and flexibility. He also argues that putting related elements together, differentiating dissimilar elements and making similar things resemble one another will provide ease of use and that interface design should keep users informed of any actions or errors through clear and concise language that they are familiar with. Indeed, he suggests that use terms and concepts that are familiar to users that taken from the experience of the user who will make most use of the system.

Preece et al. establish user-centred principles for interface design that are tied to effective user interaction and derived from the field of Human-Computer Interaction. They argue that interface design must take account of the user’s needs, experience and capabilities with the system, accommodate users’ varying interaction styles, and limit the frustrations they encounter. And they illustrate the proposed principles through case studies for the benefit of extending the skills of
developers through examples. Six specific principles (by keywords) relate to simplicity, visualisation, efficient feedback, consistency, affordances (consideration of the different type of user interaction required for different types of system), tolerance (designers should be aware of user’s physical and mental limitations (e.g. limited short-term memory) and should recognise that user often make mistakes).

While, each of these scholars has established principles and guidelines from different perspectives and research frameworks such as User-Centred Design, Heuristics, Usability Evaluation, and Human Computer Interaction, by and large they are similarly focused on understanding and supporting users’ needs and providing them with an enjoyable experience and achievement through the software application.

By applying a thematic system, these various principles have been categorised to establish a shorter list of in-common principles. Similar concepts have been categorised under a representative keyword. For example, the principle of compatibility established by Mayhew serves the same meaning as the principle of visualisation by Nielsen. Thus, one keyword that is most frequent and recognised has been applied to encompass both terms.

The process of categorising the principles was concluded by calculating which are most frequently used. Table 4.1 shows the outcome of this systematic content analysis of the principles identified in the works of the six authors through association with relevant keywords.
### Key Texts

| 7 principles based on user mental model (Norman, 1998) | 1. Visualisation  
2. **Efficient Feedback**  
3. User constraints and freedoms  
4. Natural Mappings  
5. **Consistency**  
6. Flexibility  
7. Conceptual models |
| 10 general principles of user interface design for Heuristics evaluation (Nielsen, 1990) | 1. Visualisation  
2. **Familiarity**  
3. User constraints and freedoms  
4. **Consistency**  
5. Error prevention  
6. Recognition  
7. Flexibility  
8. **Aesthetically pleasing**  
9. **Efficient Feedback**  
10. User tasks |
| 8 Golden rules of interface design for good interaction design (Shneiderman, 1998) | 1. **Consistency**  
2. **Familiarity**  
3. **Efficient Feedback**  
4. Sequencing  
5. Simplicity  
6. Reversibility  
7. Constraints  
8. Reduced short-term memory load |
| 8 interface design principles and guidelines for software developers (Mayhew, 1992) | 1. **Consistency**  
2. **Familiarity**  
3. Simplicity  
4. Flexibility  
5. **Efficient feedback**  
6. Responsiveness  
7. **Aesthetically pleasing**  
8. Invisible technology |
| The basic principles of interface design (Galitz, 1997) | 1. **Aesthetically pleasing**  
2. Clarity  
3. Compatiblity  
4. **Efficient Feedback**  
5. **Consistency**  
6. **Familiarity**  
7. Flexibility |
| General principles for interface design (Preece, 1994) | 1. Simplicity  
2. Visualisation  
3. **Efficient Feedback**  
4. **Consistency**  
5. Affordances  
6. Tolerance |

### Table 4.1: Summary of most frequently occurring recommended principles of interface design in the key literature (by keyword).

As shown in Table 4.1, the five most frequently occurring principles derived from the content analysis of the key texts are (in order of frequency) : consistency of symbols and layout within a product; familiarity with design elements; flexibility...
of the system’s response to the individual differences of users, efficient feedback provided to the user, and finally, an aesthetically pleasing interface.

4.2.2 An explanation of the key interface design principles extracted from the international literature

These five persistently cited principles for effective interface designs might be considered an essential component or even the most minimal guidelines for courseware developers. The following section describes each of them in detail.

1. Consistency within the design of a product
Throughout the literature, consistency is most commonly cited as an important principle for providing effective interface design. This principle emphasises the importance of uniformity throughout a product in aspects of the design such as colour schemes, screen composition and layout, location of elements (such as menus and navigation), the sequencing of tasks and content, and function and behaviours of attributes to ensure that similar operations are performed through the same elements. All of texts analysed advise designers to avoid inconsistencies from screen to screen (for example in the background colour used), because inconsistency is one of the most significant factors negatively affecting the rate of the application use.

Most of the texts analysed (five out of six) also explain consistency by reference to the use of similar design features and standard commands. For example, Norman (1998) and Mayhew (1992) suggest that similar label names and consistent colour schemes should be used within an application and similar buttons should be used and be located in consistent places. Shneiderman (1987) and Preece (1994) therefore suggest that similar icons within sequences of action and the use of the same terminology will lead to consistency in the presentation of the interface. And Mayhew (1992) argues that user focus may be increased through the incorporation of similar features and standard presentations within the application.
2. **Familiarity with elements and functions from prior experience**

Interface design is a form of communication design, with its primary goal being to provide efficient functionality and access to the content of an application. To achieve this, the use of familiar concepts, terminology and procedures allow the user to quickly become comfortable with the courseware system. All of the scholars mentioned above suggest that the principle of familiarity relates to the use of standardised terminology, icons, signs and layout that relate to the user’s prior knowledge—either what they have already learnt through other applications or in their day to day life. Moreover, through the use of techniques that the user already understands, and familiar concepts, images and maps that are built upon real world experiences (through metaphors), users are able to get started and make progress with the application more quickly.

3. **Flexibility of the system’s response to the individual differences**

All of the above-mentioned scholars refer to the principle of flexibility as the capacity of the application to accommodate different levels of competence. According to Shneiderman (1987), there are at least three levels of end-users that must be considered: the novice, the intermittent user and the expert. A novice user has no syntactic knowledge of the system, while an intermittent user is one with little syntactic knowledge, and a frequent or expert user has considerable prior knowledge and experience with similar applications.

While most of the scholars (four out of six of them) state that users need instant access to the functions they use, along with features that help them to escape or end the courseware system, these must be understood differently in relation to different users. Providing clear navigation for example, helps to ensure that all users are able to quickly learn how to find their way around. In this case, shortcuts might be provided to the expert user. As Mayhew (1992) points out, a one-click return to the home-page and a way of confirming where the users are in system, is necessary on each screen; but as Galitz (2002) and Shneiderman (1998) explain, a button or link that jumps directly to what users are looking for (for example, the main menu or the exit button) should appear on every screen to alleviate frustration with the application, once a user becomes expert.
4. Efficient feedback given to the user
It is well established in the literature that users are most likely to adopt software if it provides feedback through reporting a current status, action or error message effectively. Norman (1998) argues that feedback involves sending back information about what actions have been taken and what has been accomplished. Shneiderman (1998) also suggests that well designed interfaces should present appropriate and immediate feedback and place an emphasis on users’ actions. Similarly, Galitz (2002) proposes that informative feedback encourages users to continue with an activity. Nielsen (1990) therefore elaborates that interface design should notify the user in a clear and understandable way of any relevant actions, exceptions, changes of state or condition, or errors that have occurred through sound or visual cues in textual or graphical form. This helps users to gauge the effects of their actions.

5. The principle of visual communication through an aesthetically pleasing appearance of the screen
The fifth most frequently mentioned design principle in the literature relates to the aesthetics of the screen. As Szabo and Kanuka (1998) have established, an aesthetically pleasing and targeted screen appearance leads to end-users spending more time using an application. Aesthetics in this sense relates to the “look and feel” of the interface appearance. If targeted to the user group (in e.g. specifically for children in terms of colours used, etc) and reflective of the intent of the application, a well designed aesthetic approach can help to motivate users to adopt the application.

However, most of the texts analysed in depth (five out of six of them) also explain that the use of visual design elements should empower the user to clearly see what functions are available in the courseware and what the courseware is currently doing. To this end, visual communication elements must be carefully considered and it must be understood that icons, fonts, colours, animations, graphics and layout can affect the perceived, as well as real effectiveness of the interface and application. In essence, aesthetics are one of the higher order needs of end-users and provide a motivator for users to engage with the courseware system as well as make sense of it through the visual communication it provides.
Specific characteristics of these common principles also been identified through analysis conducted. As presented in Table 4.2, which follows, each principle can be broken down into particular characteristics, which can be complied into detailed guidelines. For example, the principle of consistency is accompanied by five particular characteristics that cover aspects of the overall screen layout, elements used and positioning of the main menus. The principle of familiarity with elements and functions from prior experience is accompanied by specific characteristics that include the use of standard commands, concepts and terminologies that users are already familiar with. The principle of flexibility involves particular characteristics that provide access for different levels of intended users such as the use of the elements (such as the text) that are easy to read and instructions that are direct and clear for the novice users, but must also include shortcuts. And the principle of efficient feedback given to the user is based on five characteristics that relate to clear and immediate feedback messages through for example confirmation dialogue to support the actions of the user. And finally, the principle of pleasing aesthetics and visual communication involves characteristics that relate to comfort with the screen appearance and the ability to achieve information through effective visual communication.

In summary, eighteen specific characteristics were extracted from the literature for five most commonly cited principles in the international literature. These are detailed in Table 4.2.
<table>
<thead>
<tr>
<th>Principle</th>
<th>Summary Description</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>The principle of consistency within the design of a product</td>
<td>The use of design features and layout of components within the screen should be consistent and the same actions or commands should be required for the same function.</td>
<td>1. Consistent screen layout</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Persistent use of design elements</td>
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<td></td>
<td></td>
<td>3. Persistent position of main menus</td>
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<tr>
<td></td>
<td></td>
<td>4. Consistent tools and navigation menus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5. Same effects for the same action</td>
</tr>
<tr>
<td>The principle of familiarity with elements and functions from prior experience</td>
<td>To ensure that the system and functions are easy to learn, the concepts, terminology, icons and arrangement of elements should relate to prior knowledge and experiences of users in other contexts.</td>
<td>6. Standard commands should be used.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7. Concepts, icons and terminology should be used that are familiar from other applications or real life.</td>
</tr>
<tr>
<td>The principle of flexibility of the system’s response to the individual differences</td>
<td>The courseware should cater to different levels of experience and preferences of individual users. This includes aspects of the navigation and functionality.</td>
<td>8. Design elements must be suitable to the intended user (age, experience etc)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9. Text used must be easy to read and appropriate.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10. Navigation should be self-evident as well include shortcuts, actions should be visually evident but commands may be used for efficiency</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11. Sound and/or text should be provided as alternatives to visual icons to cater for different learning styles.</td>
</tr>
<tr>
<td>The principle of efficient feedback given to the user</td>
<td>The system should constantly notify the user via clear and immediate feedback on each action performed to inform them of where they are, what they have done, and what the system needs them to do next.</td>
<td>12. Constantly keep the user informed about their current location.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13. Provide immediate feedback on actions performed through visual signs, audio effects, animations or a combination of these.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14. Feedback given should be informative and helpful to the user.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15. Feedback messages should be clear and easy to understand.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16. A confirmation dialogue should be used to prompt action.</td>
</tr>
<tr>
<td>The principle of visual communication through an aesthetically pleasing appearance of the screen</td>
<td>The screen appearance of the courseware must be both appropriate to and appealing to the target group, and ensure that users can tell what functions are available, what alternative actions need to be taken and what is being done.</td>
<td>17. Provide the user with the elements that are visually enjoyable to use.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18. Carefully consider the effectiveness of icons, fonts, colours, animations, graphics and layout to make sure that they are easy to understand and effective in communication.</td>
</tr>
</tbody>
</table>

Table 4.2: The characteristics of common interface principles, as extracted from the literature
4.2.3 The Malaysian government guidelines

The Malaysian government, through the Ministry of Education, has provided detailed guidelines to courseware developers as a tool to guide the development process of interactive courseware for the Malaysian *Smart School Project*. The next process of data collection in this research project involved the analysis of these guidelines, in order to evaluate them against the principles, characteristics and guidelines established in the international literature. Following this, an evaluation of the existing interactive courseware was undertaken to determine whether principles, characteristics and guidelines established and outlined have been applied by the courseware developers.

Following the same coding and sorting activity process outlined in the previous section, the principles outlined in the Malaysian government guidelines were collated and then were checked against the list of principles established in the international literature. The purpose of this process was to establish the most in-common interface design principles and characteristics in two different sources and whether the guidelines are comprehensive, too limited or too broad, when compared to the principles established in the literature.

These Ministry guidelines contain an introduction and summary of the guidelines’ purposes, followed by two sections. The first section provides overall architectural design guidelines with a description of design criteria and principles to be followed. The second section deals with the design process and production flow. In this chapter, the first section of the Ministry guidelines is reported (the second section is discussed in Chapter 6).

An image of the architectural design guidelines provided by the Ministry to courseware developers is reproduced in Figure 4.1. It contains design standards for the storyboard design, instructional design, interface design, technical standards, and references.
Figure 4.1: Part of the Malaysian government guidelines

Within the guidelines, each design aspect is presented with an individual explanation. A summary of topics and sub-topics is presented in Table 4.3.

<table>
<thead>
<tr>
<th>Design Aspect</th>
<th>Components</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Storyboard design</strong></td>
<td>Layout</td>
</tr>
<tr>
<td></td>
<td>Navigation</td>
</tr>
<tr>
<td></td>
<td>Graphics / Animation / Video placement in the overall structure</td>
</tr>
<tr>
<td></td>
<td>Content placement in the overall structure</td>
</tr>
<tr>
<td></td>
<td>Audio Script inclusion</td>
</tr>
<tr>
<td><strong>Instructional design</strong></td>
<td>Content / Concept / Skill Learning</td>
</tr>
<tr>
<td></td>
<td>Practice / Activity</td>
</tr>
<tr>
<td></td>
<td>Test / Assessment / Evaluation</td>
</tr>
<tr>
<td><strong>Interface design</strong></td>
<td>Navigation</td>
</tr>
<tr>
<td></td>
<td>Montage with the Malaysian Government logo</td>
</tr>
<tr>
<td></td>
<td>Screen elements</td>
</tr>
<tr>
<td></td>
<td>Text</td>
</tr>
<tr>
<td></td>
<td>Graphics</td>
</tr>
<tr>
<td></td>
<td>Animations</td>
</tr>
<tr>
<td></td>
<td>Audio</td>
</tr>
<tr>
<td></td>
<td>Video</td>
</tr>
<tr>
<td><strong>Technical requirements</strong></td>
<td>Specifications</td>
</tr>
<tr>
<td></td>
<td>Environment/ contextual requirements of the classrooms</td>
</tr>
<tr>
<td><strong>Language and References</strong></td>
<td>Language</td>
</tr>
<tr>
<td></td>
<td>English : Oxford Advanced Learner’s Dictionary</td>
</tr>
<tr>
<td></td>
<td>Malay : Kamus Dewan Bahasa dan Pustaka</td>
</tr>
<tr>
<td></td>
<td>Sign language</td>
</tr>
<tr>
<td></td>
<td>Malay : Kod Tangan Bahasa Melayu (KTBM)</td>
</tr>
<tr>
<td></td>
<td>English: American Sign Language (ASL)</td>
</tr>
</tbody>
</table>

Table 4.3: Design components covered in the Malaysian government guidelines for courseware development
The section on interface design standards is the largest component of the Malaysian government guidelines. It covers the navigation design and screen design, and focuses on the specifying of the necessary characteristics of the design elements including text, graphics, animation, audio and video components. The details that are provided are summarised in Table 4.4.
## Interface Design Standards and Necessary Characteristics

<table>
<thead>
<tr>
<th>Interface Design Standards</th>
<th>Necessary Characteristics</th>
</tr>
</thead>
</table>
| **Navigation**             | • Introduction section shall be a multimedia presentation, between 15-30 seconds, which shall include any combination of text, animation, graphics and/or audio.  
• Users shall have the flexibility to navigate to the next and previous activity, to pause and continue an activity, and to exit.  
• All icons must have “mouse over” effects.  
• Test pages should have a confirmation dialogue.  
• Every page should be easy to use.  
• Every lesson must have the same introductory montage with the Malaysian Government logo to give a standardized look. |
| **Screen Display**         | Colours for the total screen area shall provide contrast between the foreground and background. |
| **Text**                  | • Titles should use capital letters.  
• Colours used for text shall contrast against the background of the screen.  
• Fonts: Sizes and font types shall be limited to no more than 3 variations per page. |
| **Graphics**              | • All graphics must be clear.  
• All characters used (e.g. animal, human):  
  1. Must be approved by the Ministry and be used again and again for consistency  
  2. Shall be logical and not contradictory to real life situations and must enhance or support learning  
  3. Biases in graphics or animations (gender, ethnicity, religion, etc.) must be avoided.  
• Colours used should be suitable for the age group concerned.  
• Any visuals should include sound effects to sustain student interest. |
| **Animations**            | Shall be used for the purpose of supporting and enhancing learning. |
| **Audio**                 | • Voice, music narration, sound or song if include must be appropriate and should be clear.  
• Voices used:  
  1. Voice talent should be appropriate to the gender and age of the character portrayed in the courseware.  
  2. Correct pronunciation and clear intonation with neutral ethnic accent must be used.  
• Audio icons shall be provided to enable users to choose to listen. |
| **Video**                 | Video frames should be at least 240 X 180 pixels |

**Table 4.4:** The characteristics of interface design components identified in the Malaysian government guidelines.
As shown in Table 4.4, the most emphatic requirements are that interactive courseware must include a combination of text, animations, graphic images and audio components; that each page or screen should appear in such a way that it is clear and easy to use by the intended users; and the same introductory montage with the Malaysian Government logo also must be included in each lesson. In addition, specific guidelines are provided to reflect the cultural diversity of Malaysia. It is stated clearly that the courseware must avoid ethnic, cultural and religious biases in all graphic images of characters (for example, an animal or human character). Furthermore, it is also advised that all the audio, especially for the talent voice, should have a clear intonation with neutral ethnic accent and correct pronunciation. All of these design components must be approved by the Ministry; making the guidelines absolute.

It must be noted that the guidelines highlight only these basic requirements, which are not explained in detail, so it making difficult to clearly interpret and gain a comprehensive understanding of the requirements at face-value. Nonetheless, the same keywords system was used in the analysis of the guidelines, using similar keywords that were employed in the content analysis of the literature. The categorising of the guidelines against the keywords was conducted manually.

Four categories were clearly identified. They are (by keywords): consistency (of the style and standard elements within a product); familiarity (through recognizable elements and functions found in other systems and real-life activities); flexibility (where elements and commands should incorporate flexibility to accommodate different user preferences and levels of expertise) and efficient feedback (given to the user on their location, after actions, and prompts to action).

The principle of an aesthetically pleasing appearance of the screen was not explicitly mentioned, however if we consider this principle in terms of its characteristics, it becomes more clearly evident, as do the other recommended principles. The key principles extracted from the literature are therefore mapped against the corresponding summaries of the required characteristics that appear in the Ministry guidelines in Table 4.5.
<table>
<thead>
<tr>
<th>Principles</th>
<th>Malaysian Guideline Descriptors</th>
<th>Characteristics in the literature</th>
<th>Characteristics in the Malaysian guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>The principle of consistency within the design of a product</td>
<td>The use of design features for colours, text, characters, and icons should be consistent and the system should provide similarities in commands, actions, prompts, menus, and help screens.</td>
<td>Similarities of the screen layout</td>
<td>Clear sequencing of the screen appearance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consistency of elements used</td>
<td>Similarities of colours used across screens</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Same effects for the same action</td>
<td>Limited text styles</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Persistent position of main menus</td>
<td>Use of similar characters throughout</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Consistent tools and navigation bar</td>
<td>The same actions should yield the same result</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Standard tools on navigation bars</td>
<td>Consistent positioning of main menus</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The same montage used for the introduction to be used in all pages</td>
<td>Standard tools on navigation bars</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Human and animal characters shall be logical and not contradictory to real life situations</td>
<td>The human and animal characters used should be familiar characters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Concepts and terminology should be used that are already familiar from other contexts.</td>
<td>The human and animal characters used should be familiar characters.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Design elements must be suitable to the intended user (age, experience etc)</td>
<td>Provide the user with buttons to pause, continue, go back or exit the activity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Text must be easy to read and appropriate.</td>
<td>Provide the user with appropriate working sounds</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide the user with flexible navigation including self-evident paths and shortcut options</td>
<td>Provide confirmation dialogues to prompt user actions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide users with appropriate working sound and/or text as alternatives to visual icons and feedback.</td>
<td>Avoid biases of ethnicity and religion in any images</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Colours must be suitable to the age of the user</td>
<td>Avoided biases of ethnicity and religion in colour used</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Visual images must be suitable for the age of the user</td>
<td>Visual images must be suitable for the age of the user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The audio used for human characters must be appropriate to gender and age of the character</td>
<td>Colours must be suitable to the age of the user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The audio effects used as alternatives to symbols or icons must be age-appropriate</td>
<td>Colours must be suitable to the age of the user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The text characters must be easy to read</td>
<td>The text characters must be easy to read</td>
</tr>
</tbody>
</table>

Table 4.5: Contextual analysis: The principles, guidelines and characteristics outlined in the Malaysian government guidelines mapped against the principles in the international literature.
<table>
<thead>
<tr>
<th>Principles</th>
<th>Malaysian Guideline descriptors</th>
<th>Characteristics in the literature</th>
<th>Characteristics in the Malaysian guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>The principle of efficient feedback given to the user</td>
<td>Any user action should have a confirmation dialogue that is provided either in sound or images to sustain user interest.</td>
<td>Constantly keep the user informed.</td>
<td>Provide accurate responses in the confirmation dialogue.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Provide the user with the immediate feedback on actions that the user performs by using visual signs, audio effects, animations or combination of these.</td>
<td>Provide users with visual or audio effects on actions that the user performs.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feedback given after a response by the users should be informative and helpful.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feedback messages should be clear and easy to understand.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Confirmation dialogue helps to ensure user actions.</td>
<td></td>
</tr>
<tr>
<td>The principle of visual communication through an aesthetically pleasing appearance of the screen</td>
<td>The screen appearance of the courseware must ensure that users can tell what functions are available, what alternative actions need to be taken and what is being done.</td>
<td>Provide the user with the elements that are easy, effective, and enjoyable to use.</td>
<td>Each element used shall be attractive to the intended users and encouraging.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Carefully consider the effectiveness of icons, fonts, colours, animations, graphics and layout.</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.5: Continued
In general, the mapping in the Table 4.5 shows that many of the descriptions and characteristics outlined in the Malaysian government guidelines are quite similar in spirit to the characteristic of the principles that are most frequently mentioned in the key literature. For instance, the principle of consistency emerges within the prescribed characteristics in the Malaysian government guidelines through a focus on requiring a similar position; similar design features for elements such as colours, text, characters, and icons; standard commands or actions; style of the main menu, as well as the use of consistent colours, text and characters. Another important requirement is that the interactive courseware shall commence with the same introductory montage in each product. Therefore, we can conclude from this comparative analysis that both, the international literature and the Ministry guidelines proposed the similar characteristics to consistency within a product.

In terms of the principle of familiarity, the Malaysian government guidelines highlight that design features (such as graphics, icons, audio) should be used repeatedly throughout the system and the courseware packages more broadly, and that images of human characters should be based on familiar characters from books and elsewhere. This standardisation is intended to ensure that the intended users will immediately feel a sense of familiarity with the courseware, and illustrates a concern for the needs of the users in the Ministry guidelines. The international literature therefore similarly highlights the importance of standardisation of concepts, terminology and arrangements of the elements in ensuring the effectiveness of interface design.

With regards to the principle of flexibility, the characteristics of this principle as they are outlined in the literature include the importance of elements and commands accommodating different user preferences and levels of experience. This is reflected in the characteristics recommended by the Ministry that are focused on providing icons, visual images, colours, fonts and sound that are appropriate to the age of the users. It also reflected through reference to the local context, in the instruction to avoid biases regarding ethnicity, culture and religion in any images and colours used within the courseware, to help in ensuring that the software is suitable to all Malaysian ethnic groups. That is, the Ministry guidelines are concerned with the important of accommodating diverse users including the
particular demands of the local context (a factor that has not been mentioned by any of the six scholars whose literature was reviewed).

In terms of the principle of the efficient feedback, three characteristics are outlined in the Ministry guidelines. They are that the interface design shall allow users to perform the task properly, users must be provided with the visual or audio effects upon the actions they perform, and accurate responses must be made through a confirmation dialogue. This is to ensure the users are kept informed about where they are, what they are doing, and what the system requires as well as to sustain user interest. Therefore, it can be concluded through the comparative analysis of the guidelines against the literature that the Ministry guidelines are relatively similar in relation to the principle of feedback messages that are clear, useful, persistent and easy to understand.

While the principle of aesthetics in not explicitly mentioned in the Ministry guidelines as a specific requirement as it comprehensively is in the international literature, some of its characteristics are clearly identifiable. For example, the characteristics outlines by the Ministry include that the design must be attractive and encouraging the intended users (which is similar to descriptions explained in the literature), and visual communication is also indirectly referred to through the requirement that all elements must be clear, easy to understand. Thus, it can be concluded that the principle is considered in the Ministry guidelines. However, as established in the literature, while rating the aesthetic appearance of the screen can appear to be very subjective, aesthetic visual appearance is important as it helps to gain the attention of users and raises their interest in using the courseware. This aspect of the principle of aesthetics should therefore be more clearly articulated in the Ministry guidelines in future in order to provide a clearer understanding of its importance to future developers.
4.3 Content analysis: Interactive science courseware for the Malaysian Smart School Project

After completing the contextual and document analysis of the literature and Ministry guidelines, and establishing the specific principles and characteristics that are recommended by both, the data collection and analysis process proceeded to a content analysis of a sample of interactive Science courseware developed for the Malaysian Smart School Project. The purpose of this analysis was to conduct an empirical evaluation of the courseware through its comparison with the recommendations of the literature and the Ministry guidelines.

Interactive Science courseware is part of the pilot project software used in the teaching and learning of Science subjects for year 3 (9 year old students) in designated schools in the Malaysian Smart School Project. This interactive courseware was developed by multimedia developers/vendors appointed by the Ministry of Education. The design platform for this interactive courseware is stand-alone packages of CDs (comprised of three CDs per pack) as shown in Figure 4.2. The language used is English.

![Interactive Science courseware for the Malaysian Smart School Project](image)

**Figure 4.2:** Interactive Science courseware for the Malaysian Smart School Project
The process used in this evaluation was content analysis. As mentioned in the methods section in Chapter 3, it is defined in the literature as a reliable technique for determining consistency and differences between multiple variables within documents, artefacts or screen-based content (West, 2001). The overall interpretation and evaluation should be conducted through a coding system to determine patterns and generalities within a sample (Neuendorf, 2002). A sample of interactive science courseware (3 main CDs enclosed three main topics with twenty-six corresponding lessons topic) was therefore scrutinised through content analysis, and a comparison was made through a sorting activity process using a coding system.

That is, in this research project, content analysis was used as a technique to ascertain what principles, characteristics and components have been consistently used in the sample of interactive Science courseware and then compare these to the principles established in the literature and the Ministry guidelines. The process began by reviewing each screen of the courseware. The five principles described above, namely consistency, familiarity, flexibility, efficient feedback and aesthetics were used as referents. The occurrence of the principles and characteristics was recorded and calculated manually as the review was conducted.

4.3.1 Overview of the interactive Science courseware
As an overview, the interactive Science courseware consists of three main topics, namely: Learning about living things: Animal and plants; The world around us (Part 1); and The world around us (Part 2). Each main topic is presented as a series of lessons. For this research study, three main topics and the twenty-six corresponding lessons were reviewed. Table 4.6 shows how these lessons are arranged in the content of a courseware package.
### Main Topic | No. of lessons and titles
---|---
**Learning about living things: Animal and plants** | 1. External Features of Animals  
2. How to Group Animals  
3. Different Ways to Group Animals  
4. External Features of Plants  
5. How to Group Plants  
6. Different Ways to Group Plants

**The world around us (Part 1)** | 1. Magnets Attract or Repel  
2. Handling Magnets  
3. Material that Magnets Attract  
4. Strengths of Magnets  
5. Uses of Magnets  
6. How To Make A Bulb In A Circuit Brighter or Dimmer  
7. Materials that Allow Electricity to Flow Through  
8. A Switch  
9. Bending, Twisting, Stretching and Squeezing a Spring  
10. Springs Stretch Differently  
11. The Uses of Springs

**The world around us (Part 2)** | 1. Material that Can Absorb Water  
2. Some Material Can Absorb More Water Than Others  
3. The Uses of the Ability of Material to Absorb Water  
4. What is Soil Made Up of?  
5. The Flow of Water Through Different Type of Soil  
6. Suitable Soil for Plant Growth  
7. Different Substances have Different Properties  
8. Unsafe Substances  
9. Separating Mixtures

---
**Table 4.6:** Content of the interactive science courseware for year 3 (9 year old students)

Each CD in the suite of interactive Science courseware includes some preliminary components, which can be described as a front page or opening page, an introductory page, followed by a tutorial section and/ or enrichment activity section followed by a test section. Detailed explanations on each section follow.

1. **The Opening Sequence**

Upon inserting the courseware into the CD drive, the application automatically plays an introduction. First, both the Ministry logo and the name of the Malaysian Ministry of Education are presented together. Then the subject name and year level are shown, as illustrated in Figure 4.3.
2. The Introduction
An introductory screen then shows the title of the main topic and each lesson and a connected lesson topic (as shown in Figure 4.4a). A button at the bottom of the page offers users the option to skip this introduction. As shown in Figure 4.4b, brief information is then provided about the main topic, lesson topics and the overall theme to ensure students and teachers understand the nature of the lesson that is going to be presented.

To start using the application, users only need to click on which lesson topic she/he would like to learn. The text and graphics are complemented by animation and sound/audio components. Indeed, most of the introductory section is presented in the form of an animated drawing.
3. The Lesson or Tutorial Page
After the application is launched and a topic chosen, students are presented with an animated scene that introduced the title of the lesson. This leads to a tutorial or lesson page, which contains a list of links to content. In terms of the navigation system, this employs a standard interface design rule by integrating the menus of the three sections into one page, which allows students and teachers to navigate through the whole of the courseware easily and out of sequence if desired.

When a link is selected, a new screen opens, which contains several fields. A heading frames the lesson title at the top of the screen, which provides information on the lesson chosen. The main navigation remains visible at the bottom of the screen, which allows users to go back to the main page to select a different topic or exit from the application. Above it, a series of menu buttons frame of the separate lessons that are incorporated in the topic. A screenshot of an example lesson page is shown in Figure 4.5a.

Figure 4.4b: Screenshots of the introduction showing the topics that can be selected and the change state when a lesson has been chosen.
There are four or five options in these menus that scaffold each lesson. They include ‘Introduction’, ‘Learning’ (which may have multiple parts), ‘Test’ and ‘Enrichment’. This menu is located in the bottom centre of the screen and has mouse over links to indicate that parts of the screen are clickable.

Once the introduction is selected, the application will automatically play the content according to the intended sequence, starting with the introduction and ending with the test page. The links change in colour to reflect the current section that the user is in. Each screen within the lessons includes a combination of text, graphics, animations and sound/audio components. A screenshot of an example page of the learning content is shown in Figure 4.5b.
4. The Test Section

The test section contains several features. First, it provides students with an enrichment activity in order to ensure that they gain in-depth understanding of the subject content. Like other sections, the test section combines rich multimedia elements including multiple colours, animations, video and audio components, to engage users. A variety of question types are then presented. For instance, multiple-choice methods of answering are provided, which include drag and drop approaches (shown in Figure 4.6a), filling in working answers (shown in Figure 4.6b), and matching working answers (shown in Figure 4.6c).

![Figure 4.6: The introduction to the test page](image)

![Figure 4.6a: Questions on the test pages requiring a drag and drop response](image)

For the method of answering through drag and drop, users can choose any answer by simply clicking on it and dragging it into the question set.
For the method of filling in working answers, users are given multiple choice options. They must type the answer in the space provided or click on an answer choice.

Another style of answer mode is the mix and match procedure, in which users must click on the right answer and drag it to the image. Figure 4.6c shows an example.

Once questions are completed, there is the option to click on the check button to see whether the answer is correct. If not, the right answer appears. Once users finish answering all the questions, they must click on the ‘submit’ button.
Overall, the content analysis of the interactive science courseware confirms that each sections uses all five major interface design components outlined in the Ministry guidelines, namely: text, images, video, sound or audio and animation. Indeed, most individual pages have been designed with a combination of three to four component types. For example, screens in the Lesson sections are often designed with combinations of text and visual images, blended with video or animations. Thus it can be concluded that the designers of the courseware have followed the suggestion of the Malaysian government guidelines to incorporate a combination of rich media.

**4.3.2 Principles, characteristics and components used in the sample of interactive Science courseware**

To evaluate the interface design of the interactive Science courseware, an analysis of it was performed in relation to the key principles, characteristics and components that have been discussed in the previous sections on the literature and the Malaysian Government guidelines (Section 4.2.2 and Section 4.2.3). Each screen was carefully analysed using the keywords derived from the five most commonly referred to principles and their characteristics, as found in the selected international literature and in Malaysian government guidelines. Using sorting activity procedures, the screen pages that contained the principles, characteristics and components were recorded and the frequencies were calculated.

From the analysis of all screens in the twenty-six lessons in the sample of interactive Science courseware, all five principles were found, as follows.

1. **The principle of consistency within the design of a product**

The principle of consistency, which is identified in the literature as one of the primary principles for creating effective interface design, pertains to the importance of standardisation in appearance, placement, and actions throughout the interface, whereby the system should look, act and operate in the same way. This characteristic is also specified in the Malaysian government guidelines as one of the characteristics that should be followed by the developers. The review of
the interactive Science courseware indicated that, on the whole, the principle of consistency is broadly evident.

In terms of design elements, the style of screen layout is consistent in terms of the standard elements used, as is the introductory montage. A standard style guide is used for the main menu and titles, and fonts used and image styles are consistent overall. The same typeface (Arial) is also used consistently within the lesson topics across the courseware as shown in Figure 4.7.

![Figure 4.7: The same typeface is used within the different lesson topics](image)

In terms of titling, the Malaysian government guidelines require the courseware to provide similar styles in the opening montages and this was found to be the case (as shown in Figure 4.8).

![Figure 4.8: The same style of opening montage in the opening page for different lesson topics](image)
This similarity was also noted in typefaces used in the title pages, as well as layout. As shown in Figure 4.9, the same font is used and the position of the lesson title persists in subtitles and through different lesson topics, whereas differences appear in the colour used for the typeface.

![Figure 4.9: Similar lesson titles](image)

It should be noted that in terms of colour, although the Malaysian government guidelines explicitly emphasize consistency of colours, not only the titling, but also the background of the Tutorial sections clearly use different colour themes for each different lesson topic. Figure 4.10 shows screenshots that illustrate that while the similar screen layout and styles are used, different colour theme for different lesson topics employed in the first page of the Tutorial section.

![Figure 4.10: Similar styles of screen layout with different colour themes for different lesson topic](image)
While this may appear inconsistent in terms of the overall product, it has important functions. The colour differences in the environment of each lesson indicate a different feel or environment for each lesson, which both differentiates them from each other, and helps to orientation the user if they are moving back and forth between lessons. It also serves to aid memory through colour association if the lesson is returned to at a later time. Since other stylistic factors are stable, and colour is consistent within lessons, it can be assumed that this is a conscious and purposeful deviation from the guidelines.

In terms of the use of human characters, the same character is used repeatedly for the teacher (shown in Figure 4.11) within the lessons in the courseware. And, while the characters of the children change, they are illustrated in similar cartoon style.

![Figure 4.11: The same characteristic used repeatedly in different lesson topics to represent the teacher](image)

In terms of navigation, a group of similarly styled icons are used to represent the various tools of the application and this set of icons is consistently used throughout. The standard navigation bar (Figure 4.12) is placed in a similar position at the bottom of each screen (Figure 4.13).

![Figure 4.12: Sample of navigation bar](image)
In conclusion, the content analysis of the courseware shows that the characteristics relating to the principle of consistency and the related requirements in the Malaysian government guidelines are largely evident in the design of the interfaces. Design elements such as fonts and colours are consistent in all respects but in the purposeful differentiation of topics and, along with persistent icons and characters and standard positions and layout, the intended audience (particularly the students) are provided with orientation and a reliable understanding of commands and their locations across the product. Thus, it has been noted that the principle of consistency appears have been followed closely in the development of this interactive courseware. However, this principle will be returned to in the discussion on the next phase of analysis (observational of fieldwork) in Chapter 5.

2. The principle of familiarity with elements and functions from prior experiences

As has been explained, the perception of an efficient system depends not only on internal consistency, but the extent to which it conforms to the conventions of other systems, and so induces a sense of familiarity from the outset. For example, most applications and web sites use standard navigation bars, familiar icons and standardised commands, but they also use metaphors and real-life references to assist users to understand concepts. This provides the perception of familiarity and also helps to reduce confusion.
The interactive science courseware that has been developed for the *Smart School Project* also provides familiarity through the repetition of some visual images, icons, buttons, and background characters that appear throughout the lessons. As shown in Figure 4.14, the same animal characters, who is identified as “Sang Kancil”, is used to explain the lesson content across the courseware. This animal character is a well-known animal character in Malaysian children’s’ bedtime stories. Furthermore, the use of such well-known animal characters by the developers provides evidence that the developers of this courseware have deliberately adopted the principle of familiarity.

![Figure 4.14: “Sang Kancil” is a recognisable character across the interactive Science courseware](image)

3. **The principle of flexibility of the system’s response to the individuals’ differences**

As has been established, the principle of flexibility is necessary to ensure that courseware is responsive to the individual differences of users, including their preferences, age levels and skills. This principle helps to ensure that all users can use the courseware without difficulty and can understand the content easily. For example, using a combination of words, images and sounds helps to accommodate the different learning styles of users in a navigation bar, while detailed navigation and step-by-step instructions suit the novice and shortcuts should be provided for the convenience of expert or experienced users. In addition, the Malaysian government guidelines provide a local interpretation of this principle by requiring
that all the design features of the interface should not only be age-appropriate, but should also avoid any biases regarding ethnicity, culture or religion.

The analysis of the interactive Science courseware confirms that this principle has been followed. By and large, the colours are appropriate for the age of the intended user. And, in terms of usability, as shown in Figure 4.15, the colours used for the explanatory text clearly contrast with the background screen. Along with the typeface that has been chosen and the size used, this makes it easy for the target user group to read it, and hence helps to enhance the young users’ ability to understand the activities and content of the courseware.

![Figure 4.15: The colours used for the text provide contrast and make it easy to read](image)

In terms of the instructions providing flexibility for different levels of ability and different learning styles, the interfaces often provide multiple options. For example, in some sections, most of the images, icons, and commands are accompanied by explanatory words or audio effects (Figure 4.16). And, on the navigation bar, some of the buttons produce audio effects when clicked, while others have a mouse over effect (Figure 4.17).
Figure 4.16: The images are presented and accompanied by the explanatory words

Figure 4.17: Mouse over effect on the navigation bar

Often the content is also provided as both textual and visual explanations to aid differing learning styles. The choice to listen to an audio explanation of some terms has also been provided, allowing users to click either on the audio button or the graphic image. Therefore, sound can be turned on or off, which helps to accommodate different user preferences (Figure 4.18).

Figure 4.18: The choice to listen to the audio or not
This does not mean that the images in themselves cannot deliver the content and must depend on words and audio and voice versa. Rather, images are an integral part of the demonstration or content, while the text or sound is presented as additional information. It has been identified in the literature that some users may consider text elements to be more important than images in assisting understanding. By providing both options, users who prefer text as well as those who prefer visual explanations can understand and learn optimally. That is, the courseware provides flexibility that accommodates visual, textual and aural learners.

In terms of supporting both the novice and experienced or expert user, we must consider access to content and ease of navigation. Overall, the structure of the courseware is straightforward. Users can simply run the activity by clicking on the play button. Alternately, the active buttons on the navigation bar also provide the user with the flexibility to navigate to the next and previous activity. Therefore, it is easy to navigate from one page to another in the recommended sequence. Or, as can be seen in Figure 4.19, the main page of each lesson also provides active links to all content units. The experienced user can therefore easily navigate to any unit and can easily exit the activity.

![Figure 4.19: Flexibility in navigation including play, repeat, go back to previous pages and go to the next page](image)

At the same time, assurance is provided to the novice through a confirmation dialogue, which provides immediate feedback on any actions as the system recognises the actions of the user. The same confirmation dialogue is used in the
different lesson topics within the interactive courseware adding consistency. This can be seen in the Test section shown in Figure 4.20. By providing simple visual images or audio effects on actions that the user performs, the courseware communicates well with the user.

![Figure 4.20: The same confirmation dialogue used for same action in different lessons](image)

With regards to compliance with the local context and Malaysian Government guidelines relating to flexibility, attention has been paid to design features, text and human characters, which appear to have been designed specifically for the age group (in this case year 3 students aged 9 years old). As can be seen in Figure 4.21, the characters, colours and text conform with the style of children’s’ books and cartoons for the same age group. The requirement to avoid ethnic and cultural biases, have been addressed by the inclusion of representatives of each major Malaysian cultural and ethnic group. Characters identified as Asri, Siti and Cikgu Ani have names that indicate that they represent Malays, Galang represents the Indian ethnic group, and Mei Mei and Joseph represent the Chinese population (Figure 4.22).
Moreover, the features of these human characters suggest that the developers were careful to avoid bias for those three ethnics. Furthermore, the voice selection for the talent that was used for these characters is also appropriate for the gender, race and age of each character. The evidence found in the analysis on this courseware therefore suggests that the principle of flexibility and the characteristics that this has been translated to in the Malaysian Government guidelines have largely been followed.

4. The principle of efficient feedback given to the user
As most of the international texts note, providing immediate feedback is an important means of reinforcement and provides encouragement to proceed. It
should be immediate, informative and clear and easy to understand and should be in visual or audio format or both. In essence, if the user does not receive any clear response to what they have done, they may do it again. The Malaysian government guidelines also highlight that users should be kept informed of any action or error in the interactive courseware.

The analysis of the interactive Science courseware has revealed that the principle of feedback is provided in several ways. Firstly, a response is given in the form of visual images and/or explanatory text, which occurs immediately when clicking on any text button the menu bar in the Tutorial page, as shown in Figure 4.23.

![Figure 4.23: Example of immediate feedback when clicking on an active button](image)

In other examples, responses are given in the form of sound/audio effects or colour changes where by the colour of active button changes when clicking on it. On some pages however, responses are provided in the form of visual images or texts, without sound effects.

5. The principle of visual communication through an aesthetically pleasing appearance of the screen

As the literature has established, aesthetics relates to the colours, forms and fonts used, as well as the overall arrangement of the interface design. The principle of aesthetics relates to the screen appearance of the courseware, and is not simply a matter of making the interface “prettier” or attractive to the user. It helps to establish a ‘look and feel’, which should appeal to the demographic of the target group and colour, in particular, can help users feel comfortable with the system.
(Nielsen, 2000). Because it provides the first impression of a product, it should help produce a sense of familiarity and enjoyment, and it should help to capture the users’ attention and maintain their interest.

But visual design is also important to making the screen interface easier to understand, and should contribute to a more effective relationship between the user and the application. Therefore, it is closely related to the overall usability of the product.

The analysis of the courseware has established that aesthetic considerations are apparent through the choice of colour, style, font and overall look and feel, which are suitable to the demographic, and will been joy able for the user, as well as supporting them in accessing the courseware. For example, the characteristic of the font used is clear and easy to understand by the intended user and it helps to gain the attention of users and raises their interest in using the courseware.

4.4 A comparative analysis of the interactive courseware with the principles recommended in the literature and the government guidelines

After gathering and categorising the most commonly recommended principles and characteristics in the literature, and those suggested in the Malaysian government guidelines, and considering examples of how this is manifested in the courseware, a content analysis process was used to establish the extent of their presence in the sample of interactive Science courseware. The frequency of the twenty-four characteristics described in Section 4.2.3 was evaluated screen by screen across the twenty-six lessons in the sample courseware. The range of the characteristics usage was then categorised into a Likert scale: from very low, low, average, high to very high, where very low represents less than 10% occurrence; low represents 20%; medium represent 50%; high represents 80%; and very high represents 90% as shown in Table 4.7
<table>
<thead>
<tr>
<th>Principles</th>
<th>Characteristics</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>The principle of consistency within the design of a product</td>
<td>1. Persistent sequencing of the screen appearance</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>2. Similarities colour schemes used throughout</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>3. Consistent fonts and sizes</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>4. The use of similar characters</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>5. The same actions yield the same results</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>6. Similar positions of the main menus and navigation bars</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>7. Consistent tools in the navigation bar</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>8. The same montage in the introduction and pages</td>
<td>*</td>
</tr>
<tr>
<td>The principle of familiarity with elements and functions from prior experience</td>
<td>9. The human and animal characters used shall be logical and not contradictory to real life situations</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>10. The human and animal characters used should be from familiar characters.</td>
<td>*</td>
</tr>
<tr>
<td>The principle of flexibility of the system’s response to the individual differences</td>
<td>11. Provide a button to pause, continue, go back and exit the activity</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>12. Provide supporting sound/audio</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>13. Use a confirmation dialogue box to support any user action</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>14. Colours must be suitable for the intended user</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>15. Visual images must be suitable for the intended user</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>16. The text characters must be easy to read</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>17. Sound and voices must be appropriate to gender and age of characters</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>18. The audio effects used with the symbols and icons should be age-appropriate</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>19. Avoid ethnic and religious biases in colours</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>20. Avoid ethnic and religious biases in any images</td>
<td>*</td>
</tr>
<tr>
<td>The principle of efficient feedback given to the user</td>
<td>21. Use accurate responses in the confirmation dialogue</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>22. Provide users with visual or audio effects on actions</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>23. Allow user to operate the task properly</td>
<td>*</td>
</tr>
<tr>
<td>The principle of visual communication through an aesthetically pleasing appearance of the screen</td>
<td>24. Each element shall be attractive and encouraging to the intended users</td>
<td>*</td>
</tr>
</tbody>
</table>

Table 4.7: The principles and frequency level of characteristics used in the interactive science courseware.
Table 4.8 summarises the frequency distribution of the use of principles when the characteristics pertaining to them are collated.

<table>
<thead>
<tr>
<th>Principles</th>
<th>Frequency of use in the courseware</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very low</td>
</tr>
<tr>
<td>Consistency within a product</td>
<td></td>
</tr>
<tr>
<td>Familiarity with elements and functions through experience elsewhere</td>
<td></td>
</tr>
<tr>
<td>Flexibility of the system’s response to the individual differences</td>
<td></td>
</tr>
<tr>
<td>Efficient feedback to the user</td>
<td></td>
</tr>
<tr>
<td>The principle of visual communication and an aesthetically pleasing appearance of the screen</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.8**: The collated principles and their frequency in the interactive science courseware

At the level of broad analysis, this table suggests that the guidelines outlined by the Ministry have been applied, by and large. As shown in table 4.7, seventeen out of the twenty-four characteristics were applied very frequently, while two were applied to a medium degree, and only three were categorized as low frequency and two were used at a very low rate. That is, the results of this empirical analysis have determined that most of the principles established for effective interface design in the literature and the characteristics recommended in the guidelines were applied by the courseware developers at least to a reasonable degree.

More specifically, in relation to individual principles and their characteristics: five out of eight characteristics of consistency, as described in the Malaysian guidelines, achieve a high rate of frequency, and two are high, while only one characteristic was used at an average rate of frequency, and none at low or very low rates. Thus it shows that the principle of consistency is clearly evident in the courseware sample. Indeed, colour, text, characters and icon are highly consistent.
across the courseware. As these characteristics are outlined in the Malaysian government guidelines, this suggests that the developers of the courseware are either well aware of this principle, or were concerned with adhering to the requirements outlined by the Ministry (or both).

In terms of the principle of familiarity, analysis of the sample courseware determined that the two related characteristics outlined in the Ministry guidelines are very frequently used in the courseware. By employing concepts and characters that Malaysian children will be familiar with, the use of the real-world metaphors of the classroom, as well as a language and colour schemes that are similar to those used in books and cartoons, the sample courseware also evidences that it was developed with sensitivity to providing a sense of familiarity.

In relation to the principle of flexibility, whereby the interface is sensitive to different users’ needs, experience, knowledge and skill, has the largest number of characteristics in the Malaysian government guidelines (ten in all). They include general suitability to targeted user group (primary school children), catering to different levels of experience from the novice through to the experienced user, and Malaysian specific flexibility across cultural and religious groups by employing a range of characters and avoiding ethnic, cultural and religious bias in images and colours.

The content analysis of the interactive Science courseware found that the characteristics of flexibility scored very highly in the courseware. Different ways are provided for users to access functions, such as visually driven icons and navigation as well as shortcuts, and this should allow the user to access information and undertake tasks in new ways without frustration as they become more experienced with the courseware. In addition, while most of the explanations for the content are provided visually, as they are illustrated through cartoon figures, textual explanations are also provided. In addition, the specific requirements for respecting the diversity of ethnicity, culture and religion of users in the local context is clearly considered through the use of “Sang Kancil” and “Labu Sayung” characters that portray Malaysian identity, but do not bias against any cultural group and children who have a variety of ethnic names and features.
The developers seem to have responded wholeheartedly to the guideline provided by the Ministry to provide this unique aspect of the local products from generic international courseware.

The principle of feedback, whereby the interface should provide a response to user actions through confirmation dialogue, or a visual or audio to show the current state of the program to the users is directly articulated through the characteristics in the Malaysian government guidelines. However, analysis of the sample Science courseware revealed that feedback is rarely provided on actions or on the errors that occur as a result of interaction. The courseware only provides feedbacks through visual or audio effects on some actions and, unfortunately, responses of the confirmation dialogue are not accurate.

In term of the principle of aesthetics, the Ministry guidelines require that each element should be attractive and encouraging. In terms of developing a pleasurable and age appropriate “look and feel”, the analysis of the interactive Science courseware allows the conclusion to be drawn that this principle has been applied throughout courseware. And, by providing a meaningful contrast of colour combinations, along with animated and static graphic images, the interface design of the interactive Science courseware potentially provides the user with a sense of excitement and fun that might be expected to positively influence the adoption of the courseware in the classroom.

In addition visual communication can be understood as the principle form of communication in the courseware, with text, and audio providing support. While this is not clearly mentioned in the guidelines, the visual design features and elements appear to be understandable and clear and provide a simple way of finding out what is in the system and a clear indication of navigational opportunities, as well as providing visual explanations of content. In both regards it appears that the developers have been aware of the principles /or guidelines surrounding aesthetics and have adhered to them.
4.5 Conclusion

This chapter has described and compared the information gathered through a contextual analysis of international literature, a content analysis of Malaysian government guidelines and a content analysis of a sample of Science courseware that has been developed for the Malaysian Smart School Project. It has established that the five most commonly cited principles in the selected literature have eighteen characteristics, and that these principles are referred to directly or indirectly through twenty-four characteristics outlined in the Malaysian government guidelines. While the principles and characteristic provided in these two different sources may be described differently, they are fundamentally similar, with the addition of a unique characteristic in the Malaysian government guidelines concerned with avoiding biases in ethnicity, culture and religion.

Therefore, from this review of the literature and the guidelines, these five in-common principles and twenty-four characteristics were used as a basis for the content analysis of the interactive Science courseware. While it should be noted that the qualitative data of this analysis is based on some level at least, on the subjective assessment of the researcher, it is derived from the principles and guidelines from the literature as a foundation, and the interpretation of the data, which was based entirely on frequency of observation.

This content analysis allow a conclusion to be drawn on Research Question 1, namely, What interface design principles, including those established in the international literature, and those outlined in the Malaysian government guidelines are evident in the current interactive Science courseware? The answer is that all of the most frequently cited principles in the literature and the characteristics recommended in the Malaysian guidelines have been applied in the sample of courseware to a greater or lesser extent, with most evident at high rates of frequency. The five components or design elements (namely images, text, video, audio, and animation) suggested in the Malaysian government guidelines have been incorporated in the sample of interactive Science courseware, and the Malaysian specific guidelines on ethnicity have been incorporated. From this evidence, it can be deduced that the designers of the courseware were conscious
of the requirements outlined by the Ministry in the guidelines and applied them, and whether they were aware of them or not, this has meant incorporating aspects of the international interface design principles.

However, the effectiveness of interactive Science courseware and these five common principles, twenty-four characteristics and five components must be subject to further scrutiny. In the following chapter, the data from fieldwork (classroom observations, focus group discussions and in-depth interviews) will provide a comprehensive analysis of the courseware in use. This will provide a different gauge for each of the principles and characteristics, and provide an evaluation based on the perceptions of users in relation to the quality and usability of the interfaces. From this, a comparison can be made between the outcome of the analytical process of a content analysis and qualitative data derived from users’ actual experiences.
5. Evaluating the courseware in use: Fieldwork

5.1 Introduction
This chapter presents the fieldwork conducted at six Malaysian primary Smart Schools in 2010. The purpose of this fieldwork was to gauge aspects of the science courseware in use. That is, the fieldwork was designed to investigate Research Question 2, namely: How do the users (school principals, teachers and students) of interactive Science courseware for the Malaysian Smart School Project interact with the courseware and perceive it? The outcomes of this empirical research could then be compared with the outcomes of the content analysis of the existing interactive courseware.

As discussed in Chapter 3, the fieldwork involved processes aligned with ethnographic methods, undertaken in school settings. The duration of the fieldwork was approximately three months (from January to March 2010), during which time, two weeks were spent at each of the schools that participated in the research project. The process began with interviews with the school principals, followed by classroom observations of the courseware in use, then focus group discussions with students accompanied by their teachers. The fieldwork was concluded with in-depth follow-up interviews with the science teachers who use the courseware to clarify and expand upon queries that arose in the observations and focus group discussions. The processes, outcomes and interpretations of the data collected are detailed in this chapter.

5.2 The participants
As mentioned in the introduction to this thesis, there are three types of Smart Schools in the Malaysian Smart School Project: new Smart Schools, in which each student at the school is considered an expert user and is provided with a laptop (and can therefore access his or her own computing devices in the classroom); state Smart Schools, in which students are identified as a middle user
and selected classrooms are equipped with computers, a large screen display board and a shared printer; and remote Smart Schools, which have minimal equipment comprised of several computers, a large display board and projector in a computer lab that shows the teacher’s computer desktop. Consequently, students at a remote Smart School are deemed to be novice users, and can only use the interactive courseware if their teacher is conducting the class in the computer lab and projecting the content. For the purposes of this research project, two schools were selected from each type of Smart School. To provide the requisite diversity in the background of the participants, the selection of schools was made from an extensive list provided by the Ministry.

In total, six primary Smart Schools from four different states across Malaysia, were selected namely: Negeri Sembilan, Pahang, Perak and Selangor. From these schools, a total of 220 research participants were involved, including six school principals, six teachers who use the interactive Science courseware in teaching science and 208 students. Agreement was gained from each of these participants in a written consent form, as outlined in the Methodology Chapter. In order to administer the data collection process, approvals and permissions from the Malaysian Ministry of Education, QUT’s ethical clearance, and school principals of each selected school were first obtained.

The breakdown of participants across schools is shown in Table 5.1.
### Table 5.1: Number of participants involved in each physical research setting

<table>
<thead>
<tr>
<th>Physical setting (type of school)</th>
<th>Participant activities</th>
<th>Total no of participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Face to face interviews</td>
<td>Classroom observation and Focus group discussion</td>
</tr>
<tr>
<td><strong>New Smart School 1:</strong></td>
<td>1 school principal</td>
<td>40 students</td>
</tr>
<tr>
<td>Mini laptop per child, big screen in the classroom and a shared printer in classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>New Smart School 2:</strong></td>
<td>1 school principal</td>
<td>40 students</td>
</tr>
<tr>
<td>Mini laptop per child, big screen in the classroom and a shared printer in classroom</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>State Smart School 1:</strong></td>
<td>1 school principal</td>
<td>30 students</td>
</tr>
<tr>
<td>Desktop computers in selected classrooms, shared printer in a computer lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>State Smart School 2:</strong></td>
<td>1 school principal</td>
<td>38 students</td>
</tr>
<tr>
<td>Computer in selected classroom, shared printer in computer lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Remote Smart School 1:</strong></td>
<td>1 school principal</td>
<td>28 students</td>
</tr>
<tr>
<td>One computer, big screen, projector and shared printer in a computer lab</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Remote Smart School 2:</strong></td>
<td>1 school principal</td>
<td>33 students</td>
</tr>
<tr>
<td>One computer, big screen, projector and shared printer in a computer lab</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

220 participants

5.3 Understanding patterns of use: Interviews with school principals and science teachers

School principals were interviewed to gain information about the current level of courseware usage at their schools and factors contributing to the extent of uptake and frequency of use. As mentioned in the Methodology chapter, each school principal was interviewed in the Malay national language. Each session lasted approximately thirty to forty-five minutes and was conducted at their respective
schools and recorded on a tape recorder. The questions asked were consistent and are attached as Appendix 9 of this thesis.

The interview content was transcribed by the researcher and then translated by the National Institute of Translation Malaysia. The transcripts were then analysed using coding scheme procedures suggested by Frankfort-Nachmias and Nachmias (1992), as per explained in the Methodology chapter. The detailed results are described in the following sections, through two themes that reflect the aims of interview. The first relates to the level of interactive courseware use in the classroom and the second pertains to factors affecting the level of uptake and frequency of use.

5.3.1 The uptake of interactive courseware in schools

The interviews established that all school principals involved in the study (six in all) encourage their teaching staff to use the interactive courseware in the classroom. Representative statements include:

I ask teachers in my school to use the courseware very often to support their teaching process. (School Principal Interview, respondent 1)

Teachers in my school use the courseware very often to support students learning processes. It is a requirement for them to use it. (School Principal Interview, respondent 2)

As the principal, I really encourage teachers to use it in class. (School Principal Interview, respondent 3)

I always asked all teachers to use the supplied courseware. (School Principal Interview, respondent 4)

Similarly, the science teachers who participated in in-depth interviews (six in all) acknowledged the benefit of using interactive courseware as a supplementary tool to support the learning process. Indeed, both teachers from new Smart Schools expressed the belief that their students become more interested and focused in class if interactive courseware is used. They explained this by saying:

I believe that interactive tools will enhance my students’ learning performance. (Teacher Interview, respondent 1)
I notice my students’ performance becomes better because most of them are more focused. (Teacher Interview, respondent 2)

Teachers from the state *Smart Schools* stated that the interactive courseware could help students become more creative. As one declared:

*I think that the use of interactive courseware will enhance the creativity of my students.* (Teacher Interview, respondent 4)

And a teacher from another state *Smart School* echoed this by claiming that:

*I found the interactive courseware helps my students become more creative.* (Teacher Interview, respondent 4)

From such responses, it can be concluded that the teachers who participated in this research project have a positive attitude towards using interactive courseware in the classroom. However, this enthusiasm and positive attitude is not the only factor determining the extent of use. The figures on the extent of use suggest that other factors also come into play.

To establish the extent of use of the science courseware, the school principals from the three different types of *Smart School* were asked whether the courseware is used daily, weekly or monthly. Table 5.2 shows the results against the type of school.

<table>
<thead>
<tr>
<th>School Type</th>
<th>Daily</th>
<th>Weekly</th>
<th>Monthly</th>
</tr>
</thead>
<tbody>
<tr>
<td>New <em>Smart School</em> 1</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>New <em>Smart School</em> 2</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>State <em>Smart School</em> 1</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>State <em>Smart School</em> 2</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Remote <em>Smart School</em> 1</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>Remote <em>Smart School</em> 2</td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Table 5.2: The frequency of interactive science courseware use in the schools

As illustrated in the table, the frequency of courseware use at both new *Smart Schools* is reported as frequent, in contrast to remote *Smart Schools*, where both
school principals acknowledged that their schools only use the courseware on a monthly basis. The courseware use at state Smart School varied with one principal reporting that their school was a moderate user and used it on a weekly basis, while the other uses it frequently. That is, the usage rate of courseware varies according to the type of Smart School.

5.3.2 Factors influencing the level of use

To further investigate this level of usage at the different types of schools, all the school principals were asked about the factors that influence their teachers in implementing the courseware at their schools. Questions were asked about whether the school has enough computers and other support facilities to implement the interactive courseware; whether the school has technical support staff; whether the school’s teachers are skilled in using interactive software, and the general perceptions of the courseware itself. Analysis of the interview transcripts identified a number of issues and concerns raised by the participants.

In short, five main factors appear to influence the level of use of the courseware in schools. They include the standard of the interactive courseware; the quality of the interface design; infrastructural limitations; technical support; and the level of teaching experience amongst staff. This range of factors, as identified by each school, is detailed in Table 5.3.
A brief overview of these factors can be summarised as follows:

1. **The quality of the courseware**

The main factor effecting usage, which was most often cited by the school principals, is the perceived relevance of the interactive courseware. The respondents referred to this problem at several levels. The first issue relates to the content of the courseware. Most school principals (four out of six) consider that much of the content in the current interactive science courseware is not compatible with the current national Science textbooks. As one principal from a new *Smart School* said:
Our teachers can teach students with interactive courseware at any time, but we need a good product. How can teachers use it if some of the content is totally different to the textbook? (School Principal Interview, respondent 2)

Another school principal from a remote Smart School went further stating that:

There is wrong information in some sections. Even the terms used are so different. So how can we use it in classroom? (School Principal Interview, respondent 5)

Another two school principals (one from a new Smart School and one from a state Smart School) claimed that the interactive science courseware lacks pedagogical coherence compared to expectations of a sophisticated learning tool in which every topic is covered, and is well presented, with useful and appropriate exercises to complement the content. They claimed,

The courseware should be an advanced tool, as claimed by the Ministry. But I have found that it is not. It really makes me upset. (School Principal Interview, respondent 1)

I am very disappointed with what has been provided in the courseware. I was told that this courseware will help teachers, but when we used it, I noticed it really interferes with teaching. (School Principal Interview, respondent 3)

From these answer, it appears that the quality and content of the current interactive Science courseware is disappointing to the schools. Clearly, the content of interactive courseware, as well as its presentation, will affect the extent of use of the courseware in the classroom, regardless of different school backgrounds.

2. Interface design quality

The second major issue raised by school principals relates to interface design problems. Four out of six school principals commented that they are very concerned about the quality of the interfaces and mentioned that either the look of the interactive science courseware is not well suited to students or that is not engaging enough. As one principal from a new Smart School stated:

Comparing the interactive courseware to the printed learning material, the current interactive courseware is much better in terms of
presentation. A lot of pictures and animations are presented in the interactive courseware. But then, the current look of the interactive courseware is not really attractive to me. I believed my students also feel the same.... As a part of the teaching and learning material, it should be more attractive. (School Principal Interview, respondent 1)

Another school principal from a state Smart School supported this by saying:

I strongly believe that, if the appearance of the interactive courseware was more attractive, the learning process would be more interesting. (School Principal Interview, respondent 4)

Besides this issue of look and feel of the interface, a principal of a new Smart School also claimed that there have been times when the interface design creates frustration for both teachers and students because it is not user-friendly enough. As he argued:

As a user, students should be able to concentrate on the interactive courseware because all the information is supposedly there. But it does not happen in the science courseware. Some of the students are not familiar with the terms or icons used. (School Principal Interview, respondent 2)

Such issues around interface design quality inevitably have a relationship to the frequency of courseware use. Of course, the more reliable, appropriate and appealing the interface design in interactive courseware, the more often teachers will use the courseware in the classroom.

3. Infrastructure limitations

Another major difficulty reported by school principals is related to the level of infrastructure at their schools. A strong correlation is evident between the type of school (and hence the number of computers and computer labs it has) and the frequency of courseware use. The number of computers and computer labs and the location of the computers for each school that participated in the study are illustrated in Table 5.4., which can be compared with table 5.2, which shows relative rate of use of the courseware.
<table>
<thead>
<tr>
<th>School</th>
<th>No. Of student per class</th>
<th>No. of computers</th>
<th>No. of computer labs</th>
<th>Location of computers</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Smart School 1</td>
<td>40</td>
<td>80</td>
<td>2</td>
<td>Computer laboratories and classroom</td>
</tr>
<tr>
<td>New Smart School 2</td>
<td>45</td>
<td>85</td>
<td>2</td>
<td>Computer laboratories and classroom</td>
</tr>
<tr>
<td>State Smart School 1</td>
<td>36</td>
<td>30</td>
<td>1</td>
<td>Computer laboratory and classroom</td>
</tr>
<tr>
<td>State Smart School 2</td>
<td>38</td>
<td>35</td>
<td>1</td>
<td>Computer laboratory and classroom</td>
</tr>
<tr>
<td>Remote Smart School 1</td>
<td>30</td>
<td>18</td>
<td>1</td>
<td>Computer laboratory</td>
</tr>
<tr>
<td>Remote Smart School 2</td>
<td>28</td>
<td>15</td>
<td>1</td>
<td>Computer laboratory</td>
</tr>
</tbody>
</table>

Table 5.4: Computers and computer labs at different Smart Schools

As shown in the Table 5.4, there are clear differences between the school types in relation to the number of computers and computer labs, which are much lower at remote Smart Schools (ranging from 15-18 computers) compared to new Smart Schools (ranging from 80-85 computers). This is largely due to the facility allowances provided by the Ministry of Education, based on the different types of school.

Perhaps unsurprisingly, the problem of infrastructure was emphasised by both school, principals from remote Smart Schools, where the ratio of computers to students is very low. For example, one principal said that:

*We can teach the students with computers and by using interactive courseware at any time, but we need good facilities, especially with enough computers! Currently we just have 35 computers and commonly students in one class are 40 to 45.* (School Principal Interview, respondent 5)

And other principal commented that:
We only have 15 computers in a computer lab.... So how can we use the interactive courseware with limited computers and more than 30 students in one class? (School Principal Interview, respondent 6)

The principal of one remote Smart Schools also declared that the current computers at his school are too old and outdated. He continued:

....and the computers that we have now are outdated and some are too old to be used by the students. ... the computers are too slow as well.
(School Principal Interview, respondent 6)

Clearly then, the classification of the school and the consequential availability of technology resources impacts on courseware use, and this plays out in uptake by teachers. Interviews with teachers from new Smart Schools suggest that they use the courseware once a week compared to the teachers at remote Smart Schools, who used it once a month. As one of the respondents from a new Smart School said:

When I teach the lessons in my class, I always use the interactive courseware. I give my students a chance to explore the CD. They can use it by themselves. That's why, at least once a week, I will make sure that each class that I teach will have a chance to use the courseware.
(Teacher Interview, respondent 2)

By contrast, a teacher from a remote Smart School, who must drive the courseware and project it onto a screen with the students following her interaction, gave a very different answer:

Not too often. I just use it when I think it's a must. It depends on the topic that I am going to teach but I prefer to use the traditional methods.
(Teacher Interview, respondent 5)

To overcome this problem of infrastructure, some school principals have taken their own initiative. In particular, both principals from a state Smart School reported that their school has purchased several computers from a private company, using their own school budget and the collection of money from parents. Through this initiative, one of the principals from a state Smart School stressed
that their students consequently have more opportunities to use the interactive
courseware in their learning.

4. Technical support

Technical support is another reason widely regarded by school principals to be a
factor that limits the use of the interactive courseware at their schools. A shortage
of technicians at schools was cited by the majority of school principals and while
none have a specific technical support person at their school, neither do they
receive any technical support from the government. Therefore, they commonly
ask the teachers for help to maintain the computers and take care of the interactive
courseware. As one principal from a state Smart School commented:

*I just get technical assistance from my teachers who are competent in the
computer field.* (School Principal Interview, respondent 3)

Another principal from a state Smart School saying this:

*I am not a technical person. To use the interactive courseware frequently
you need to have at least basic technical knowledge. Commonly I just ask
for assistance from my colleagues.* (School Principal Interview, respondent 4)

And a principal from new Smart School claimed that:

*I have been here for 6 years. No one has come as a technical support
officer or takes responsibility for that. I just get teachers who are more
skilled on the computer to help.* (School Principal Interview, respondent 2)

But where the technical expertise is not available from within the teaching staff,
the outcome is clear. As one principal of a remote Smart School commented:

*So far we have tried to solve problems by ourselves. If we can’t solve
them, we stop using [the courseware]. This is the best way I think.*
(School Principal Interview, respondent 6)

Through these responses, it is evident that schools will use the interactive
courseware more frequently if the computers and courseware can be administered
and supported, and if that expertise is not available, the courseware is likely to be
abandoned.
5. Teaching Experience

The teachers’ interviews revealed that the level of teaching experience of the science teachers also impacts on the degree of courseware use at each school. The experience of science teachers at the schools concerned varies, from 8 years to 6 months, as does the frequency of use; as shown in Table 5.5.

<table>
<thead>
<tr>
<th>Teacher</th>
<th>School Type</th>
<th>Years of experience</th>
<th>Frequency of courseware usage</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>New Smart School 1</td>
<td>3 years</td>
<td>High: *</td>
</tr>
<tr>
<td>T2</td>
<td>New Smart School 2</td>
<td>8 years</td>
<td>Average: *</td>
</tr>
<tr>
<td>T3</td>
<td>State Smart School 1</td>
<td>6 months</td>
<td>Low: *</td>
</tr>
<tr>
<td>T4</td>
<td>State Smart School 2</td>
<td>8 years</td>
<td>High: *</td>
</tr>
<tr>
<td>T5</td>
<td>Remote Smart School 1</td>
<td>5 years</td>
<td>Average: *</td>
</tr>
<tr>
<td>T6</td>
<td>Remote Smart School 2</td>
<td>5 years</td>
<td>Low: *</td>
</tr>
</tbody>
</table>

Table 5.5: Profile of experience among teachers against the level of courseware use by them.

As shown in Table 5.5, all teachers participating in this study have teaching experience using the courseware, to varying degrees. One participant has been using the courseware for less than one year, three for between three and five years, and two for eight years. However, where teachers had the same experience (e.g. eight years of teaching experience), different rates of courseware use were reported by the teachers at different types of schools. On the other hand, both teachers from a remote Smart School (which have limited infrastructure) with five years’ teaching experience reported that they did not regularly use the courseware.

Therefore, it can be concluded that uptake and use of the courseware is more strongly related to the type of facilities at a school than years of experience of its teachers. However, it should be noted that experience can be a factor. One teacher from a state Smart School indicated that she uses the courseware moderately because she has just taught for just six months. Therefore, being quite new to
teaching may have an impact on the level of use of the courseware, and there is some correlation between the levels of courseware usage with the length of teaching experience.

When given the opportunity to raise other contributing factors, the principals also raised the teacher’s competency level in using the interactive courseware. Three school principals (one from remote Smart School and two from state Smart School) expressed that teachers’ skills and ability and confidence also influence the rate of courseware use and interactive tools more generally. However, school principals also indicated that teachers would like to integrate more computer applications into their teaching and suggested that perhaps more in-service courses or training could be carried out with the aim of training teachers in order to make full use of technology in teaching.

5.3.3 Discussion
A number of conclusions can be drawn from the outcomes of the interviews with school principals and teachers. Firstly, a positive attitude to using interactive resources (in principle) is common among teachers and school principals, and this undoubtedly affects the level of interactive courseware use at some types of school. However, there are other factors that impact negatively upon uptake.

Primarily, the results from both sets of interviews suggest that the use of interactive courseware at schools is highly dependent on the quality of courseware, including its content and interface design. In fact, there appears to be a strong correlation between the level of courseware use and the perception of the content, activities and interface design performance. In this regard, even though teachers acknowledge that students become more interested and focused in the classroom when the courseware is used (due to its inclusion of rich media), it was established that inappropriate and incorrect content and problems with the interface design are the most obvious causes of the interactive courseware being less often used than anticipated.
From this, it can be concluded that teachers will use the interactive courseware more often in the classroom if they consider it to be appropriate in terms of content and if it has an attractive and intuitive interface design. This finding bears out the claims made by international interaction design experts such as Preece, Rogers and Sharp (2002), as well as Balinsky (2006), and Shields and Kukulska-Hulme (2006), that effective interface design contributes to the level of product use.

The second major factor influencing uptake is the characteristics of the school and its designated type of Smart School. For instance, the current use of interactive courseware across the three different types of Smart School differs significantly, with new Smart Schools using the interactive courseware much more frequently than remote Smart Schools. As these school types have different levels of facilities, it can be said that the uptake and use of interactive courseware in schools is strongly influenced by the extent of facilities and infrastructure within a school, such as the number of available computers and computer labs. The extent of infrastructure is clearly a primary factor in supporting courseware use. If the school staff have a positive attitude but have a limited number of computers and computer labs, the usage level of the interactive courseware inevitably suffers. For that reason, some schools have thought it necessary to take their own initiative to overcome the problem of low frequency of the interactive courseware use at their schools, rather than just depending on the government subsidies.

The level of courseware usage is also impacted by the level of technical support, and without such support the project can be abandoned. In addition, teachers who are new to the technology may need extra support and training to start using the interactive courseware more frequently. Thus, to achieve a successful level of interactive courseware usage at school, an appropriate level of technical support and in-service training needs to be considered, as well as the provision of the necessary infrastructure or a scheme to support schools to increase the level of courseware use.

In summary, it has been established that the level of interactive courseware use in the classroom is highly influenced by the courseware content and activities and
the quality of interface design, which is essential to strengthen and sustain teachers’ motivation and interest in using interactive courseware in the classroom. However, the success of the courseware implementation at schools cannot be achieved if sufficient technical support and infrastructure is not provided.

5.4 Observations of the courseware in classrooms

So far the effectiveness of the interface design principles, characteristics and components in the courseware have been established through reference to the literature and government guidelines, which have been tested against the sample of existing courseware. These initial forms of analysis have helped to establish the extent that these principles are present and contribute to users’ interaction and learning experience. Moreover, this process has helped to establish the actual needs of the teachers and students as an end-user.

After gaining an initial understanding of the level of use of interactive courseware at schools through the interviews discussed in the previous section, classroom observations of the students and teachers were conducted, followed by focus group discussions with students and interviews with the science teachers. The purpose of these methods, which can be aligned with a small-scale ethnographic study, was to tease out additional information about specific difficulties faced by the users of the courseware, as well as their preferences. Three different methods (interviews, observations and focus groups) were considered to be valuable means to cross-check the analyses conducted so far.

Classroom observations were conducted at two of each of the three different types of primary Smart Schools located in four different states across Malaysia, as described in detail in Section 5.2 above. The Ministry advised that each school is allocated 1 hour and 25 minutes per week for Science subjects and that students have a Science class once a week. Observations were conducted over two weeks at each school, to ensure reliability. They involved one class at each school, consisting of between 37 and 45 students per class.
The method used was non-participant observations, as described in the Methodology chapter. That is, observations were conducted without disturbing the students and teachers in their work environment or making any intervention in the teaching and learning process. As the researcher remained unobtrusive at the back of the class, several limitations were encountered. For example, it was difficult to observe each of the students at the same time. To overcome this inevitable limitation of a single researcher, all observations were videotaped using several video cameras installed on selected computers from different angles. In addition, photographs were taken to capture the way students and teachers use the interactive courseware in the different settings of available Smart School learning environments.

Three examples of different types of Smart School classroom environments appear in figures 5.1 to 5.3, which show the students in their classrooms at a new Smart School, a state Smart School and a remote Smart School respectively.

Figure 5.1: Students using the interactive science courseware at a new Smart School
Detailed notes were taken during each observation, which described the interaction of the students with the interface design components; the length and level of students’ engagement with the courseware; and any distraction faced by the students and teachers in the surroundings of the classroom. The way teachers delivered instructions in teaching through the courseware, their level of confidence in using the courseware, and how students respond to the learning activities were also observed.

5.4.1 Summary of the observations

This section summarises the results of the classroom observation. In essence, the data is presented in relation to two themes. The first refers to the overall level of
confidence among teachers using the courseware. The second relates to the most commonly cited interface design principles and components cited in the literature and the students’ and teachers’ engagement with the courseware in relation to them.

1. Confidence in use
In regards to the level of confidence amongst teachers in using the courseware, it was observed that five out of six teachers participating in this research project appeared very confident in using the interactive courseware as a teaching tool in the classroom. Only one teacher appeared to be somewhat unsure (she was new to the subject with only 6 months teaching experience). Confidence level did appear to be highly influenced by the level of experience in using the courseware. In fact, both teachers who have been teaching for 8 years (one at new Smart School and one at state Smart School) were very confident. This might also be related to experience of use, since both use the courseware as a daily practice. Nevertheless, two teachers (one at a remote Smart Schools and one at a state Smart Schools) demonstrated that they had to arrange additional activities to facilitate student engagement with the interactive courseware because students could only simply watch the computer via a projection screen in class.

2. Engagement with the courseware
With regards to the level of engagement of students with the courseware and its interfaces, various students’ reactions were recorded during the courseware use in class, based on facial expressions, body language and other responses. This is summarized in Table 5.6.
### Table 5.6: Level of student’s engagement through body language while using the courseware

<table>
<thead>
<tr>
<th>Facial expressions</th>
<th>Body posture</th>
<th>Other Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Engaged</strong></td>
<td></td>
<td>Writing notes</td>
</tr>
<tr>
<td>Smiling</td>
<td></td>
<td>Asking questions</td>
</tr>
<tr>
<td>Watching</td>
<td></td>
<td>Discussing content amongst themselves</td>
</tr>
<tr>
<td>Concentration</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disengaged</strong></td>
<td>Sleepy appearance (e.g. Eyes drooping)</td>
<td>Talking to others about unrelated topics</td>
</tr>
<tr>
<td>Bored expressions</td>
<td>Heads on the table</td>
<td></td>
</tr>
<tr>
<td>Looking around</td>
<td>Slumped in their chair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Playing with hair</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Staring into space</td>
<td></td>
</tr>
</tbody>
</table>

As summarised in Table 5.6, the observations found signs of disengagement, of the students when using the courseware independently. Large numbers of students started talking when courseware usage began. Although a few students were very excited with the animations presented in the main sections, these students were largely unable to work independently with the courseware in the following sections. In particular, the observations indicated that some students didn’t know where to start and had difficulty moving from one screen to another. During the observations of independent use, students frequently had sleepy and bored facial expressions, were talking to their peers, and looking around. Indeed, it seemed that students were much more responsive to the directions and instruction given by the teacher than the courseware.

It was also evident that all students only appeared to respond attentively to some of the media components such as animation, videos and graphic images and smiled and remained engaged when these particular components were presented in the courseware. It was also observed that these particular components were by far the most likely to trigger responses, such as writing down notes and asking questions and they often served as a starting point for discussions. This suggests...
that students were trying to interpret the content of the courseware through these components.

In terms of specific levels of effectiveness of the five interface design components (audio, video, text, animation and graphic images) in engaging students with the interactive courseware, this was measured through a Likert-scale range from low to high, in which the most effective component is rated in the high numerical range, while the least effective is rated in the low range. The summary shown in Table 5.7 below notes the frequency of students engaged pleasurably with each component across all types of Smart School.

<table>
<thead>
<tr>
<th>Classroom</th>
<th>Media component type and engagement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Audio</td>
</tr>
<tr>
<td></td>
<td>Low</td>
</tr>
<tr>
<td>New Smart School 1: Classroom 1</td>
<td>*</td>
</tr>
<tr>
<td>New Smart School 2: Classroom 2</td>
<td>*</td>
</tr>
<tr>
<td>State Smart School 1: Classroom 3</td>
<td>*</td>
</tr>
<tr>
<td>State Smart School 2: Classroom 4</td>
<td>*</td>
</tr>
<tr>
<td>Remote Smart School 1: Classroom 5</td>
<td>*</td>
</tr>
<tr>
<td>Remote Smart School 2: Classroom 6</td>
<td>*</td>
</tr>
</tbody>
</table>

**Table 5.7:** Student engagement with various media component types

In six different observation settings, only two media component types, namely animation and video, received consistent positive responses from students and, while they demonstrated a moderately positive response to graphic images, text and audio components received consistently low responses from the participants.
The observation data showed that most of the students from all types of *Smart School* tended to be more focused on the courseware when animation or video was running. This was particularly evident when students worked with the animation and video in the Tutorial pages of the courseware when they were smiling and interacting cheerfully. However, it should be noted that the effectiveness of these two components in promoting student interaction and engagement in the learning experience was influenced by the quality of video and animation.

In the literature, it is stated that images can increase the motivation of end-users to participate in the formation of concepts. Furthermore, when still graphic images are combined with other components, they help users understand the content of courseware. However, in terms of engagement with graphic images, as shown in Table 5.7, it is important to note that they received a moderate response from the overall students. In particular, most of the students at remote *Smart Schools* had bored expressions and some looked around rather than focusing on the interactive courseware when graphical images were on the large projector screen. However, although the overall students’ responses were neutral, by contrast students from new and state *Smart School* seemed to somewhat enjoy the graphic images, especially those used for familiar human and animal characters. Thus, again it seems that students who can simply watch the courseware and cannot not interact with it themselves due to the school type and facilities, appeared less engaged.

The text components were the most ineffective tools in terms of engaging students’ attention. This was particularly evident in relation to the body text in the Introduction page and Tutorial page sections. However, students had a more positive response when the composition and organisation of the body text was more eye-catching. The text pages were the most problematic for students at state and remote *Smart School* where limited facilities mean that students cannot go at their own pace, or drive the navigation themselves, but simply watch it on the big screen as the teacher interacts with it. Students at these schools appeared quite unmotivated to read small text or large quantities of text and tended to chat with their peers instead of reading it.
The content analysis of the interactive science courseware (described in Chapter 4) found that sound is a minor component within it and that, other than during animation and video, it is usually simply used in the form of a key clicking sound (for emphasis and for feedback on navigation). In some lessons, no voice instruction or text is provided, so the teacher’s full assistance is needed to provide a script and instructions. Where sound is included, teachers had to actively encourage students to play and listen to the audio through the “click to listen the sound” prompts. Therefore, most students tended to be neutral about the sounds accompanying graphic images and they tended to respond little to the feedback sounds when interacting with the software. However students at both remote Smart Schools, who may not have heard the responsive clicks to the teacher’s interactions, were not sure whether the page had been visited before by looking at the changed colours of the link text alone. This suggests that feedback sounds may be taken for granted, but are nonetheless important for orientation within activities.

5.4.2 Discussion

In summary, different user responses were observed according to the different school facilities and the way in which the courseware is used in the classroom. Where students were able to directly interact with the courseware, their responses indicated that their engagement in some components was higher than those who could simply watch it being used. These different responses will be further clarified in the section reporting on focus group discussions with the students. However, from the observations alone, it can be concluded that the classroom environment appears to be an important factor that influences student engagement with the courseware. Supporting these varying modes of use should therefore be considered in future design and development of the courseware.

However, it can also be stated at this stage that not all the interface design components used in the existing interactive courseware engaged students in learning, promoted student interaction, and motivated them to use the courseware to the same degree, and that while the animation and video attracted attention to a high degree, the designers of the courseware were not entirely successful in
providing effective interface design in relation to the use of text, images and audio components. Students therefore tended to deduce the key learning objectives primarily from the animation and video components and the teachers.

5.5 Focus group discussions with students and teachers

After the observations were completed and analysed, focus group discussions were conducted with students, accompanied by their teachers. The purpose was to investigate what had been observed at a deeper level and to determine the students’ preferences and perceptions of the interface design components. Six focus group discussions were carried out at six different schools. Overall, thirty-six students participated in these group discussions (consisting of six participants from each class/school). Students who had been involved in the observations, and who also volunteered, were selected by their teachers for the focus groups. The first focus group was conducted on 21 January 2010 for 35 minutes, and the last focus group took place on 29 March 2010 for 41 minutes.

A standard focus group discussion protocol was used. Before commencing the discussion, the researcher provided background information about the researcher’s background, purpose of the study, and the duration of the discussion. While the six focus groups were conducted at six different times, the questions for all groups were the same, for consistency. The focus group discussions were recorded with permission from the participants. To limit shyness and anxiety, the teacher was present at all times. Once the students relaxed, questions were posed about their background, then questions (see Appendix 11 for full list of questions) were posed as open-ended questions, with supplementary questions to seek clarification or more detail when necessary.

The tape-recorded discussions were then transcribed by the researcher and analysed using thematic content analysis, drawing upon common themes generated by the discussion. These themes, which were based on any difficulties faced by the students in using the interactive Science courseware, and their perceptions of each of the interface components, are described in the following two sections.
5.5.1 Students’ perceptions of the strengths and weaknesses of the interactive courseware

In the student focus group discussions, it was important to first assess the respondents’ basic attitudes towards experiences of the interactive courseware. Focus group discussions therefore began with the participants being asked whether they use the interactive science courseware. In response, almost student (20 out of 30 students) indicated that they had experience of learning through interactive courseware. They were also asked whether or not they encounter any problems with it. Out of 30 students across all types of *Smart Schools*, 4 commented that they don’t encounter any problems. They were asked to expand and some broadly replied that this new learning tool is easy to use. As one participant answered:

*I don’t have any problem with the courseware. To me it is really good and I enjoy using it.* (Group Discussion 1, respondent 4)

Several students commented that they prefer it to other learning approaches, for example a typical representative reply from this perspective was:

*I am happy using this courseware. It is a fun tool and easier than reading a textbook.* (Group Discussion 2, respondent 10)

Against this positive feedback however, there were other students (18 out of 30 students) who stated that they are not really interested in using the courseware. (This distribution was not even; with students from state *Smart School* in particular claiming that they encountered difficulties). Further investigative questions were asked to ascertain the reasons. Several students suggested that the courseware is not easy to use, for different reasons. One claimed that is was not easy to use until you became very familiar with it, stating that,

*If you use it frequently, it is not so difficult ... sometimes very interesting! ...my teacher tells me that if I repeatedly use the courseware ...then maybe I will feel at ease.* (Group Discussion 4, respondent 20)

Another answer highlights difficulties with the language used in the courseware:

*I found the courseware difficult to use because it is in English.* (Group Discussion 2, respondent 9)

Other answers related to technical problems. For example,
It does not motivate me to use it because every time I try to open it, it takes a very long time. (Group Discussion 4, respondent 17)

Along with these broad issues, including the language used, technical problems and familiarity with the courseware, other issues contributed to the difficulties with the courseware among students. Two main problems were identified in relation to the current interface design. They are navigation and colour problems. To further clarify these issues raised by the students, the teachers were asked about them in follow up interviews and explained them as follows:

1. **Navigation**

   Navigation is a critical aspect of interface design and users must be able to navigate with ease through the courseware with activities structured in a way that is conducive to helping them accomplish their goals. However, from observations of the students who were working independently on the courseware in classroom, it started to become clear that the navigation in the sample interactive courseware presented difficulties to the students. Therefore this became a topic for discussion in the focus groups. Most of the students participating in the focus group discussions criticised the navigation system and commented that it was the most frustrating aspect of the interface to them.

   With regards to identifying specific problems, most of the participants (18 out of 30 students) claimed that buttons on the navigational menu bar are the most problematic in terms of usability, because they are not intuitive and do not function properly, making it difficult to navigate forward, backward or home easily. Students commented that they also were not sure what would happen if they clicked on buttons and that it was hard to tell if the buttons are highlighted or not after use. There were numerous comments from participants on this, for example:

   *I can’t really find exactly where the back button is and sometimes the buttons are not even working properly.* (Group Discussion 2, respondent 8)

   *It does not provide clear links to help me to go back and forth whenever I want.* (Group Discussion 2, respondent 10)
It is hard to use the menu bar for the first time. (Group Discussion 3, respondent 15)

The navigation gives me trouble going back and forward and even exploring what’s inside. (Group Discussion 4, 22),

Similarly, several teachers commented on this issue in follow up interviews. For example:

Initially, most of my students had difficulty finding the play and exit button. But then, they will use these buttons after I have shown them. (Teacher Interview, respondent 3)

Not only my students, but even I had problems with the back and forward buttons. Not all active buttons on the navigation menu bar are functioning well. (Teacher Interview, respondent 5)

The back buttons are the wrong way around: when you click up it goes forward. Sometimes when I click on a home button, it does not work. Apart from that I think it’s brilliant!!! (Teacher Interview, respondent 2)

A problem occurs when I want to play the video in the courseware. I want to play the video that explains the topic, and then when I want to pause the video, I cannot pause the video. Instead, I have to stop it.... a technical problem I guess. (Teacher Interview, respondent 1)

Besides these issues, respondents pinpointed other difficulties with the navigation bar. Indeed, most of students (20 out of 30 students) commented that the graphic images used for icons are not comprehensible without consulting the mouse-over explanatory text. Comments relating to this include:

The images used for the icon really make me confused. (Group Discussion 1, respondent 4)

I couldn’t find it until my teacher showed it. If I knew earlier, I believe it would’ve made it a little bit easier to use the courseware. (Group Discussion 2, respondent 7)

It is difficult to understand icons that only use images. (Group Discussion 6, respondent 28)

I was not able to recognize functions because the icons are simple images. (Group Discussion 4, respondent 16)
Another technical issue relates to the icons. Several students commented on this. The following is a typical statement from them:

*I can’t tell whether the button icon is functioning or not since its colour does not change when the mouse passes over it.* (Group Discussion 5, respondent 21)

This frustration was also expressed by three out of six teachers, who verified that many of their students were confused by the active buttons on the navigation menu bar in different ways:

*Most of my students are confused by the images used for the active buttons.* (Teacher Interview, respondent 2)

*I noticed the active buttons on the navigation often make my students confused. Sometimes, they don’t even know whether there are changes or not.* (Teacher Interview, respondent 5)

*Confusion with the active button discourages my students.* (Teacher Interview, respondent 6)

From these responses by the students and teachers, it can be concluded that the navigational menu bar in the interactive science courseware creates several problems for students’ interaction, in terms of technical issues, confusion about the meaning of the icons used and procedural issues to do with change states. It would be helpful for such usability issues to be addressed in future courseware.

2. Colour problems

Students in the focus group discussions also commented that the use of different colours for the same icon in different contexts confused their interaction with the courseware. For example,

*It was difficult to determine because different colours are used for the same thing.* (Group Discussion 2, respondent 9)

Another student elaborated,

*Sometimes it was blue, but in some pages it was orange.* (Group Discussion 1, respondent 2)

While this issue is related to the principle of consistency, other students discussed the use of colour in terms of aesthetics. Comments were made such as:
It would be better if it was more colourful, not only dominated by brown. (Group Discussion 2, respondent 8)

I lost interest in this courseware….the colour used for each lesson is not attractive to me. (Group Discussion 3, respondent 13)

The colour was not appealing at all…it makes us frustrated. (Group Discussion 4, respondent 18)

As discussed in Chapter 2, according to the literature, the use of colours impacts on the users’ perception and experience of an application. For example, soft colours make the users feel more comfortable (Nielsen, 1990) and bright or primary colours appeal to children. The Malaysian government guidelines also recommend an appropriate colour pallet should be used for the target group. Since students themselves clearly suggest that some of the colours were not really appropriate to them, or not visually appealing, perhaps more consideration should be given by the designers to this element, particularly in relation to the age of the students, and their perceptions of colours.

5.5.2 The perceived value of the multimedia components

Researchers in the area of Human-Computer Interaction argue that combining multi-media components such as graphic images, animation, video, text and audio helps to support students’ engagement (see for example Mayer, 2001). However, as discussed in the previous section, the different components have different effects on student interaction, and do not offer the same degree of enjoyment and encouragement to interact with the courseware. In the following section, the insight of the focus group discussions relating to each component is discussed in turn.

1. Graphic Images

Focus group discussions established that the students are attracted to the interactive courseware by the large quantity of visual images, which makes their learning more interesting in comparison to other learning tools. As one student said:
When I was in year 1 and year 2, I regularly used the courseware to explore certain lessons. I really enjoyed it because there are a lot of pictures. (Group Discussion 2, respondent 10)

Other participants shared this view, for example:

I like all the pictures and they are very helpful to understanding the content. (Group Discussion 3, respondent 13)

The students were therefore asked how they make meaning when seeing these components, and why. From the responses received, it became clear that these students believed that graphic images provide insights into the content. For example,

Images help me to have a better understand the type of lesson. (Group Discussion 3, respondent 11)

Students also commented that the background images used in the courseware support the content since they provide contrasting colours to the text, and help them to differentiate the foreground from the background.

In addition, many said that well-known graphic images used for the human characters helped to motivate them to access the content because they felt familiar to them and that made it more enjoyable. As one student claimed:

I did really enjoy the use of Sang Kancil! I know Sang Kancil already. (Group Discussion 1, respondent 3)

Together, this feedback suggests that the use of graphic images in the courseware increases students’ engagement with content, supports their access to the content and provides a sense of familiarity.

However, the students also suggested that the visual or graphic images used in icons do not describe the concepts that they stand for well. As the students said:

I can’t understand the meanings of the icons by looking at their simple images. (Group Discussion 3, respondent 14)

It is not easy to recognize the meaning of icons through images only. (Group Discussion 2, respondent 7)

The students commented that they often needed to mouse over icons where possible to see a textual explanation.
2. Animations
Most of the students (23 out of 30 students) agreed that the animations used in the interactive science courseware attract their attention to a high degree, and the majority of them suggested that more animations should be included in future courseware. Of particular note, the students say that they are attracted to the courseware through the animations and commented that they motivate them to engage with the courseware more. This enthusiasm is reflected in comments such as:

*I like animation of plants...amazing!* (Group Discussion 1, respondent 3)
*I like the snail animations. I can focus more.* (Group Discussion 5, respondent 21)

Moreover, responses by the students suggest that the animations assist them in understanding the content of the subject. For example:

*The animation at the beginning of the lesson does give me clearer information and helps in understanding the content.* (Group Discussion 1, respondent 5)
*The animation is really good. It gives me more information about what we are going to learn.* (Group Discussion 3, respondent 13)
*The animation helps me to understand more about the topic.* (Group Discussion 1, respondent 2)

Teachers also commented that they believe that the animations enhance the learning process. As one teacher commented:

*I think the animation is very attractive. ... It really enhances the teaching and learning process. For example, the introduction of a science concept can be explained easily with the animation assistance from the courseware.* (Teacher Interview, respondent 3)

And they agreed that it makes students more focused. As another teacher commented:

*Students are not only more interested but actually comfortable. In fact, when the animations are fun, students enjoy playing with the courseware, especially if the animation has the look of a real lab workbook ... using lots of detail, such as presenting the specific physical subject matter and*
Some teachers explained in detail how the animations are a particularly useful way to focus students’ attention and provide insights into the content in new and valuable ways:

*Really, really helpful! To me the courseware provided is very colourful with animations and all. It captures the students’ attention and helps them to understand the concept much more easily. For example, the topic of magnets illustrates clearly how one pole attracts or does not attract. Students can imagine it better than by explaining this on the board with chalks. It is too abstract.* (Teacher Interview, respondent 2)

According to both students and teachers then, animations in the courseware not only make it more engaging and motivate students to use it for longer, they also help students to understand the content better and learn more quickly. Although the quality of the animation was not considered to be sophisticated, in general it seems relevant because it provides demonstrations that relate to the science content and concepts that are being taught.

3. Videos

In the focus group discussions, students indicated emphatically that, like the animations, the videos in the interactive science courseware are engaging and that the courseware would benefit from more of them. For example:

*When my teacher runs the videos in the courseware, I really enjoy it!* (Group Discussion 6, respondent 24)

*I especially like it when the video is operated in the courseware. They should put more videos in.* (Group Discussion 6, respondent 28)

Other comments also suggest that the videos help students to access content and gain a deeper understanding of the topics being learned than other forms of content presentation. The effectiveness of the videos in this regard was evident through students’ responses such as:

*The lessons that contain video are easier to understand because if we read a text consisting of words, we need to read the whole text to*
understand the content, but not so through video. (Student, Group Discussion 3, respondent 11)

I am so excited when the video is run. I especially like the video of the butterfly. I can easily understand the life cycle of the butterfly when it is shown through video. (Group Discussion 3, respondent 15)

From the teachers’ point of view, the video is also one of the most accessible components. As one teacher elaborated:

I had been teaching for more than 7 years and I constantly use this interactive courseware in my class. What I have noticed is that when video in the courseware is used to explain some content, students become more focused. It’s much easier! (Teacher Interview, respondent 4)

Another teacher supported this by saying:

In my class I always find that my students become more focused when the video is presented. I think they like [the lesson] more. Indeed, I think it is essential. (Teacher Interview, respondent 5)

However, some teachers raised technical issues with the video components:

Videos take a long time to load. (Teacher Interview, respondent 2)

Sometimes the videos cannot run smoothly. (Teacher Interview, respondent 1)

These issues may relate to the age and quality of the hardware, rather than the software, but do point to a contextual issue of use. That is, if the courseware is used in contexts with limited infrastructure funding and support, it may not run effectively and so cannot include extensive rich media properly.

In summary, it has been established that the students find the video components enjoyable as they enliven the courseware, while learning through video content makes concepts more accessible and easily understandable. These attributes were confirmed by teachers. Therefore, it can be concluded that the video elements of the courseware facilitate student engagement and support their learning experiences.
4. Text

It has been established in the literature that information presented in text is often better when supplemented with visual images (Hooper & Hannafin, 1988). The Malaysian government guidelines also suggest that text should be accompanied by visual images to gain students’ attention and help clarify the content. Perhaps unsurprisingly then, during the observations, negative reactions were noted when students were required to read large quantities of body text in the courseware. The problem was particularly noticeable for the students from remote Smart Schools who do not have direct contact with the courseware but read it from a distance while it is projected onto a large screen at the front of the class.

To ascertain more detail on this issue, students from remote Smart Schools participating in the focus groups were asked for clarification. Their main criticism was to do with the context of use of the courseware in their classrooms. For example:

*I can’t read it at all from a distance. The font is too small.* (Group Discussion 5, respondent 21)

*I sit at the back of class. I can’t read the text that is very small.* (Group Discussion 6, respondent 28)

Throughout the discussions, students constantly indicated that the size of the body text is too small, causing readability issues for them.

In addition, most of the students from all type of Smart School found that the text component is not particularly helpful in explaining content when used alone, and that it does not engage them in an interesting way. As three students commented:

*It is not helpful because it is boring.* (Group Discussion 1, respondent 1)

*I was not able to understand the content because a lot of text makes me bored.* (Group Discussion 4, respondent 16)

*There’s so much text to bore me!* (Group Discussion 5, respondent 25)

However, a few students (10 out of 30 students) commented that the text becomes more effective when visual or graphic images are incorporated into the composition of the body text. Several students indicated that the incorporation of images not only helped them to become more interest and keep their attention on
the courseware, but also assisted them to understand concepts by making them less abstract. Indeed, several students stated that they understand what is described in the body text clearly if visual images are provided. As four students stated:

*I can understand what is explained in the text better if it is presented with some images.* (Group Discussion 4, respondent 17)

*I can identify images more than words.* (Group Discussion 5, respondent 22)

*The words cannot explain everything. If the words have an image, I can understand better.* (Group Discussion 4, respondent 18)

*Images may explain better than words because you often do not need to read what is written [when there are images].* (Group Discussion 4, respondent 18)

Based on such responses, it can be concluded that the use of text can be made more effective through design considerations such as font size, and the inclusion of supporting elements such as visual images to support understanding.

5.6 Triangulation of the findings and discussion

The learning process requires engagement of students with the subject matter, and it is through this engagement that learning occurs. In the case of interactive courseware, this engagement of users with the learning materials depends on effective facilitation by the interaction and interface design of the courseware, which provides access to, and engagement with, the content. As Bates (2005) has argued, high quality software that has been designed specifically for educational purposes tends to be embraced by students and educators. However, while it has the potential to enhance learning outcomes and provide users with a great deal of convenience, accessibility is important to make the tools effective; accurate and abundant content is crucial; and appropriate design that ensures suitability for the teaching context is necessary. Moreover, students’ and teachers’ expectations and concerns must be taken into consideration to ensure the uptake of the courseware in schools.
In this research project, these aspects of courseware design have been scrutinised in relation to the courseware developed for primary science subjects in the Malaysian Smart School project from multiple perspectives. Firstly, to provide the basis for evaluation, five key interface design principles were identified from a contextual document analysis of the key literature, and twenty-four characteristics of these principles were extracted from the Malaysian Government guidelines for developers, as well as the guidelines relating to five media types (components). A content analysis of the existing courseware was then conducted to ascertain whether the courseware that has been produced for the *Smart School* project conforms to these recommendations. This chapter has then gone on to present the findings of fieldwork, which has been conducted to establish empirical evidence (from quantitative and qualitative data collected through observations, focus groups and follow up interviews) on the effectiveness of the courseware. Attention has been paid to factors that contribute to student engagement with the courseware and the learning content; the most effective and engaging multi-media components; and any problems experienced by the students and teachers, in relation to the principles, characteristics and components established in previous chapters.

Triangulating the outcomes of the classroom observations, focus group discussions and in-depth interviews, makes it possible to draw overall conclusions about users’ experiences of the courseware, and their perceptions of its strengths and weaknesses. That is, it is possible to provide some answers to research question 2, namely: How do the users (school principals, teachers and students) of the interactive science courseware in the Malaysian *Smart School Project* interact with the courseware and perceive it? This research question relates to the overarching question of this study which is: How does the interface design in the interactive science courseware of the Malaysian *Smart School Project* accommodate user needs, facilitate user interaction, and support the overall learning experience and how it might be improved?

In short, the responses gathered from fieldwork showed that some of the participants enjoyed the courseware in general but encountered several barriers in the interface design performance. In fact, students observed in the classroom
using the courseware showed some frustration with aspects of the interface design. Similarly, answers given by the students in the focus groups also identified that not all principles, characteristic and components of the courseware lead to usability and engagement with the content. It is important to note however that the effectiveness of the courseware has to be understood within the context of the Malaysian education system. For example, the lack of facilities and infrastructure within a school, such as limited number of available computers and computer labs in each school, as well as aging and slow hardware in some instances could be a primary factor affecting students’ experiences.

5.6.1 The existence of principles and characteristics

From the contextual analysis of the international literature and the Malaysian government guidelines, five commonly cited principles for creating effective interfaces were named (by keywords) as: Consistency, Familiarity, Flexibility, Efficient feedback and Aesthetics. The content analysis of the courseware concluded that these principles have been largely applied in the design of the interactive Science courseware. However, it is also important to consider how the end-users encounter and perceive the presence of these principles in use.

Having conducted three methods of analysis, drawn from ethnographic approaches to the study of phenomenon in context, namely classroom observations, focus group discussions and in-depth interviews, it is now possible to triangulate the outcomes and conclusions against these principles. Table 5.8 collates this multi-perspectival information.
<table>
<thead>
<tr>
<th>Principles</th>
<th>Characteristics from the guidelines</th>
<th>Classroom Observation</th>
<th>Focus Group</th>
<th>In-depth Interview</th>
<th>Summary responses of stakeholders</th>
</tr>
</thead>
<tbody>
<tr>
<td>The principle of consistency within the design of a product</td>
<td>Clear sequencing of the screen appearance</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Students confused with inconsistency of colours for the same icons.</td>
</tr>
<tr>
<td></td>
<td>Similarities of colours used across screens</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Limited text styles</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use of similar characters throughout</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The same actions should yield the same result</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Consistent positioning of main menus</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standard tools on navigation bars</td>
<td></td>
<td></td>
<td></td>
<td>Not standardised, so students cannot navigate well.</td>
</tr>
<tr>
<td></td>
<td>The same montage used for the introduction to be used in all pages</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>The principle of familiarity with elements and functions from prior experience</td>
<td>Human and animal characters shall be logical and not contradictory to real life situations</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Students are familiar with the human characters used from other Malay stories.</td>
</tr>
<tr>
<td></td>
<td>The human and animal characters used should be familiar characters.</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Familiarity is also derived from characters in other Malay stories.</td>
</tr>
<tr>
<td>The principle of flexibility of the system’s response to the individual differences</td>
<td>Provide the user with buttons to pause, continue, go back or exit the activity</td>
<td></td>
<td></td>
<td></td>
<td>Students + teachers frustrated by lack of clarity. Some buttons do not function well.</td>
</tr>
<tr>
<td></td>
<td>Provide the user with appropriate working sounds</td>
<td></td>
<td></td>
<td></td>
<td>Some sound is not working properly. Students need to be prompted by teachers to trigger the sound.</td>
</tr>
<tr>
<td></td>
<td>Provide confirmation dialogues to prompt user actions</td>
<td></td>
<td></td>
<td></td>
<td>Feedback message are not varied and are not motivating.</td>
</tr>
<tr>
<td></td>
<td>Avoid biases of ethnicity and religion in any images</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Avoided biases of ethnicity and religion in colour used</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Visual images must be suitable for the age of the user</td>
<td></td>
<td></td>
<td>Yes, but students are more interested in video than images.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colours must be suitable to the age of the user</td>
<td>Yes</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>The audio used for human characters must be appropriate to gender and age of the character</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The audio effects used as alternatives to symbols or icons must be age-appropriate</td>
<td>Yes</td>
<td></td>
<td></td>
<td>Some sound is not working properly.</td>
</tr>
<tr>
<td></td>
<td>The text characters must be easy to read</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>The small body text is hard to read, and too dense.</td>
</tr>
</tbody>
</table>

Table 5.8: Summary of the evaluation of principles and characteristics through classroom observations, focus group discussions and in-depth interviews
<table>
<thead>
<tr>
<th>Principles</th>
<th>Characteristics</th>
<th>Classroom Observation</th>
<th>Focus group</th>
<th>In-depth Interview</th>
<th>Responses given by respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The principle of efficient feedback given to the user</strong></td>
<td>Provide accurate responses in the confirmation dialogue</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>No feedback given for some actions.</td>
<td></td>
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<tr>
<td></td>
<td>Provide users with visual or audio effects on actions that the user performs</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Not present for some actions and not always functioning.</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Allow user to operate the task properly</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td><strong>The principle of visual communication through an aesthetically pleasing appearance of the screen</strong></td>
<td>Each element used shall be attractive to the intended users and encouraging</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teachers and students like the overall screen appearance.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.8: Continued
Against the principles of consistency, flexibility, familiarity, efficient feedback and aesthetics, the following conclusions can be drawn:

1. **The principle of consistency within the design of a product**
   As established in the literature and contextual review, the principle of consistency, which involves a persistent style throughout the product and the use of standard elements, is particularly effective in facilitating user interaction and limiting confusion among users. Nielsen (1990), for example, suggests that users will be more confident and willing to learn if the same action produces the same effect consistently. The Malaysian government guidelines for courseware developers also emphasise this principle.

   The triangulation of the data gathered in this study allows us to establish that consistency is not comprehensive. Classroom observations established that students experienced moderate ease of use in relation to concepts and characters as well as design elements were applied (such as colour, font and layout), and consistency could be assumed to be a necessary factor in this. However, teachers and students participating in this study reported that they are often frustrated, particularly with the navigation bar, because of inconsistencies in the icons and colours. Therefore, it is recommended that the principle of consistency should be applied more rigorously by the courseware developers in order to create an effective interface design for future interactive Science for the Malaysian *Smart School Project*.

2. **The principle of flexibility of the system’s response to the individual differences**
   As established in the literature review, the principle of flexibility is necessary to ensure that courseware is responsive to the individual preferences of users and differences in age levels and skills, so that all targeted users can interact with the courseware without difficulty and can understand the content easily. The Malaysian government guidelines provide a local interpretation of this principle by requiring that all the design features of the interface should not only be age-appropriate but should also avoid any biases regarding ethnicity, culture or religion.

   The analysis of the courseware suggested that this principle has been closely followed. By and large, the colours appeared to be appropriate for the age of the intended user and, in terms of usability, the colours used for the explanation texts contrasts well with the background images on the screen. However, focus groups and in-depth follow-up interviews
revealed that students do not find the predominant use of colours appealing to their age group, and observations (as well as focus group discussions) uncovered that students are frustrated by small text, which suggest that this is not age-appropriate. This was particularly evident in the remote Smart Schools where the context of use requires students to read from a distance as the content is projected onto a single screen. On the other hand, none of the participants expressed concerns about biases of ethnicity and religion or any images or colours used, so this could be a confirmation that those issues are accommodated well.

Therefore it can be concluded that some attention might be given to the target audience’s colour preferences. On the other hand, the local conditions in terms of culture and religion are accommodated well. What is not taken into account however, is the variation in local conditions of use. The courseware appears to have been designed with assumptions about how it will be used (with each child interacting via a single computer). However this is not always the case and in Remote Smart Schools the students can only see the projections while the teacher interacts with the courseware. Therefore, attention needs to given in the Malaysian Government guidelines to these contextual variations and the differing experiences that arise from it. Recommendations need to be put in place to accommodate these varied experiences in terms of usability (e.g. font size) and engagement (e.g. more videos and less text).

3. The principle of familiarity with elements and functions from prior experience
It is well established that familiar characteristics should be employed in interface design, through the employment of standard layouts, approaches to icon design and concepts as well as well-established terminology and processes. As Mayhew (1992) explains, familiarity with the product through reference to prior experiences allows users to immediately feel comfortable with how a product operates, and how it fits into their lives. This means that employing familiar computer-based concepts and using real-world metaphors are very helpful. The Malaysian government guidelines reflect this principle by emphasising that students should be provided with familiar concepts, and that screen appearance should align with prior knowledge of the students.

The content analysis of the interactive Science courseware identified that some of the characters used in the courseware were based on familiar story characters. In the classroom observations, the effectiveness of this strategy was confirmed as most of the students
seemed to recognise the animal characters from storybooks and welcomed that. Students in the focus group also acknowledged that the navigation bars and their placement is similar to other products that they have used before. Thus, it is likely that the students apply this prior understanding in their learning activities with the courseware. Therefore the use of this principle should be maintained in the future development of interactive science courseware in Malaysia.

4. The principle of efficient feedback given to the user

Confirmation feedback is important for any actions performed within an interactive system. As Nielsen (1990) claims, user interaction without feedback is unproductive. Norman (1998) has established that feedback may simply be a response that confirms that the action has occurred or, at another level, may confirm whether a user’s answer is correct or incorrect. However, as he goes on to explain, a more helpful form of feedback involves a more sophisticated explanation that gives learners relevant information on how to adapt and correct their performance.

The content analysis established that feedback functions are present in the interactive Science courseware. And students by and large commented on clear and immediate feedback after they perform an action. For example, two students commented that:

\[ I \text{ got the answer immediately! } (\text{Group Discussion 3, respondent 12}) \]

\[ I \text{ got a response on what I did straightaway from the courseware. } (\text{Group Discussion 6, respondent 28}) \]

This feedback function was found to be effective by most students in that it allowed the students to check their actions and answers. However, student observations revealed frustration with some buttons that are not functioning well, and some sound feedback that is not working properly. And, in the focus groups, some students also noted that they hope that future courseware will provide them with more in-depth or detailed feedback with varied messages that are motivating in new ways. As one student commented:

\[ \text{The feedback given is always the same, such as congratulation!, well-done! Can it appear in other words? } (\text{Group Discussion 3, respondent 11}) \]

Some teachers noted that students sometimes look confused by the responses given and that the style of the feedback did not provide a variety of motivational messages, which would be beneficial.
It can therefore be established that students may need more guidance on how to correct their answers or be given hints on how to try again which, unfortunately, is not currently provided in the courseware. The principle of effective feedback could therefore benefit from more consideration in the development of future *Smart School* interactive courseware.

5. **The principle of visual communication through an aesthetically pleasing appearance of the screen**  
The literature has established that aesthetics in interface design relates to a balanced and elegant overall arrangement of the composition of the interface, as well as the use of appropriate colours, forms and fonts used, which creates an identity of the product that is attractive to the target audience. This helps users by producing familiarity and enjoyment, so capturing users’ attention and helping maintain their interest. The Malaysian government guidelines also recommend an appropriate colour pallet that appeals to the target group, namely school children.

In the observations, it was noted that students were engaged with and motivated to use the courseware for only a short time, and when the reasons for this were followed up in focus groups some of the students suggested that the colours were not really appropriate for them, and that the felt that they were boring.

In terms of communication through visual images, it was noted in the observations and confirmed in the focus groups discussions that the motion graphics in the animations were both engaging and effective in the communication of content and concepts. This also applied to still images that are used to explain concepts and establish metaphors (of classrooms, gardens, labs etc). However the students’ confusion in navigation and implementation of tasks that was apparent in the focus groups was explained in the focus groups in terms of the use of images in icons, which are at times unclear and need textual explanations to be understood.

Therefore, issues of targeted aesthetics need to be emphasised by the Malaysian government, especially in term of providing colour that is appropriate to the age of the students, and their perceptions of colours. In addition, while the use of graphical images in stills and motion graphics should be applauded, the design of icons needs attention and specific guidelines may assist in this aspect of the courseware. In summary, based on the evidence gathered...
from classroom observations, answers given by students in focus groups and teacher interviews, it can be concluded that not all principles and characteristics outlined in the Malaysian government guidelines have been properly applied, and even when some of them are applied in the courseware, the outcomes do not always lead to attracting and maintaining the interest of students and teachers in the courseware. This suggests that the existing guidelines may need to extend into more detail for the future development of interactive Science courseware in Malaysia.

5.6.2 Recommendations for extending the characteristics requirements in the existing guidelines

From the findings drawn for the content analysis, observations, focus groups and interviews to ascertain teachers’ and students’ concerns and expectations, it can be concluded that several additional characteristics should be added to the existing Malaysian government guidelines to assist developers in designing the interface’s screen appearance, arranging the components, and providing systems feedback. These extended characteristics are proposed in Table 5.8.
<table>
<thead>
<tr>
<th>Principle</th>
<th>Characteristics in the Ministry guidelines</th>
<th>Additional characteristics recommended from this study</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>The principle of consistency within a product</strong></td>
<td>The clear sequences of similar screens</td>
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<td></td>
<td>The consistency of the colours</td>
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<td></td>
<td>The consistency of text style</td>
<td>Use similar designs for icons with the same meaning</td>
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<td></td>
<td>The consistency of characters</td>
<td>Colour changes in icons used in the navigation bar should be the same throughout</td>
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<td></td>
<td>The same actions yield the same result</td>
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<td></td>
<td>The similar position of the main menu</td>
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<td></td>
<td>The standard tool on navigation bar</td>
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<tr>
<td></td>
<td>The same introductory montage</td>
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<tr>
<td><strong>The principle of flexibility of the system’s response to the individual differences</strong></td>
<td>Provide the user with buttons to pause, continue, go back or exit the activity</td>
<td>Navigational buttons must be functioning appropriately</td>
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<td></td>
<td></td>
<td>Icons on the navigation bar should include image and text</td>
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<td></td>
<td></td>
<td>Provide a combination of images text and voice instructions to sustain student interest and appeal to different learning styles</td>
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<tr>
<td></td>
<td>Provide users with an appropriate working sound/audio</td>
<td>Information presented through text must be readable by all the students in different contexts. Avoid the use of small body text in general</td>
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<td></td>
<td>Have a confirmation dialogue to confirm any user action</td>
<td>Avoid the use of blinking text</td>
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<td></td>
<td>Avoid biases of ethnicity and religion in any images used</td>
<td>Provide graphic images with text information as a supportive learning tool</td>
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<tr>
<td></td>
<td>Avoid biases of ethnicity and religion in colour used</td>
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<tr>
<td></td>
<td>Visual images must be suitable to the intended user’s age</td>
<td>Provide users with more video or animation in explaining content</td>
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<tr>
<td></td>
<td>The colours used must be suitable to the intended user’s age</td>
<td>The design features used for any component should be accessible by most students</td>
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<td></td>
<td>The audio used for human characters are appropriate with gender or age</td>
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<td></td>
<td>The audio effect used for the symbols or icons should be appropriate</td>
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<td></td>
<td>The text characters used should be easy to read</td>
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<tr>
<td></td>
<td>The text characters must be suitable to the intended user group</td>
<td></td>
</tr>
<tr>
<td><strong>The principle of efficiency of feedback given to the user</strong></td>
<td>Provide accurate responses on the confirmation dialogue</td>
<td>Immediate feedback should be clear and easy to understand by the student</td>
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<td></td>
<td>Provide users with visual or audio effects on actions that the user performs</td>
<td>Immediate feedback should be placed together with a motivational message, which is not always the same.</td>
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<tr>
<td></td>
<td>Allow users to operate the task efficiently</td>
<td>Provide users with colour changes or images on actions that the user performs</td>
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Table 5.8: The set of additional characteristics recommended from this study
Additional characteristics that might be recommended out of this study, which relate to the principle of consistency, include that icons for the navigation bar should be both visual images and text explanations. The navigation bar should function as expected by users (technical problems and bugs should be rectified); the design of icons should be in a similar style throughout the courseware and the colour of icons on the navigation bar should be persistent from page to page.

In relation to the principle of flexibility, in order to maintain student interest, information presented through text should of a sufficient size to be easily read by all students, even when projected on to a screen at the front of the class. Therefore small body text and blinking text should be avoided. In addition, images, video and animations should be employed as much as possible to provide an alternate path to understanding (and it should be noted that these two components are very popular with students and teachers). Likewise, to accommodate different user preferences and learning styles, any graphic images could be accompanied by text and voice instructions.

As requested by the students and teachers, the interface design of future interactive science courseware should also provide immediate feedback to acknowledge actions and it needs to be clear and easy to understand through colour changes, sounds or images. But it should also give varied and second and third level feedback, which involves acknowledging whether an answer is right or wrong and how the response might be improved in future.

5.7 Conclusion

Previous chapters have reported on the comparative analysis of principles, characteristics and components that have been established in the literature and recommended in the Malaysian government guidelines against a content analysis of the interactive courseware to establish the quality of the interface design. This chapter has taken a complementary approach and has reported the outcomes of fieldwork (conducted via classroom observations, focus group discussions and in-depth interviews) to explain how the interface aspects of the interactive courseware is experienced and perceived by students and teachers in terms of facilitating their interaction and supporting the overall learning experience.
The quantitative and qualitative data obtained from the fieldwork has established the usefulness of interactive courseware in schools and the willingness of school principals and teachers to employ it in principle. All teachers who participated in this research project agreed that when the interactive courseware is being used, it increases their students’ interest and they become more engaged in their learning process in the classroom. This confirms previous studies on the use of interactive courseware in the classroom, which have consistently found that students commonly experience positive effects on their learning when using interactive courseware as a complement to traditional methods (Bee Theng & Chia Hua, 2008; Jennings & Onwuegbuzie, 2001; Khoo, 2003). These results also support the argument made by Stolterman (2008) and Sutcliffe, Kurniawan and Shin (2006) that the enjoyment offered by interactive courseware can increase learners’ motivation and participation.

However, the school principal interviews in this research project have identified three main factors that contribute to the extent of courseware usage in their schools. These include the provision of adequate computing facilities; the availability of technical support; and the quality of the interactive courseware. If any of these are lacking, they present barriers to use. The effect of poor interface design as a major barrier to courseware usage has been reported in several prior studies on the implementation of interactive courseware in the Malaysian Smart School Project (Azian, 2006; Bismillah Khatoon Abdul Kader, 2008; Cloke & Sharif, 2001; Thang et al., 2009b). These studies have concluded that the interactive courseware for the Smart School Project has failed to provide a high quality learning experience for students and teachers because of poor interface design that does not accommodate their learning styles, access to content and their interaction with the functions. They have also concluded that this affects the teachers in terms of their interest and motivation to use the interactive courseware as a new method of teaching.

The findings from this fieldwork confirm this previous research as well as identifying other factors such as facilities, and support. However the findings of this study extend these findings by helping to clarify the arguments raised by previous researchers in Malaysia by pointing to specific issues and by providing a foundation for comparison against well established international design principles and the Malaysian government guidelines.
By identifying key principles of effective interface design from the literature, the study has provided a rigorous and appropriate basis for critique. By comparing the courseware against them, and then going on to evaluate students’ and teachers’ interactions and perceptions of usability and engagement, this study provides empirical evidence that helps to confirm the validity of the principles provided by the Ministry of Education. It is also able to propose refining the existing guidelines and provides new recommended characteristics for the development of interactive courseware in the future. This is a major objective of this research study: to recommend a new or extended set of principles and characteristics for effective interface design for future courseware developed in Malaysia.
6. Understanding the design of the courseware interfaces as part of the software development process

6.1 Introduction

In order to understand how the interface design issues that have been identified in the Malaysian Smart School Project courseware have arisen, the development process has been investigated as part of this research project. This investigation was conducted through two methods: a contextual document analysis and face-to-face interviews with the courseware developers. The main purpose of the contextual document analysis was to determine models for the software development process that have been proposed in the international literature, as well as the processes recommended by the Malaysian Ministry of Education in their guidelines. The objective was then to establish whether the ministry guidelines correlate with international expectations of best practice. The primary purpose of the interviews with the courseware developers was to determine whether the developers were aware of, and applied, international models and/or the processes suggested by the Ministry.

The overall goal of this comparative process was to understand whether there are any issues in the current process of software development that affect the interface design adversely and, in conjunction with the data from school principals’ and teachers’ interviews, to establish how the working relationships between the stakeholders (including the government, the developers and the end users of the courseware) are structured and whether this has any impact on the quality of interface design. These objectives relate to Research Question 3, which asks: How is the interface design of the courseware developed and does this contribute to the quality of the interface design?

6.2 Models for software development in the literature

The software development process can be described as a development life cycle. In order to manage and ensure the success of computer software, a series of structured development activities has been developed over many years and these have been formulated into development processes. Throughout the literature, a variety of systems development models can be found, each outlining detailed structures and processes and a variety of activities that
are closely linked. While many models are acceptable, depending on the circumstances and the goals of the product, it should be noted at the outset that variant approaches impact on aspects of the outcome (Bradler, 1999; Bostock, 1996; Lee & Sullivan, 1996). Therefore, an appropriate development model should provide the developer with a systematic, well-disciplined and practical approach to the design, development and maintenance of the software.

There are three classic development models established in the literature, which will be summarised in detail here. And, because this research project focuses on interactive courseware for educational purposes, a well-known instructional system development model that is identified in the literature will also be described. This includes then: (1) the classic waterfall model, (2) the iterative model, (3) the spiral model and (4) the ADDIE model for instructional system development. Within all of these models, software developers and educators commonly work together to generate the learning content, formulate the learning activities and assessment strategies and determine the feedback on the developed software.

A brief overview of the approaches of each model follows:

1. **The classic waterfall model**

   The best-known and perhaps oldest process for software development is the waterfall model, which has been used since it was proposed by Winston W. Royce in 1970 (Beynon-Davies, 1993). It involves a phased process, which includes requirements analysis and planning, design, development, implementation and evaluation, in a sequence as follows:

   1. *The requirement analysis and planning phase* involves defining the target users of the potential product and identifying their requirements and needs (in the case of courseware this would include the needs relevant to the students and teachers and the learning objectives).

   2. *The design phase* focuses on determining the design solutions to be used by considering approaches to delivery formats, structure (which is commonly referred to as information architecture and is guided by a flowchart and storyboard), interface and screen design, and elements of the look and feel.

   3. *The development phase* where the design components and programming are assembled as a functioning prototype. Alpha and beta testing occur at this stage.

   4. *An implementation phase*: where the end product (or in some models, a prototype) is implemented and provided to the target user (or a representative sample group).
5. *An evaluation phase:* which focuses on gathering feedback on the end product from actual users.

These phases are summarised in Figure 6.1.

**Figure 6.1:** The waterfall model: progress flows from the top to the bottom like a waterfall
(Source: Beynon-Davies, 1993)

The development process of the waterfall model moves from one phase to the next phase only when the previous phase is completed and perfected. According to Preece (1994), this model attempts to separate the development life cycle into discrete activities by creating a series of linear actions in which each step forms the basis for the next step, and the correctness of each step can be checked. For example, as Figure 6.1 shows, when analysis is complete, the process proceeds to the design stage and, when it is complete, development commences and so on.

In the waterfall model, the interface design occurs in the design phase and the development phase when an instructional plan is provided by the development team, including a set of requirements and flow charts that show a general path of connections in the interface design. At this point, designers carefully consider the arrangement of screen layout, a style guide for
graphic elements, and a navigation system that can engage users in meaningful and authentic tasks (Wilson & Cole, 1991; Wilson et al., 1993). To make this process efficient, effective communication between members in the development team such as a graphic designer, programmer, instructional designer, and a content expert is essential.

This waterfall model offers an advantage to developers because it breaks a complex task down into smaller tasks and it allows everyone involved in the development process to see exactly what has been completed and what remains to be done throughout the process. Nevertheless, a number of problems with the waterfall model are identified in the literature. The main weakness is that it does not include an opportunity for end-users to review and evaluate the potential product being created until it is complete as it does not include interim feedback between stages. Therefore correction becomes much more difficult. Moreover, once the process has progressed, there is no way the product under development can go back to the previous stage because it always moves in a single direction. In response to this problem, some alternative models have been introduced, some of which involve the steps of the waterfall model as a foundation.

2. The iterative model
The iterative model, which was introduced by Boehm in 1985, provides an alternative model for the software development process. In terms of the phases involved, it incorporates planning, requirements and analysis, design, evaluation, and implementation. It is therefore similar to the waterfall model but it involves a cyclic process which includes multiple iterations or versions in a repetitive process. This model introduces prototyping, testing and analysis during the design phase and involves redesigning on the basis of the feedback received, in order to refine the quality of the final product. This iterative cycle within the model is represented in Figure 6.2 by the green arrows.
The most important advantage of the iterative model is that prototyping in the design stage offers the developers the opportunity to elicit periodic, objective feedback on the appropriateness of the solution, which allows the developer to make incremental adjustments and make corrections based on a better understanding of the needs and requirements of the user. By implementing this cyclic process, which involves input from the end-users at an early stage on aspects like the proposed look and feel of the application, developers can capture and fix possible weaknesses in the underlying interface design at the prototype phase, rather than after all the components have been integrated into the design.

This model therefore emphasises the importance of collaborative work between developers and users, which is necessary for the product under development. Early input from end-users not only has the potential to highlight problems earlier in the design phase, this method can shorten the development time of a project (Connell & Shafer, 1989). It minimizes the risk of conflict between users and the development team that can arise in the waterfall model, and it can help to ensure that risks are minimized because it ensures that the product will be effective and appropriate for the user. Besides helping to ensure that the actual needs of users are met, so increasing the values of the product to the user, it also provides a sense of ownership by these stakeholders over the product because of their input into it development.
3. The spiral model

In 1988, Boehm proposed further modifications to overcome the limitations of the waterfall model and the iterative model. This model is referred to as the spiral model or Boehm’s Model. The steps employed are similar to the steps in the traditional waterfall model because, like the iterative model, it is an improved version of the waterfall model on which it is based. It combines the advantages of prototyping within the progression of the waterfall model and involves a number of iterations as it passes through four main steps: analysis of requirements, planning, development and evaluation. As shown in Figure 6.3, these unfold as a spiral.

![Figure 6.3: A spiral model: progress flows of development must be repeated more than once (Source: Boehm, 1988)](image)

Like the iterative model, from the early stages through to final product development, the process is highly dependent on prototyping designs, which are evaluated by representative users. With this focus on prototype design and testing, the spiral model emphasises flexibility in meeting end-user requirements to minimise the risk of ineffectiveness. While developers make changes in structure, content and presentation of the material, at the time in which problems or potential problems are encountered, the spiral model explicitly encourages alternative approaches to be considered to address them.

The first iteration of the spiral model is considered most important. This is because normally, at the first iteration, most potential risks, obstacles and needs are identified. In the
next iteration, all the factors and problems discovered in the first phase will be resolved with great care before being re-tested.

Because the process emphasises risk analysis, and because the knowledge of end-users is actively incorporated and contributes to the design solution, not only representative user groups, but highly skilled people in the areas of planning, risk analysis and mitigation, development and customer relations are involved in the process outlined in the spiral model. In addition, because it involves several periods of consultation and multiple cycles, the model requires more time to complete. This model can therefore be expensive to implement and may only be cost effective for large-scale software development projects, where both the budget and risks are higher.

4. The ADDIE model
In the literature on software development for educational courseware, there is strong support for the inclusion of an instructional design perspective in the process. It is argued that expertise on teaching and learning is essential for the development of a more effective product (Duffy & Jonassen, 1991). The ADDIE model is one of hundreds of instructional design models proposed for guiding the process of development for educational materials.

The process of the ADDIE model involves similar phases to other generic models. These include Assessment, Design, Development, Implementation, and Evaluation. While these core steps of the ADDIE model may follow generic models, the ADDIE activities are not organized in a linear or straight-forward way. They are cyclical (Gustafson & Branch, 2002) and recursive like the spiral and iterative model, but their central focus is on evaluation, which sits at the heart of the model. The iterative aspect of this model is represented by the line and arrows running vertically down the left side of the model and the two-headed arrows between each component, as depicted in Figure 6.4. Each step has an outcome that feeds into the next step in the sequence but evaluation is a persistent interim step to ensure perpetual quality improvement.
As a useful model for creating effective interactive learning material for education, this model highlights analysis as the most important step in the process. The analysis of users' needs and requirements, as well as input of instructional designers, helps developers—particularly the designers—to establish a clear understanding of the gaps in the users’ existing knowledge and skills and strategies to bridge them. Therefore, during the analysis stage, the designer identifies the learning problem, the goals and objectives, the users’ needs, instructional strategies and methods. This step is necessary in order to define the parameters for the production of the product, including the learning environment, any constraints on limitations or opportunities, delivery options, and the timeline for the project.

In this model, the creation of the content and production of learning materials occurs during the design phase. Generally, rapid prototyping of the interface design is conducted at this stage to facilitate feedback. Mood boards for the look and feel and detailed storyboards present paths through content. Some scholars describe this as a brainstorming step, where feedback is part of the analysis of the needs of users or audiences.
Using information gathered from this analysis and design phase, the development stage begins, complete with evaluation and measurement of how well the product achieves its objective. The evaluation of the ADDIE model consists of two parts: formative and summative. The formative evaluation may involve peer review, a walk-through of a rapid prototype, observations of the target group using the software and interviews (individually or in focus groups) with potential users. In each stage of development, these evaluations inform all aspects of the design including the interfaces, navigation, and how the software’s functionality supports student learning. Summative evaluations consist of tests, based on performance, and provide formal opportunities for feedback from the users. Both tiers of evaluation provide insights into any false assumptions on the part of designers and developers, as well as design errors, and any barriers to achievement of the desired outcomes.

A software development process must therefore be understood as a phased and rigorous endeavour comprised of many separate but inter-related activities that each have a bearing on the creation of products. While all of the four models discussed above help to ensure this, all have advantages and disadvantages. If the problem is well defined and well understood and needs little change, the life cycle of the waterfall model may be sufficient to produce a product in the most cost-effective way. However, if the developer lacks a clear understanding of needs of users, they are unlikely to be able to produce comprehensive and entirely appropriate specifications at the beginning of the process. In this case, the developer must choose a longer life cycle and more complex approach, which involves stakeholder participation (e.g. spiral model or iterative model). And, to promote the use of technology as an effective tool to support learning, the instructional design process of the ADDIE model is perhaps the best system design process currently available that can be practiced by the developers. In addition, this model emphasises that input should be sought from all stakeholders prior to and during the development of courseware to ensure quality outcomes, minimise user frustration and facilitate meaningful product delivery. Many education experts therefore argue that it is the best approach currently available for designing effective educational courseware. This is particularly the case in relation to interface design because, as Bodker (1991) and Rushby (1992) have recognised, interface design is one of the most important and complex activities in the software development process.
6.2.1 Interface design within the development process

No matter which development process is used, the design and production of the interface is particularly important, because users tend to rate the usability of a product on its interface design performance. This is because the interface is their first contact point (Faulkner, 1998), and users will tend to make judgements on first impressions, which are created by the interface rather than functionality (Mayhew, 1992). Indeed, many products are never used because potential users never get past the initial interfaces (Galitz, 2002).

Besides, establishing the look and feel of a product (which should balance an expression of the product ‘identity’ with the sensibilities of the target group of users), there is considerable agreement in the literature that effective interfaces are those that are easy to use and which enable users to achieve their goals in the context of product use (Mayhew, 1992). Therefore, the development team must decide how users will interact with, and navigate through, the software system and choose appropriate methods within the interface to provide instructions to users, and provide multiple types of feedback. Thus, courseware developers need to consider how the interface design affects users’ experience, as well as which elements and principles need to be incorporated in a particular context and for a particular audience.

Given this complexity, interface design can be viewed as a complete systems design process in its own right. As Bodker (1991) and Shneiderman (1998) argue, interface design is not something that can take place late in the development process after all the important decisions have been made, but is something that must be continuously addressed throughout the process, usually by a specialist interface designer in the development team. And, to develop an effective interface, a detailed understanding of the users and their needs is required, which should involve stakeholder consultation, if not participation in the design process itself.

6.2.2 The role of the user in the development process

Any software application has to meet the requirements of a real group of end-users in a cost-effective manner (Kennedy, 2001). It is therefore now widely acknowledged that designing and producing an effective interface must begin by considering the needs of end-users (see, for example, Schneiderman, 1998). That is, when designing any computer software (including interactive courseware), it is important to not only consider how it will
successfully meet the specifications of the product requirements, but the different expectations and needs of its end-users. By gathering information from users, it becomes possible to understand their goals, behaviour, preferences, and general work practices. This includes consideration of how the product will be used, how interactivity will suit the users’ goals, and how they will relate to its interface and content. The input of users helps create better quality systems. Conversely, the lack of user involvement is often associated with the failure of software. (Gould & Lewis, 1985)

The type and extent of user input varies in different development models. At the very least, the development team must have information on who the users are, what they want to do, where they want to use the software, and how they will use it. This clearly involves analysis of the characteristics of the users and their goals, as well as how these goals have been achieved in the past. The iterative model and spiral model take this further and include the process of feedback, which influences the direction of the design and, in the case of the ADDIE model, it may involve redesign work. Muller et al. (1997) go further to claim that user involvement in the development process is so important that stakeholders should be involved as co-designers. In this case, user’s involvement is not simple information gathering, where users are considered to be informants, but active contributors to designing the system.

The international literature is therefore clear that empowering and involving end-users in the development process is important, as it has proven benefits in the development of effective interface design and usable software. Indeed, Preece, Rogers and Sharp (2002) assert that the degree of user involvement not only affects the level of user satisfaction, but is related to perceived courseware success. User participation is particularly essential in the early stage of development to ensure the success of the system, in which development approaches such as prototyping, is valuable. However, as Oliver & Herrington (2003) suggest, in practice, courseware developers often assume that designing simply involves common sense, while they also commonly hold different views on the required functionality of a product.
6.3 The software development process in Malaysia

To understand the current software development process in Malaysia against this background of international views, an analysis of the Malaysian government guidelines was first conducted to determine the process recommended by the Malaysian Ministry of Education in their guidelines for the developers. The purpose of this was to see how these guidelines compare with the systematic, well-disciplined and practical approaches of the four models discussed above. A review of the Malaysian government guidelines is presented in the following section.

6.3.1 The software production flow outlined by the Ministry

As stated in the Methodology chapter, the courseware developers involved in the development of interactive courseware for the Smart School Project must go through a tender process by submitting an application with a sample of their past work and a financial plan to the Ministry. The Ministry then appoints selected courseware developers to the project and provides them with development guidelines.

The Malaysian government guidelines have two sections. The first part, which has been discussed in detail in Chapter Four under Section 4.2.2 (Comparative analysis of the courseware with the government guidelines), relates to the specific design requirements. The second part outlines specifications for the production process, along with submission requirements. It is this section that will be discussed here.

A flowchart of the development processes that is provided to courseware developers in the Malaysian government guidelines is reproduced below in Figure 6.5.
As shown in the diagram, the recommended process begins with developing a lesson map and storyboard as part of overall planning activities. Following that, the preparation of multimedia content and technical development should take place, according to the guidelines. These design and development activities required only the involvement of the development team. Then, the courseware goes through the testing and evaluation stage. It must undergo beta testing by the Ministry and any refinements to the final look of the product must be made by the developer before the courseware is deployed into the schools.

The steps outlined in the Ministry guidelines are therefore quite similar to the traditional waterfall model described above. That is, the process begins with a planning phase, followed by design and development, then testing, and ends with evaluation of the product during implementation. The guidelines do not include any improvements on the model that are proposed by the iterative, spiral or ADDIE models. For example, no prototyping method is set out as part of the planning or design and development phases, and no mention is made of user input or involvement during any phase in the flowchart. Instead, several stages require approval from the Ministry to proceed to the next steps. Thus the current production flow outlined in the Ministry guidelines focuses solely on the roles of developers and the Ministry. And, while it has been established in the literature for some time that involvement and input from users is important, this does not feature in the Ministry guidelines, and users...
are not necessarily involved at any level. That is, the guidelines replicate an outdated and broadly criticised development model.

### 6.3.2 Processes followed by the courseware developers

To understand whether the methods and processes of a standard development model described in the international literature, or in the Malaysian government guidelines have been followed by the developers of the *Smart School* courseware, face-to-face interviews with the developers were conducted. The interviews were designed to provide insights into how the production and development of courseware is practised in Malaysia at present, including whether the developers comply with the Ministry guidelines; the extent that the developers’ understand the role and principles of interface design; and the extent to which prototyping and user involvement is included in the development process.

As explained in the Methodology chapter, twenty courseware developers from a number of development companies, which have been involved in producing the Malaysian *Smart School* courseware, were approached by phone and email in early April 2009 from Australia. They were then emailed information letters and consent forms. Ten of these courseware developers agreed to become research participants. Fieldwork in Kuala Lumpur, Malaysia was then carried out in May 2009. Interviews were conducted at the courseware developers’ offices through the use of similar procedures used in interviews of school principals and teachers that have been discussed previously. Table 6.1 shows a summary of the interviews consisting of interviewees’ roles, duration of the interviews, and dates of data collection.

<table>
<thead>
<tr>
<th>Interviewee role</th>
<th>Average Duration (minutes)</th>
<th>Date of data collection</th>
</tr>
</thead>
</table>

**Table 6.1:** Summary of interviews with courseware developers
In individual, open-ended interviews, each developer was asked a series of investigative questions, which can be seen in Appendix 12 of this thesis. A video-recorder and audio-recorder were used to record the interview sessions with permission of the interviewees. At the beginning of the interviews, it was explained to the participants that any comments by them would be de-identified and so would form an anonymous response. The data gathered from the interviews was then transcribed by the researcher and translated by the National Institute of Translation Malaysia.

Interview questions focused on the level of involvement of courseware developers in the software development process, their current practices of interface design production for interactive courseware, and the degree of implementation of guidelines provided by the Ministry. Three related themes arose out of the content analysis of the interview transcripts. The first two reflect the interview questions and include the current process of development and the common steps involved and practiced, and understandings of the role of interface design among the courseware developers. However, while the focus of the interviews was on the development process and design understandings, many participants also used the opportunity to express particular concerns about their broader experiences as courseware developers. Therefore a third theme appeared: the challenges faced by the courseware developers in the current development process. Each of these themes is detailed below.

### 6.3.3 The development process for interactive courseware in Malaysia

In general, the interviews revealed that the current flow of software development practised by the Malaysian courseware developers is similar to the product life-cycle of the waterfall model. However the responses show that most of the Malaysian developers also initiate a requirements and planning phase up front, and include iterative phases in the development stage and evaluation stage to refine the courseware. Therefore, it is not carried out in an entirely, linear way. The process, as it was explained by the developers, is tabulated according to responses given in Table 6.2.
### STEPS OF DEVELOPMENT BEING PRACTICED

<table>
<thead>
<tr>
<th>Developers</th>
<th>Planning</th>
<th>Analysis</th>
<th>Design</th>
<th>Development</th>
<th>Evaluation</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>User need analysis</td>
<td>Product Requirement analysis</td>
<td></td>
<td>In house Testing</td>
<td>User Testing</td>
</tr>
<tr>
<td>1</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>2</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>3</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>4</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>5</td>
<td>Yes</td>
<td>No</td>
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<td>6</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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<td>7</td>
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<td>8</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>9</td>
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<td>Yes</td>
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<td>Yes</td>
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<tr>
<td>10</td>
<td>Yes</td>
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<td>Yes</td>
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</tr>
</tbody>
</table>

**Table 6.2:** Summary of steps practiced by the interviewed Malaysian developers
Therefore, developers’ interviews have determined that five particular steps are being practiced, which are similar to those most commonly referred to in the literature. They include the requirements and planning stage, analysis stage, design stage, development and testing stage, evaluation and feedback stage and finally, the delivery and implementation stage. This courseware development process is visualised in a diagram in Figure 6.6 and is then compared to the waterfall model in 6.7.

Figure 6.6: The common flow of the development process currently implemented by courseware developers in Malaysia
However it is important to clarify that the identified differences from the waterfall model (the inclusion of a requirements and planning phase and an iterative phase), does not bring the process in line with the Spiral, Iterative or ADDIE models. Firstly, while the interviews revealed that most of the Malaysian courseware developers (8 out of 10) initiate a requirements and planning phase up front, this includes (1) details of a development work schedule, (2) tasks to be accomplished by the development teams, and (3) the scope of work to be done, and the project manager usually consider factors such as the capability of the team, the budget constraints and completing the task within the given time frame. This detailed and careful planning does not include a user needs analysis, but an analysis of the ministry guidelines.

Secondly, while the process includes iterative phases in the development stage and evaluation stage to refine the courseware, the interviews revealed that the iterative phase is not entirely similar to the iterative process suggested in the Spiral, Iterative or ADDIE models in which, if an error or mismatch is noticed at any phase of the project by target group feedback, the previous stage is repeated from the beginning. In the current practices of developers in
Malaysia, a revision process only occurs if an error is revealed within the development and evaluation stages. The reason provided by the participants is that to make changes then is less time consuming and expensive than the ADDIE model where a change means a total rework. Moreover, the changes are based on internal reviews and requests by the Ministry only. No testing is undertaken with user groups so changes are not based on their feedback. In this regard, it can concluded that the iterative process being practiced by the developers in Malaysia is simply to ensure that all Ministry requirements are signed off, rather than to produce a product that optimally fulfils end-user needs.

According to the literature (eg. Stellman & Greene, 2005), there are three types of analysis that must be conducted before the design process begins: a user needs analysis, a product analysis, and a systems requirement analysis. However, it became clear in the interviews that no participants indicated that they conduct a user needs analysis before starting the design process. Almost all project managers and their development teams simply conduct an analysis of the tender documents and the guidelines provided by the Ministry. As explained by the participants involved, this involves focusing on specific media requirements and instructional specifications in the Ministry’s guidelines. Further information is gathered from printed textbooks and other relevant sources in order to achieve the requirements of these specifications.

When asked specific questions about why a deeper understanding of the user is not sought, various responses were given. One project manager argued that it is unnecessary, based on the assumption that these needs were understood in advance. He stated that:

*We are the developers of the interactive educational courseware so we should know the basic requirements of the courseware. So I don’t think we need to do a user needs analysis.* (Developer Interview, respondent 2)

Other developers cited various pragmatic reasons relating to access to user groups, budget and time. These broad issues are encapsulated by one of the project managers who stated:

*According to the contract, the period of time to complete the courseware is one year. But then, if you can see, it is not a one year project. In actual conditions we have only 8 to 9 months to finish the project. So we have to speed up ... If you conduct a needs analysis with the user, it will take more time. It is not easy to get permission from the school principal to enter their school. It will involve more additional work and will take you several months to get permission even though they are in the same...*
ministry. Our concern is to complete the process of the courseware development as early as we can, so that we can move on to another project. (Developer Interview, respondent 3)

Another raised schedule constraints in another way, saying that:

So far, we haven’t yet conducted a user needs analysis with the students. This is because we are familiar with the Ministry project. We also don’t have time to concentrate on that because we are not only taking jobs from the government. At the same time we also have to complete other jobs. (Developer Interview, respondent 1)

In relation to the other critical point at which user input is recommended in the literature, namely user testing during and after the design and development phases, the interviews clarified that this does not occur either. The participants reported that the only testing to occur is within their own production team. This testing is performed to ensure that the interface design and interactive courseware has been developed in accordance with the specifications, and that it meets the requirements in the tender documents and guidelines received from the Ministry, as well as perfecting the functionality of the courseware by identifying bugs. As exemplified by one of the project managers:

When the lessons are completely designed, in house testing will be conducted by a team leader from each of the different departments. Usually during this process we will make sure that all the functions are working properly. For example, if the voice said “this is a ball” the arrow must be pointed towards the ball not other things. (Developer Interview, respondent 1)

Clearly the developers try to implement the requests of the Ministry. As one commented:

We conduct product testing but only among our team in order to determine the weak points of the courseware, and we modify it before sending it to the Ministry. Generally, this testing is primarily focused on evaluation of the courseware functionality. (Developer Interview, respondent 3)

However this dependency on the ministry guidelines and oversight means that the developers feel that they do not need to take responsibility for any deeper understanding of the users, their needs, or broader design aspects such as the interface design. As one project manager summarised:

Actually, the authorization of decisions, especially on interface design, is in the Ministry hands, not ours. (Developer Interview, respondent 4)
This suggests that the developers do not consider it part of their role to undertake user testing, as the Ministry has ultimate responsibility for quality and what defines it.

In summary, the courseware developers do not consider end-user involvement necessary or possible within the timeframe, nor their responsibility. However, self-claimed familiarity with the tasks required is not enough to ensure that the interactive courseware is embraced by end-users. As the literature has established, compared with other models of software development, such an approach carries with it a high potential for deficiencies in the content, interface and interaction design of software products.

### 6.3.4 Perceptions of learning concepts among courseware developers

As has been established, through reference to the literature, the success of interactive courseware not only depends on courseware developers having an in-depth understanding of the role of interface design (which is crucial to ensuring that users can interact effectively and find what they are looking for efficiently), but also an understanding of the users’ needs in terms of the role of the courseware. However, the interviews revealed that most (8 out of 10) developers who participated in this research project lack an in-depth knowledge of the principles of interactive learning.

However, instead of taking the initiative to learn pedagogical frameworks, they rely on the guidelines and requirements of the Ministry, along with general principles for software design and understandings gained from prior involvement in the development of other types of interactive material such as corporate videos and multimedia presentations. This is illustrated by a project manager’s response that,

> We just develop it based on our previous experience. (Developer Interview, respondent 2)

The assumption that this is adequate is revealed in the comment of another developer that,

> There is not much difference when you are preparing digital learning material. The difference is just a platform of delivery. But at the end of the day, it depends on the user. Either they like to use it or not...it is just about preparing the look of the product. (Developer Interview, respondent 4)
Yet, designing interaction and interfaces for courseware is a very different task to generic software and it is not just a matter of developing interesting graphics and presentation by combining multimedia elements. Interactive courseware has emerged as an instructional technology with the potential to overcome limitations of traditional media and provide the prospect of engaging learning environments with strong visual and interactive elements. Therefore, an understanding of this potential, as well as the understanding that each piece of learning material has different user needs and contexts, is essential.

Reliance on previous experience from different contexts appears to have led the majority of courseware development teams involved in the courseware for the Malaysian Smart School Project (9 out of 10 developers) to assume that the development of educational courseware simply requires an ‘improvement’ process, which involves converting a printed version of course material into an electronic format. One participant demonstrated his understanding of the difference by this response:

> Designing interfaces for the computer screen is different from printed design. You cannot simply prepare the interfaces without having some understanding about the overall concept. (Developer Interview, respondent 3)

However, as another, more representative, informant said:

> ... Sometimes we just convert the sample test from the existing textbook into the interactive courseware. It’s easier than spending a long time on analysis of the requirements. (Developer Interview, respondent 2)

Designing effective interfaces for interactive material is not only a matter of transmitting information between the computer and individual through graphic presentation and the inclusion of multimedia. Interactive courseware should create experiences for the user that provide them with capabilities, engage them in activities, and create a desire to continue to using the application – all in the interests of ensuring that they understand the educational material presented. By revealing that developers simply convert printed material into a digital format, albeit with multimedia components, the responses gathered in this study suggest that the courseware may fall short in terms of this potential.
6.3.5 Issues and challenges faced by the courseware developers

Some of the causes of these issues can be related to the challenges faced by the courseware developers. Those highlighted in the interview transcripts include time constraints, authority for decision-making, the availability of expertise within the team, and the nature of relationships between key stakeholders. These are each discussed in detail below.

1. Time constraints and authority for decision-making

When discussing problems faced in the courseware development process, most developers (8 out of 10) reported that they have difficulties with the current production flow due to the directives of the Ministry. 7 out of 10 argue that it is hard for them to provide high quality products when the authority for the allocation of time, as well as approval of the final product, belongs to the Ministry. The courseware developers clearly expressed that they would like more time (and by implication budget). They feel they must reduce the time-lines and development costs in line with tender allocations by the ministry. And frustrations with Ministry oversight was perhaps most succinctly expressed by the following quote:

There are lots of opinions, lots of reviews, and lots of contradictions in the process of completing this interactive courseware. (Developer Interview, respondent 4)

The developers called for more agency over decision-making and less red tape in the development process, as well as greater funding of development time—all of which are in the hands of the Ministry.

2. Multiracial influences and cultural demands

Adding to production pressures is another challenge faced by the courseware developers in Malaysia—the cultural and multiracial demands of the local context. As noted in the discussion on the Ministry guidelines, developers must be sensitive in terms of the use of graphic images and colours in the interfaces. The graphic images that are used must represent Malaysian identity. However, due to cultural and religious diversity in the three main ethnic groups in Malaysia, the courseware cannot preference one ethnic group of users, particularly in any human and animal characters. By way of example, the developers cannot use the image of swine because swine can be an ethnic symbol of the Chinese community, or images of cows, which are favoured by Indian society.
In terms of colour usage, it has been determined that colour can represent different meanings in different cultural groups. For example, red is significant in the images of the Chinese culture in which it is believed that red is a symbol of good wishes and good fortune. On the other hand, green in Malay society is a symbol of religion. Because of these representational and colour requirements, the courseware developers cannot simply use copies of visuals from courseware of other countries. They have to spend considerable time preparing contextually specific images for the interface design.

3. Team roles and expertise

Like the development of systems at large, designing and producing educational courseware requires a broad range of expertise. As established in the international literature, a development team usually requires a range of staff with specialised skills, such as programmers, interaction designers, interface designers, instructional designers, language editors, graphic designers, voice talent, animators and illustrators. Along with programmers who design the backend, instructional designers establish the learning objectives, content experts provide the teachable materials of the subject, interaction designers establish the navigation and functionality, graphic designers produce visual images and aspects of navigation and interaction such as icon design, and interface designers take responsibility for the look and feel, combining images, text and icons into the screen layout, and ensuring clear and intuitive communication through the arrangement and layout of elements. Clearly, each of these experts plays a different role in the development process and they must work closely together to ensure consistency and coherence in the product.

However, what became clear from the interviews was that in the Malaysian context, the teams of courseware developers are small, with an average sizes ranged from 5 persons per team to 8 persons per team (with others supporting the team on a short term or casual basis). The developers stated that they are happy with small teams, for example:

*We started with a team of five people. I thought that five was a perfect size.*

(Developer Interview, respondent 6)

Another developer acknowledged this:

*When we started the development, we just had six people involved, who are 2 programmers, 2 graphic designers, and I illustrator. That is good enough I think.*

(Developer Interview, respondent 7)
However, most participants (7 out of 10 developers) acknowledged that their current production team does not have the required range of expertise in relation to interaction and interface design. As some claimed:

We have to rely on our graphic designer to take over the work related to interface design. (Developer Interview, respondent 4)

We just have a graphic designer. And he is the person that is responsible for all views of interface design. (Developer Interview, respondent 1)

While each development team typically has a seasoned project manager, who recognises the importance of interface design in the development process, the interviews established that the number of team members involved is so limited that team members must multi-task.

Furthermore, the Malaysian Ministry of Education guidelines require that the interactive courseware must be presented in a rich multimedia format and include real-life simulations of actual experiments or situations. In order to fulfil this requirement, the developers must include appropriate interactive animations or simulations in the interface design. One project manager describes this as follows:

The Ministry always requests non-static designs for their project. Which means the entire courseware must be presented as fully interactive. They also prefer real life simulations. (Developer Interview, respondent 4)

Because of the limited size and range of expertise in the teams, animations and interface design are often outsourced to third parties. As one participant commented:

If we do not have enough of a workforce, especially skilled workers, tasks will be outsourced to others. And frequently we outsource the job of preparing the interface design to a freelance designer who is also a friend of our designer. But then, it is based on our designer’s recommendations. (Developer Interview, respondent 1)

Another response attributes outsourcing to time pressures:

We need to outsource some of the tasks if our team is otherwise occupied. The reason is we need to complete the MOE project commonly within 8 to 9 months. Frequently we will outsource the most complicated tasks that take a long time to finish. (Developer Interview, respondent 8)
An important challenge for the courseware developers in Malaysia then is to produce the courseware with limited teams, multi-tasking across areas of expertise, and a disconnected development team, which inevitably arises through outsourcing.

4. Pedagogical knowledge within the development team

Another major challenge faced by the production teams is also related to pedagogical expertise. Most of the team members, including the interaction and interface designers, do not have content expertise on the curriculum they are working with, not any training in pedagogy. The process relies on the provision of the necessary disciplinary content and instructional design for the courseware from content experts who are based in the Ministry team before the production begins. According to the participants, this content expert is usually a former teacher. If the interface designer or graphic designer in the developer’s team has difficulty understanding a specific concept, they will pose questions to this content expert in the Ministry team during the early stages of the design process.

Unfortunately, most of the courseware developers who participated in this study feel that the content expert in the Ministry team assumes that their interface designers have an understanding of pedagogical concepts, while this is not the case. One project managers explained this by saying:

*It is not easy to fulfil their requirements because no one in our team is a teacher. Ministry have a content expert and we need to work with them. But they expect that our designers know everything. That is the problem. Sometimes, miscommunications between our designer and the content expert happen.* (Developer Interview, respondent 2)

When asked if he considered that this difficulty contributes to the effectiveness of the interface design during implementation, he went on to say:

*Even though we follow the requirements in the tender document ... As developers, we just prepare it according to what is required by the content expert in order to get approval from the Ministry. We aren’t bothered with what happens later; though we worry it will affect the effectiveness of the courseware.* (Developer Interview, respondent 2)

If, as the literature emphasises, the use of computer software in teaching and learning should reinforce students’ individual learning process, enable students to understand principles and
concepts easily, and improve students’ performance (Khalili & Shashaani, 1994; Khoo, 2003), then a basic understanding of pedagogical strategies, if not curriculum knowledge among the production team members is necessary in order for the team to produce effective interactive courseware. Instead, expertise is fractured between the software companies and the Ministry, and then further divided through the outsourcing process. This atomisation of the production team means that the overall development does not proceed from an in-common or shared understanding of curriculum, learning objectives, pedagogical principles or user needs.

5. Input on user needs from teachers as stakeholders

Some developers acknowledge the need for user-centred design and the input from stakeholders this requires. However, the developers’ interview transcripts indicated that, even if they attempt a process of consultation to ascertain user needs, the courseware developers face difficulty in obtaining permission and cooperation from schools. As one project manager claimed:

We need the support of teachers and we actually should be talking to students. We believe students and teachers can give us lots of good ideas about how they actually work and how they learn and the social environments that they’re used to. However, the permission to enter the school is hard to get. So how do we gather their real needs? (Developer Interview, respondent5)

Another mentioned that he has tried and failed:

I have tried to make contact with the schools to get some info. Unfortunately they did not paying any attention to our request. I think they might think we are going to be annoying them. (Developer Interview, respondent2)

From these recounted experiences, it has become clear that, even those developers who understand that consulting with end-users at various stages of the design process can provide them with a voice, and the opportunity to be constructively involved in the decision and development process, can face obstacles to access which limit this possibility.

6.4 Teachers’ involvement in the development process

To further clarify the relationships between the various stakeholders, interview questions were posed to school principals and teachers in order to ascertain their awareness of, and willingness to be involved in, the development process. The interviews with six school principals and six teachers established that few have been directly involved in the
development of interface design for the interactive courseware. The only exception was reported by a school principal of new Smart School, who stated that:

As far as I know, just one teacher has been asked to participate in the development process of interactive courseware. (Principal Interview, respondent 4)

However, this input was limited as the teacher explained:

I have been asked by the Ministry to be involved in the development of interactive courseware. But I have only participated in the discussion at the early stage of lesson mapping. (Teacher Interview, respondent 1)

The in-depth interviews with teachers established that most are very dedicated and willing to be involved in courseware development. Four out of six teachers have the opinion that it would be very advantageous if they could be involved in the development process in future. Example comments show their enthusiasm for such involvement:

I would think I’m a lucky person if I am asked to be in the project because I can give more information and can share my experience. I’m a pioneer. I think not everyone should have the opportunity. (Teacher Interview, respondent 4)

I can see that it’s the best way to help in improving the quality of courseware ... I hope I will be able to help the developers by giving my ideas, so that the courseware will be more interesting for my students. (Teacher Interview, respondent 5)

Others indicated willingness to contribute if the Ministry asked them to engage in the process. As explained by one of the teachers:

I would be very happy if the Ministry asked for [my involvement]. Perhaps, I can share some of the suggestions that I gathered from my students, such as students would prefer more video presentations rather than still images. (Teacher Interview, respondent 3)

Similarly, another said:

I would like to be part of the team if they asked. But so far no one has asked for that. (Teacher Interview, respondent 2)

Teachers clearly believe that they could contribute to the improvement of the product in the development phases, through their familiarity with the learning activities and the learning environment and understanding of what works and is well received in the classroom. This was illustrated by four out of six teachers, through these claims:
I think as a subject expert, I have the ability to give more. I think through discussion, the developers or even the Ministry people could see what the real requirement is. (Teacher Interview, respondent 2)

I think one of the best ways is group discussion among the developers and the teachers. Sometimes the developers also want rough ideas about the subject. (Teacher Interview, respondent 1)

As a science teacher, I need to be familiar with the subject that I teach. Teaching the same thing every year will make me expert on the subject. So I think through that experience, I can help the developers or even the Ministry in preparing the interactive courseware. (Teacher Interview, respondent 5)

Some interview subjects went further; to question the expertise of the developers in providing appropriate learning tools, as the following emphatic responses show:

I have been teaching science subjects for more than 8 years. I absolutely know what my students really want and what things are best for my students. Do you think the developers know more than me? ...At end of the day, I and my students are the ones that will be using the courseware. (Teacher Interview, respondent 2)

Do you realize that they (the developers) are not involved in teaching? So how can they know our difficulties? (Teacher Interview, respondent 1)

As a teacher, I was teaching the same subject for almost 4 years. Have the developers been in teaching before? (Teacher Interview, respondent 4)

Through two different sources (school principals’ and teachers’ interviews), it is clear then that educators are willing to be involved in the development process and, indeed, think that it is essential. They feel that their credibility as a subject expert can be employed better, and by and large suggest that group discussions with them would be the best approach when undertaking systems requirements and user need analysis. Such involvement of teachers in courseware design is clearly recommended in the literature, which acknowledges that the teacher is one of the knowledge experts in the domain of learning and teaching (see for example Andrewartha and Wilmot, 2001).

As key stakeholders, teachers involved in this study also stated that they are willing to be involved in the analysis and testing phases, since they are in direct contact with students
using the courseware, and because they have a fluent knowledge of the subject material. As one quote by a principal summarises:

*I think the developers need to ask the teachers further regarding this matter. Don’t just simply produce a tool without verifying it ... teachers are the ones that are with students everyday in class and they are familiar with what student really needs.*

(School Principal Interview, respondent 4)

Such user testing is a standard part of software development, but it does not occur in this process, even though teachers and principals are willing to be involved. The involvement of the schools, particularly teachers, in the analysis and testing processes would have a significant positive impact on the performance of the courseware and hence the level of courseware usage at the schools as it would provide teachers with a channel to express their ideas which may include worthwhile advice. However, as mentioned previously, the majority of courseware developers interviewed are not concerned with focusing on the needs of the teachers and students through user needs analyses and testing because of the time and cost of doing so. One of the courseware developers summed this up as follows:

*... If you conduct a needs analysis with the user, it will take more time. It is not easy to get permission from the school principal to enter their school. It will involve more additional work and will take you several months to get permission even though they are in the same ministry.* (School Principal Interview, respondent 2)

It appears then that the involvement of the stakeholders in the courseware development—either within user needs input or evaluation, is a process that the teachers believe is essential but the developers believe is not possible, if they believe it is even necessary.

### 6.5 Discussions and key findings

Through an exploration of the development process and the triangulation of sources, including a contextual document analysis of the secondary sources found in international literature, and primary sources including the Malaysian government guidelines and interviews with developers, teachers and school principals, four main themes have emerged in relation to the development process. They are the disjuncture between the current development process in Malaysia compared to other well established current development models; the extent and areas of the expertise of the developers; the lack of input from end
users; and the currently fractured relationship among key stakeholders (the developers, Ministry and end-users including teachers and school principals).

6.5.1 Identifiable issues with the current interface design production and software development process and the skills of developers.

Broadly, the lifecycle of the development process for interactive courseware in Malaysia closely follows the standard phases of the instructional design system, which include analysis, planning, design, development, implementation and evaluation. As discussed in the literature and summarised in Section 6.2 of this chapter, this life-cycle can be carried out in various ways such as those described in the linear (waterfall), iterative, or spiral models. The results of this study show that the process currently practised in Malaysia follows linear steps similar to the waterfall model, and does not involve substantial iterative phases. There are two stages that are executed through an iterative cycle in practice (the development stage and evaluation stage). Looping back and forth between the development stage and evaluation stage is carried out to perfect the interactive courseware. However, due to the pressures of time and limited budget, and the Ministry’s exercise of sole authority on decision-making around aspects such as the interface design production, most courseware developers commonly practise this iterative phase for a short time and conduct it in-house, to ensure technical robustness and compliance with the guidelines. Therefore the process is, by and large, linear in the way of the traditional waterfall model, which has been roundly criticised in the literature.

As established in the literature, the iterative, spiral and ADDIE models include initial user needs analysis with input from stakeholders, including end-users, as well as repetitive iterative cycles in order to refine the product through communication between the developers and end-users. In essence, this process presents the developers with insights into the users’ needs, goals, practices and expectations, as well as the opportunity to elicit objective feedback on the appropriateness of the solution from users. However, the results of this study show that none of the courseware developers who participated in this study undertake a user needs analysis or initiate feedback from users on the product design and use. Instead, the designers in the development team simply use their previous knowledge and experience to devise and execute a design solution.
It could perhaps be concluded from this that the courseware developers are more focused on profit considerations than producing an effective product with interface design that accommodates users’ needs. However, various factors have been put forward by the developers. The most common reasons for lack of consultation is that they are familiar with the project and the needs of the Ministry, that they are given limited time to complete the scope of the project (that is, the cost and time constraints imposed by the Ministry on the developers preclude a consultation process which would be time-consuming), and that access to end-users is difficult. Moreover, what has also become evident through the interviews is that the courseware developers think that their primary objective is to meet the Ministry’s requirements and specifications, and that they do not have the agency to, or responsibility for, understanding the users’ requirements. It is understandable that they assume that this is the Ministry’s obligation, if the guidelines are presented as comprehensive and binding.

Another phenomenon identified from the interviews is the lack of pedagogical knowledge and understanding of interactive learning concepts among the courseware developers. This is due to the designers in the development team having no experience of, or training in, teaching. However, the courseware developers do not feel an obligation to contribute pedagogical knowledge to the process of interface design production because the content expert in the Ministry team provides instructions and presumably contributes to the guidelines. However this expert does not work with the development team through the process and is geographically and structurally dislocated from the development team.

The contribution of expertise from different fields is particularly important when developing content for educational courseware. System engineers, programmers, graphic designers, writers, and editors must integrate educational material. While curriculum and content might be provided by an educational specialist, also required is expertise in developing effective interfaces for students’ and teachers’ needs. That is, the development teams in Malaysia not only need a content expert actively involved in the design, but also require an instructional designer who has an understanding of learning models/theories for the effective development of interaction and interface design that engages students with content and facilitates effective testing and feedback. Accordingly, the active involvement of a content expert and an instructional expert to the development team not only helps identification of requirements, but also contributes to more effective performance of the courseware. The dislocation of the content expert and instructional designer from the development teams may be attributed as a
potential source of conflict and communication issues between the Ministry and courseware developers, but it is also likely to be a key reason for issues arising in the quality of the courseware.

Given these constraints, the most pragmatic route for developers in Malaysia to take is to simply convert existing printed learning modules into a digital version. It has been well established in the global literature that such a practice affects the effectiveness of the courseware in use. It is therefore a significant problem in the software development system in Malaysia, and can be identified as a factor that strongly contributes to the problems in the interface design, as well as more general issues with the courseware, which impact on its effectivity and uptake.

6.5.2 Lack of involvement of end-users as key stakeholders

The literature establishes that interface design is the main factor in ensuring that interactive courseware is able to cater to the end-users’ needs (Nielsen, 2000; Norman & Spohrer, 1996). Interface design that been developed without a deep knowledge of the intended users may therefore not be useful or even usable. The literature is clear that it is very important for developers to have an understanding of the users in order to develop effective software that meets the requirements of the user and will be used frequently and meaningfully (Galitz, 2002). Therefore, the importance of user involvement in the software development process has been well established as a key factor in the success of development (Olsson, 2004) and uptake of courseware (Kujala, 2003). In the last few decades, the concept of user centred design (Norman, 2002) has been adapted into a learner-centred approach, which has been introduced in models such as the ADDIE models to overcome the absence of end-user involvement that was a problem with the waterfall model. Facilitating the involvement of end-users at an early stage, throughout the design process and in reviewing and testing, is encouraged because it not only impacts on the potential that the software will meet their needs, but also ensures that they have a stake in the outcome, which also helps to ensure the uptake of material.

However, in the current practice of courseware development in Malaysia, the end-users are understood to be passive consumers in the process, and are not involved in the analysis, design or testing stages. Establishing systems, interaction and content requirements, as well
as product testing, generally comprises the minimum recommended input by end-user stakeholders. They therefore currently constitute the most problematic phases in the design process in Malaysia. This might be attributed to the authority of decision-making in the design process, as the courseware developers have stated they had no decision-making rights on this issue, and cannot access the end-users. Nonetheless, some of the courseware developers also tend to overlook the importance of user needs and the significance of user involvement.

Given the well-established understanding in the literature, as well as the clear indication provided by this study, of the importance of the role of user involvement in developing suitable interfaces, it is therefore recommended that the Ministry and the developers in Malaysia should consider the benefits of user input within each iterative cycle. That is, this study provides a foundation for recommending the importance of involving teachers in making decisions about design solutions, and well as evaluating the courseware at various phases. It should be noted that this is a more time-consuming process than the current practices, and therefore makes the development process more costly. However, it would provide a stronger foundation for the design of the courseware and would also allow the developers to make corrections on the potential product and ensure the delivery of an end product that is more effective, engaging and more frequently used in the classroom.

6.5.3 The current relationships between main stakeholders
This research project has also uncovered substantial issues with the current relationship between the main stakeholders in the courseware, i.e. the Malaysian Ministry of Education, the courseware developers, and the school principals and teachers. The literature on the courseware development process is primarily focused on how interactive courseware should work as a learning material for end-users (Shneiderman, 1998; Galitz, 1997) but a study by Iivari (2004) explains that effective communication between the stakeholders is essential in order to ensure the quality of the end product because each stakeholder has their own experience, discipline and contextual expertise, and responsibilities. Designing interfaces, in particular, is not a simple task in the development process but it is arguably the most important part of the whole development system. If interface design fails to communicate clearly to users, they may end up frustrated. Very often however, courseware developers,
funding stakeholders and end-users have different perspectives on interface design, which need to be reconciled.

In the Malaysian context, it is particularly important for all stakeholders to work together and collaborate actively in all activities in the development process because the level of knowledge and skills of the stakeholders is very different. For example, as discussed above, since the developers in Malaysia lack pedagogical skills, content knowledge and an intimate understanding of students as users, it is very important that they should directly involve teachers in focus groups, or other information gathering processes in order to understand how they operate in the classroom, and what their needs and teaching goals are, beyond the presentation of the subject content of the knowledge domain. Users (particular teachers in this context) should be experts on courseware use, their subject domain, and their needs, as well as that of the students, and developers should be experts on development including programming, information architecture and interaction and interface design in general. These two domains of expertise are complementary and both are required for the production of a successful product and need to be integrated effectively.

However, the investigation of the current development process through the analysis of the government guidelines and interviews with developers and teachers in Malaysia, indicates that all of the main stakeholders are not meaningfully engaged with each other because of the clearly differentiated roles they play. The courseware developers are responsible for most stages in the development process, while the Ministry has power over decision making, thus playing the most important role in ensuring the effectiveness of the courseware design. The students and teachers meanwhile play no role at all prior to using the interactive courseware. Therefore, the roles of stakeholders are completely fragmented, and in the current practice of software development in Malaysia, communication between teachers, courseware developers and the Ministry often breaks down.

This is illustrated by the way in which the communication between courseware developers and end-users is derailed. Since the requirements process and access to schools is controlled by the Ministry team, the designers in the development team have no first-hand contact with the potential users. And, while the school principals and teachers are highly conscious of the quality of the courseware and the interface design in particular, because it influences the level of effectiveness of the courseware used at their schools, courseware developers are not
thinking in terms of how to present the content to end-users in a way that will help them learn most effectively, as much as they are focused on finishing the development process within the allocated time and to the specific Ministry requirements. This disjunction is not only a major failing in the process, but is also evident in the outcome: the usage and effectiveness of the interactive courseware at the schools.

Therefore, while it is recommended that the important principles of user-centred design and target group involvement in the development process should be applied to any future development of Smart School Project courseware in Malaysia, in general the relationship between stakeholders must be addressed with clear processes for communication and stakeholder co-operation. Teachers and principals input should be communicated directly to the developers, as well as to the instructional designers and content experts in the Ministry, allowing the schools to provide knowledge and the information regarding their needs to the developers. The Ministry should therefore provide leadership by not only providing oversight and expertise on the government’s goals for education and learning, as well as broader conventions on world-wide best practice on courseware design and pedagogical approaches to e-learning, they should also facilitate this communication process. That is, to create good communication between the stakeholders, two basic requirements are needed. Firstly, all stakeholders must have an opportunity to communicate effectively and to understand the problems, needs and goals of the other stakeholders and secondly, all involved need to respect and recognise the expertise of the other stakeholders. However, first the communication channels need to be opened.

6.6 Conclusion

This chapter has set out to provide answers to Research Question 3: How is the interface design of the courseware developed and has this contributed to the quality of the interface design? To answer this question, the current practices of interface design and the development process in Malaysia have been explored through the different perspectives of the main stakeholders (the courseware developers, the Ministry and end-users). This investigation has helped to ascertain reasons for issues in the courseware that have led to low uptake and issues with the interface design that have been identified by previous researchers. In summary, the findings from the different data sets (contextual document analysis and interviews with the courseware developers, school principals and teachers) have revealed that
current production of interface design and software development processes in Malaysia may be responsible for the issues in the interface and courseware more broadly.

Primarily, the development process largely ignores the importance of user involvement and prototyping methods as recommended in the international literature. A number of reasons have been identified. Firstly, the Ministry policy on design and the existing Malaysian guidelines provide no comprehensive explanation about, or requirement to conduct, user need analyses and product testing. Secondly, the limited time and budgets allocated by the Ministry were identified as a sub-theme, and it was argued by the informants that these constraints require the courseware developers to concentrate solely on Ministry requirements rather than contextually specific end-user needs, which are time-consuming to acquire. And, importantly, relationships have not been established or encouraged among the main stakeholders (developers, the Ministry and schools), so meaningful contact between them does not occur.

Out of these primary issues, a number of significant factors arise. Because sole authority for decision-making is held by the Ministry, developers respond to the letter of the guidelines they are provided with, to the exclusion of other types of research or analysis. And, because there is limited pedagogical knowledge within the development team, a misunderstanding among the courseware developers about the concept of interactive learning arises, which may, in turn, lead to the reductive strategy of simply converting the printed learning modules to an electronic format. In addition, because of limited communication between the stakeholders, each function within their tightly designated roles, so sharing and integration of specialist expertise does not occur. For example, courseware developers conduct their product testing within their own team in response to the Ministry requirements, without involving the teachers and students. And a deficit of skills in the development teams leads to the outsourcing of major interface design components, which further fragments the design process and design roles.

These shortfalls in the design and development process of the interactive courseware largely align with the findings of studies in other contexts. As outlined in the literature, there are four main factors that influence the production of interface design. They are the user needs and requirements analysis, functionality, decision-making and creativity (Eberts & Brock, 1988; Kulik & Kulik, 1991). This research study has revealed problems within the courseware
development process that may influence all of these factors. Firstly, the current lack of user involvement delimits the user needs analysis and requirements. Secondly, a lack of awareness of interface design and pedagogical theory and strategies among the designers can be related to the effectivity of the interface design and the functionality of the courseware in general. Thirdly, the centralisation of decision-making in the Ministry limits the capacity of developers and teachers to understand each other’s need. And finally, the limitation and requirement specificities in the guidelines limit creativity and the potential for innovation.

From this discussion, the question about how the interface design of the existing interactive science courseware is developed and whether this has contributed to the quality of the interface design is answered. In summary, all of these shortcomings in the development process contribute to the quality and performance of the existing interactive courseware for the *Smart School Project*. Therefore, these factors must be considered by the Ministry and by courseware developers prior to future development. In the following chapter, a new framework for the software development process that could be suitable for Malaysian context will be proposed.
7. Proposed framework for the Malaysian software development process and extension of the current guidelines

7.1 Introduction
Based on an analysis of current development processes in Malaysia, the previous chapter identified a number of issues and problems arising from the current development process in Malaysia and the impact they have on the interactive courseware of the Smart School Project. In particular, the developers in Malaysia are ignoring the importance of user involvement in the development process, particularly in testing the product. The literature contains a store of proposed solutions based on user participation and engagement in software development.

Accordingly, in this chapter, a new framework is proposed to guide the development process, including some potential methodologies that address the relationships between the key stakeholders and facilitate the important process of end-user involvement in the development process. In addition, the guidelines for the organization of a more effective software development process in Malaysia are extended in this chapter, particularly in relation to interface design.

7.2 Proposed framework for the Malaysian software development process
In proposing a framework for the Malaysian software development process here, the aim is not to simply put forward another model for software development. Rather, it is intended to counter the weak relationships that currently exist between the main stakeholders and the lack of user involvement in the design and evaluation process. Thus this proposal first involves including teacher’s involvement with a view to acknowledging and benefiting from their expertise in the domain of classroom teaching, pedagogy in general and understanding of interactive learning concepts, and incorporating this knowledge into the design considerations. The best way to ensure that end-user needs are taken into account in the software
development process is to continuously incorporate their involvement in the development process.

In proposing a new framework, it is therefore important to first consider the various models that incorporate user input. There are several approaches to user involvement established in the literature. For instance, users can be involved at the early stages of the process when the requirements are determined. At this level, they are commonly involved in providing insights into their specific needs, and consequently contributing to the user needs analysis. The second type of user involvement is during the prototyping phase, in which the user is involved in testing low fidelity and high fidelity prototype versions of the interaction and interface design. At this level, users might be observed interacting with the prototype or may complete a survey about the various features to provide their feedback and offer critique and suggestions to the designers. This type of feedback is incorporated into the iterative model discussed in the previous chapter, and it contributes to redesign and improvements in the next iteration.

Another phase of user involvement is after the production of the system. Here, users interact with a Beta version of the actual product and give their opinions and report any problems they encounter. Revisions at this stage are then included in a revised version of the product. At this point, however, only minor changes are possible rather than structural or major interface design changes, as these underpin the entire application.

Beyond these bracketed forms of user input, approaches to extended user involvement are available. They include user-centred design (UCD), participatory design (PD) and, most recently, co-design. These three approaches are driven by the impetus of empowering stakeholders in the design process and involve more intensive collaboration between designers and other stakeholders. In short, the end users who will use the outcome contribute to the design process, with the designer acting as a facilitator of this contribution. As shown in Figure 7.1 these models were developed some years ago but they have recently gained ground in terms of popularity and implementation.
Each of these approaches has its own strengths, which are worth considering in detail as explained below:

1. User centred Design
User-centred design involves the input of users throughout the design process (Miyata & Norman, 1986). It not only focuses on understanding the user of the software being developed, but also requires an understanding of the tasks that the users will perform with the software and the environment (organisational, social, and physical) in which they will use the software. Therefore, the main characteristic of a user-centred design approach is to focus on the needs of the users. In short, there are four key principles of user-centred design: active involvement of users, appropriate allocation of functions between users and systems, multidisciplinary design teams, and iterative development of design solutions. That is, the product is incrementally designed and evaluated through reference to users to ensure it meets their needs. This differs markedly from the waterfall model.
The rationale for user-centred design is that the continuous iterative inclusion of end-user information is the best way to create products that are useful and beneficial (Landauer, 1995). A user-centred design approach then should optimise a software system’s usability because it is based on the self-articulated needs and feedback of end-users. Because it takes the user’s expertise into account, it reduces the distance between the user and the software (what Miyata & Norman (1986) call the conceptual “gulf of execution”).

The main attribute of interactive courseware is the goal of helping the user to learn topics that they are not already familiar with. In this case, ease-of-use cannot be the only concern for the designer. Users also must be supported in new processes and in merging new content and information with pre-existing knowledge. In addition, the Malaysian teaching and learning context is unique, and it is necessary to take the unique contextual needs of the users into account; and user-centred design is potentially beneficial in doing so.

2. Participatory Design
The participatory design approach creates an opportunity for the involvement of end-users as both stakeholders and active collaborators. In particular, it supports the active involvement of potential users or current users in the design and decision-making processes as members of the design team. Therefore, participatory design is recognised as a design philosophy that encompasses the user in the whole design cycle from the requirements analysis, to driving the processes of a rapid iteration designing, through to product testing (Dix, Finlay, Abowd, & Beale, 2004).

Through participatory design, the insights and expertise of the end user is deeply integrated into the product, helping to ensure that it meets their needs. And, because users are involved in product development in a central role through the participatory design approach, they may feel that their ideas and suggestions were considered and valued during the process and so feel more invested in the success of the outcomes. Therefore, this involvement can lead to a sense of ownership over the final product and a greater willingness to adopt it.

Differences can arise between designers and end-users within such a collaborative development process. To deal with this, participatory design is not a single method but involves several dimensions, such as ensuring an effective relationship between users and the developers, and other stakeholders in the design activities. Indeed, Blomberg and Henderson
(1990) promote participatory design as a way to overcome a lack of communication between developers and end-users, and advise that this design process can mediate the interests arising from the different perspectives of stakeholders. Thus, this method is highly recommended for the future development of interface design for interactive courseware in Malaysia for enhancing better relationships.

3. Co-Design

As the development of the Malaysian Smart School Project’s courseware involves many stakeholders, a co-design process provides another suitable approach to design and development. It offers an opportunity for multidisciplinary stakeholders to be involved in the development process. As defined by Fuad-Luke (2007), co-design embraces participatory design and other design approaches to encourage active participation of various stakeholders. Like Participatory Design (PD), it entitles the user to have a voice in determining how the product is designed and, in doing so, the design outcomes are potentially improved and are more effective.

Because co-design is mindful of ways of collaborating with the different stakeholders, and establishes ways in which different kinds of related knowledge and expertise can be brought together, it aims to foster broad consensus. If implemented in the software development process in Malaysia, it could potentially improve the relationship problems that occur between the stakeholders, and ensure that stakeholders’ interests are taken into account in the design and development process. Thus, co-design would allow the designers in the development team and Ministry staff to proceed without having to guess whether the interactive courseware might be rejected by the teachers and students as end-users.

These three methodologies could be considered by the Malaysian Ministry of Education. Each would involve inviting teachers, and perhaps students, to participate in the software development process as active participants. In their full form at least, these approaches are a radical departure from the linear and closed waterfall model that most closely approximates the development of interactive courseware in Malaysia.

It is important to note however, that involving users extensively throughout the design and development process from the initial stage through to testing, and involving them as co-designers, has time implications and increased cost must be considered against the benefits of
improved performance and uptake. Taking cost implications into account, a middle ground might be adopted through a new model that utilizes the strengths of the waterfall, iterative, spiral and ADDIE models established in the previous chapter and combine them with the user oriented approaches discussed here. This new proposed framework is illustrated in Figure 7.2.

Figure 7.2: A new proposed framework for the software development process in Malaysia

This model provides a life cycle structure that, like established models, focuses on five main phases in the software development process. As illustrated in the figure however, the iterative and linear approaches are combined. The repeated iteration approaches were adopted from the spiral and iterative model and from the ADDIE model, which places feedback in the centre of the process so that it becomes an integral and integrated step. In particular, collaborative approaches to iterative design are suggested for the phases of design,
development and evaluation to cement relationships between the three key stakeholders in the current software development process (the Ministry, courseware developers and teachers) and embrace and integrate their many skills, insights and areas of expertise into the development process.

The major modifications occur in three phases that are identified in the literature as crucial points of the software development process, namely the analysis phase (Stage 2) a feedback phase (Stage 4) which is incorporated into the alpha testing after the design phase (Stage 3) and a feedback phase incorporated into beta testing after the development phases (Stage 5), leading back to the design phase and the beginning of a repeat cycle.

Similar to previous models, this proposed framework begins with requirements and planning. In this phase, it suggested that developers should set out to gain an understanding of the project scope, requirements, costings and schedule tasks and milestones that need to be accomplished. However, the developers and the Ministry would also need to involve users in an additional analysis stage because simply understanding the scope, cost, and schedule of tasks is not enough to determine the actual needs of students and teachers. While the current software development processes being practiced in Malaysia includes a general analysis of the tasks given in the Ministry guidelines, this new proposed framework sees this phase include determining students’ and teachers’ needs, the contexts of use, and appropriate delivery mediums for the purposes and contexts of use. This standard step occurs in almost all established models and is essential due to the fact that the courseware is developed for particular users. It has been proven to lead to a dramatic increase in the quality of product when applied.

The third phase in which changes are proposed is the design phase. The key objective of the design stage is to construct a storyboard and prototype based on the available information and requirements provided by the Ministry and the evaluation of user needs. The use of prototyping tools here is a valuable way of building early designs and demonstrations of interfaces, because it offers an opportunity to purposefully select aspects of the interface design that would benefit from early feedback before going on to develop the entire application. Such prototyping provides a particularly effective means of communication between the users and the developer. The basic idea is to gauge the appropriateness of the design components suggested in the prototype to the audience, to ensure that elements
communicate clearly, are used in a proper sequence, are consistent, and so on. As suggested in the ADDIE model, the evaluation at this stage is formative, and should be conducted with different levels of users in the target group to ensure flexibility. If the user is not satisfied with the prototype the developer should revise it to make it more effective, efficient, appealing, functional and/or usable.

Once the prototype is stabilised (which may take multiple redesign phases after feedback or evaluation reports on low fidelity paper prototypes through to high fidelity prototypes) the process can proceed to the development stage. Then the beta version of the prototype should go through summative evaluation. As defined in the ADDIE model, the purpose of this more formal evaluation process is to gauge how well intended users succeed with both interaction and the specific learning materials, and to ascertain whether the interface design is effective in supporting users to achieve these goals.

From the surveys and interviews, it became clear that, in the current system, the involvement of the user does not occur. However, in the early stages, user involvement is important to provide information regarding their knowledge, skills and working culture. Thus, this proposed framework suggests user input into the analysis phase. In addition continuous evaluation and revision in the design and development stages by conducting product testing with teachers, students and Ministry officials (rather than simply in-house testing by developers and Ministry evaluations) is recommended to help to ensure that the application will achieve its pedagogical and cultural goals, that appropriate interface design components preferred by the students and teachers are used, that quality and fit to purpose will be assured, and that the potential for low uptake and use of interactive courseware will be reduced.

The advantages of this proposed model, in which user involvement is emphasized at various stages of the process, will provide the courseware developers with two opportunities. Firstly, it will allow them to identify the real needs of the teachers and students as end-users and this will allow them to flesh out an appropriate interpretation of, and solution for, the Ministry requirements. Moreover, the involvement of users in user needs analyses, feedback and iterative loops suggested here, to complement the evaluations of the ministry and in-house evaluations, will allow a sense of incremental input and ownership by all of the key stakeholders, which will in turn help to ensure the success of the product in terms of uptake,
and continued effective use. This is surely the shared objective of the Malaysian Ministry of Education, the developers and the teachers.

7.3 Extended guidelines for the design and production

In addition to this proposed framework for development, another outcome of this evaluation process is a set of extended guidelines for the design of interactive science courseware for the Malaysian Smart School Project. As established in the literature review, to be effective, guidelines are broad principles that must be tailored and in place before the development process begins and they should be offered to the designer as a resource, rather than imposed as a standard design contract (Smith, 1986). In themselves, guidelines cannot assure an effective and appropriate design, for a variety of reasons—not least of which is that they are not context specific and therefore cannot replace user insights into their needs in a given context. That is, applying guidelines will not necessarily save the design process, but can help developers to create a more usable product through the provision of broad principles.

As has been argued throughout this thesis, best practice interface design requires the implementation of well thought out and understandable guidelines in addition to user input. However, in Malaysia developers currently fail to fully apply the Ministry guidelines due to limited time and cost, and decision-making policies, and instead largely depend on their own knowledge and experience.

Nonetheless, this study proposes several additional basic guidelines to extend the existing Malaysian government guidelines provided to developers for the design of future interactive courseware. They are as follows:

1. **Ascertain a comprehensive understanding of the end-users’ needs through direct contact with teachers and involve teachers as team members and stakeholders in the development process.**

The first additional guideline arises from the importance of involving end-users in the development process in order to understand their needs. In line with this, it is important that courseware developers in Malaysia gain a comprehensive understanding of the end-users’ needs through direct contact with teachers (and, ideally, students). This involves conducting a
user needs analysis at the beginning of the development process, and might also provide the opportunity for input into the design process to ensure that the product effectively meets their needs.

This extended guideline is intended to facilitate stakeholders’ relationships which are currently lacking. The Ministry must support teachers to be involved as an integral part of the production team. This is because teachers can contribute clear guidance on learning objectives, and help the designers in the development team to optimise solutions for the integration of content, meaningful interaction and effective and appropriate interface design. However, it should be understood that the courseware developers should retain the authority to modify and make amendments or modifications to the design to meet contextual user needs.

This recommendation extends instructional requirements outlined by the Ministry, to further ensure the appropriateness of the design to the contexts in which it will be deployed, and to those who will use it, but also to ensure that the interactive courseware can be used by the end-user effectively.

2. **Conduct product testing as many times as necessary with all stakeholders.**

The second additional guideline is that developers should undertake testing of products with teachers and the Ministry staff iteratively rather than simply involving their own team members in testing at the end of the development process. Most importantly, product testing should be conducted as much as possible, from multiple perspectives, and this might involve not only teachers but also representative students because they are also end-users. And testing should be undertaken on low and high fidelity versions of prototypes as well the final product, to ensure the opportunity for feedback from the students and teachers to be incorporated before the point when only minor, superficial amendments can be made.

The Ministry must therefore give authority to courseware developers to conduct product testing and supervise them in conducting product testing with teachers/students.

3. **Create meaningful relationships between interface design components.**

In consideration of the concerns expressed by teachers and students in the fieldwork, a further suggested extension of the guidelines is that courseware developers should create
meaningful relationships in the interface design, particularly between graphic images, text, animations, and videos components. In developing each of these components, designers must carefully consider the needs of teachers and students but also have a clear understanding of how each interface design components are associated with each other from the user’s perspective. For this reason, developers should put themselves in the users’ place to determine if the interface organization makes sense, but should also seek feedback from them.

4. **Attain a fundamental understanding of interface design**

   The literature establishes that interface design is the filter of information, which controls the extent to which users can access information and what they can do with the content. Therefore, poor interface design adversely affects users' understanding and interaction with the courseware (Balinsky, 2006; Thurmond, Wambach and Conners, 2002). Consequently, it is imperative that designers gain a working understanding of interface design and how to make it function effectively (Johnson, 1997) in terms of interactivity, communication, use of multimedia and adaptability. The requirement that developers in Malaysia—particularly their designers—have a fundamental understanding of the roles and functions of interface design is essential.

5. **Attain a fundamental understanding of the concepts of interactive learning**

   This requirement is aligned with the basic concepts and principles that are addressed by instructional design strategies. Whether developers have this knowledge largely determines whether the courseware facilitates learning objectives or not. Understanding of this concept will help to ensure that the courseware that is designed for students will facilitate learning in the context of computer-based learning. This requirement is in addition to the input of teachers, not instead of it, and it will help to support a common ground for collaboration.

### 7.4 Conclusion

In response to prior studies, evaluations conducted by the Ministry of Education, the concerns of stakeholders, and weaknesses in the current development process that have been identified in this research study, this chapter has proposed a new framework for the software development process, and additional guidelines for interactive courseware design production in Malaysia. A rationale for, and explanation of, the proposed framework has been presented. In essence, it highlights the importance of end-user involvement in the software development
process, which is overlooked at present. Significantly, the proposed framework helps to support the development of relationships between all stakeholders and outlines the activities that should be undertaken by each of them.

This chapter has also suggested additional guidelines for interface design and courseware production that have arisen out of the research, and can be included in a future review of the current guidelines by the Ministry. In summary, this includes guidelines that promote user involvement, and ensure that developers understand the specific interface design principles, contexts and requirements for educational software, which is different to other types of interactive software.

This chapter thereby answers Research Question Four, which is: Drawing on the analyses of international literature, the Malaysian government guidelines, the existing interactive Science courseware, and end-users’ observed and reported experiences within this research study; are there any aspects of the design process in the current framework that can be changed to benefit stakeholders and perspectives? And, what principles, characteristics and development guidelines can be recommended for future interactive Science courseware for Malaysia’s educational context?
8. Conclusion and Recommendations for Future Work

8.1 Introduction

As the final chapter of this thesis, this chapter revisits the journey of this study and summarises its conclusions. It reviews the aims and objectives of the research and shows how the goals planned at the beginning of the research project have been fulfilled, while many interesting and unexpected findings have also emerged. It also brings together the range of recommendations that have emerged as outcomes of the research project.

This chapter is divided into four sections. First, it provides a summary of the key research findings and a discussion on how these findings relate to the research question established at the beginning of this thesis (Section 8.2). Then it proceeds to outline the significance of the findings with respect to practice and theory, and considers ways in which each aspect of the key findings contributes to the advancement and application of new knowledge (Section 8.3). Following that, possible directions for future research into courseware development and interface design are presented (Section 8.4). In the final section of the chapter, the conclusions that have been drawn from the research project are summarised (Section 8.5).

8.2 Summary of research findings

Taking interactive science courseware as a sample study, this research project has critically investigated the nature, extent and reasons for lower than anticipated uptake and use of the interactive courseware in the Malaysian Smart School Project that has previously been reported. It has focused on the interface design of the courseware because previous researchers have attributed issues with the courseware to it. An analysis has been carried out by comparing the design principles evident in the interactive courseware to those recommended in the literature and the Ministry guidelines; by observing how the interface design is perceived by students and teachers, and how it affects users’ interaction with the courseware in the classroom and impacts on their learning experiences.
Important findings of this research project include verification that the current level of courseware uptake at schools is lower than anticipated, and that the relationship between the issues associated with the interface design and the level of courseware usage at schools has been confirmed. The school principals and teachers, who were interviewed as part of the data collection, strongly agreed that the quality of interface design in interactive courseware and its perceived pedagogical effectiveness, along with computing facilities and technical support, have significantly contributed to the level of use of the courseware in the classroom. Fieldwork, including classroom observations and focus group discussions have further established that, while students and teachers appreciate the opportunity to adopt the interactive courseware, the level of courseware usage is affected by the quality of interface design and whether the courseware meets teachers’ and students’ needs. This study therefore contributes to the outcomes of previous studies on the implementation of the interactive courseware in the Malaysian Smart School Project by supporting their conclusions that interface design is a factor, but it also extends them by identifying both the specific issues in the interface design, as well as additional factors.

It also extends previous studies by investigating how these issues have arisen through empirical analysis of the development process that is practised by courseware developers in Malaysia. By comparing recommended models and the phases and sequencing outlined in the international literature with the guidelines provided by the Malaysian Ministry of Education, and the information provided by developers in interviews, specific issues associated with the current development process in Malaysia have been identified. In particular, it has been concluded that the developers do not understand, and so take little account of, the end-users’ needs, and this gives rise to issues in the courseware outcomes. While stakeholder participation and need is strongly recommended in the international literature in order to make a positive impact on the quality of a design outcome, and is therefore at the core of numerous established design methodologies, in Malaysia there are a number of factors that contribute to this oversight. These include the Ministry policy of centralising design decisions and approvals within the Ministry; a lack of understanding of the role of interface design as well as the benefits of end-user involvement in the design and evaluation process by the development teams; and the time and costs required for focus groups, interviews and surveys of representative end-users. This lack of involvement of students and teachers as end-users impacts negatively on the rate of interactive courseware uptake in schools, due to resulting perceptions of appropriateness of the content, quality of the interface design, and
pedagogical effectivity. In short, a key finding of this research is that the interface design quality and interactivity of the courseware is affected by the lack of user involvement in the current development process, which leads to deficiencies in usability, consistency, flexibility and appeal of the courseware to the target group, and this, in turn, has an impact on the extent of uptake and use of the courseware in schools.

This research project has also identified issues relating to relationships between the key stakeholders in the courseware during the development process. It was concluded that the various stakeholders are not closely integrated in the current process because of the different roles that they play, which are tightly delegated to specific teams and expertise, and this leads to a fracturing of responsibilities and the development process in general. It also leads to a lack of understanding of other stakeholders’ needs. Limited time allocation and budgets for the project were identified as sub-factors associated with this issue. This forms another key finding of the research, but it should be noted that this is not only an issue in Malaysia but has also been identified in previous international studies.

In response to these concerns, several potential methods of user involvement have been identified including participatory design, user-centred design and co-design, and a modified framework for the software development process has been proposed that addresses the collective needs of stakeholders (the Ministry, the courseware developers and the end-users).

In addition, principles that might be included in an expanded set of guidelines for provision to developers by the Ministry have been proposed. While these include guidelines for the development process, they also respond to a primary objective of this research project, which has been to establish a set of interface design principles for effective interactive courseware. Through a triangulation of data derived from a range of methods, this study has found that the characteristics required by the Malaysian government guidelines largely map on to the principles for effective interface design in the international literature, namely (1) consistency of the style and elements used; (2) familiarity provided through reference to the conventions of other software and the use of metaphors for other prior experiences, (3) flexibility of elements and commands to accommodate different user preferences, (4) feedback on actions that is efficient, clear and immediate and (5) aesthetics relating to the overall screen appearance that are appropriate to the target audience, screen layout and clarity of visual communication. In addition, the Malaysian guidelines also include the requirement to avoid
Ethnic, cultural and religious bias. While it is noted that the principles and characteristics provided in the international literature and Ministry guidelines are described differently, they are fundamentally similar. However, only three out of the five required media components (video, graphic images and animation) outlined in the Malaysian government guidelines were considered to be effective from the users’ perspective.

These outcomes have addressed the main research questions, and the aims and objectives described at the beginning of this thesis, with particular reference to providing empirical evidence on the extent of uptake of the courseware and the quality of the interface design of the Smart School science courseware; identifying factors that have affected the rate of courseware uptake at school; establishing an extended set of interface design principles including characteristics and components to help facilitate user interaction; discovering the current relationship between the key stakeholders involved in the software development process; and providing an extended set of principles to guide the design and development of future courseware for the Smart School Project that guarantee user involvement in order to ensure that the resulting courseware is appropriate to, and accommodates, the various stakeholders’ needs.

8.3 Research significance

This research project would not be built on a viable foundation without the contribution of earlier research conducted in related fields. And the results from previous research on interactive courseware in Malaysia have provided a valuable resource to make this research project more fruitful. However, while numerous studies have concluded that the interface design of the current interactive courseware in Malaysia has failed to accommodate users’ needs, interaction and overall learning experiences, limited research has so far been carried out in Malaysia to explain in detail the exact nature of, and reasons for, these problems in the interface design. By critically investigating the extent, nature and reasons for them, this research project provides empirical evidence that helps to clarify the extent to which the interface design in the existing interactive courseware for the Malaysian Smart School Project meets the actual end-user needs, and how these outcomes have come about. These conclusions have provided the basis for additional outcomes that include a new set of interface design principles and extended guidelines for the development process.
8.3.1 Theoretical implications

This study also points to new knowledge through the theoretical and practical implications of its results. Firstly, the study adds empirical evidence to support theoretically proposed principles of interface design for Multimedia Based Learning. It increases the theoretical understanding of the relationships between interface design quality (in terms of the look and feel, accessibility and usability) and learning engagement. It also adds substance to the proposition that utilizing interactive courseware in a productive way requires an understanding of the complexities of implementation and its potential for users. And it contributes to discussions among scholars from the field of E-learning on the gap between educational intent and the reality of user experiences with interactive courseware.

Secondly, this research has implications for theories on software development. While there have been many proposals for user participation in the development process, including User Centred Design, Participatory Design and Co-design, as well as critical discussions on the use of the Waterfall, Iterative, Spiral and ADDIE models in the development of effective interface design and interactive courseware, this study provides empirical evidence for the importance of user participation, particularly in product testing, and it helps to establish the implications that arise when this does not occur and when user needs relating to their goals practices and contexts of use are not clearly understood.

8.3.2 Practical implications

Another contribution of this study is its practical implications. Reports from the Malaysian Ministry of Education have established that the courseware developers do not fully follow the guidelines produced for interface design, and courseware more generally. By conducting a comparative analysis of the Malaysian government guidelines with a content analysis sample courseware, as well as interviews with courseware developers, insights have been gained into the extent of compliance with the guidelines.

By analysing interface design characteristics and components in the sample of Malaysian interactive courseware against international principles and standards, as well as against the Ministry guidelines, this research project has helped to establish what interface design principles, characteristics and components have been applied in the Malaysian interactive courseware. And, by conducting observations of real users and gaining focus group feedback
from them, this research has also offered valuable information on the phenomenon of end-users’ interactions with the interactive courseware in the classroom, as well as perceptions of effectiveness of the courseware in relation to interface design principles, characteristics and components. These insights into the perspectives of end-users’ (teachers and students) have provided the basis for recommendations for an extended set of design principles for use in the future. This has significance for the Malaysian government’s department of education, as well as potentially impacting on the development of more effective interactive courseware and hence courseware usage in Malaysian schools over time.

In addition, while the findings offered in the previous studies have focused primarily on the user’s perspective, they do not include the perspectives of all stakeholders. By ascertaining the developers’ points of view as well as the users’ perspectives, this research project provides empirical evidence on the current relationship between the main stakeholders and its impact on the development of interactive courseware. Moreover it helps to identify how issues have arisen and, based on this, new guidelines and requirements have been recommended for the development process and the facilitation of relationships between the ministry, developers and end users. This also has significance for the courseware development process and hence the Malaysian education system, as well as key stakeholders including students.

8.4 Recommendations for future research

The results of this research project point to a range of possibilities that can be investigated further in future research. These include:

1. Extending the scope of study
The scope of this research project has largely been limited to a study of interface design due to time and resource constraints of a PhD project. It could be useful to explore other areas such as experience design or interaction design in relation to the quality of courseware in Malaysia. For instance, from an interaction design research perspective, it would be interesting to explore how different interaction design components affect the performance patterns of student engagement. And, focusing on learning experiences could reveal other interesting phenomena and correlations between user satisfaction and the pedagogical
effectivity of interactive courseware. Such studies could employ the same research methodology as used in this study to extend the investigations presented here.

2. Extended research setting and sampling
In terms of research settings and sampling, this research project was conducted in the Malaysian context. The empirical evidence gathered in this study suggests that there may be an urgent need to investigate other settings with a wider scope of sampling. For example, future studies could consider students from different year levels, genders or ages, or students with different social and cultural backgrounds. In addition, similar studies could be developed in other countries, which may provide interesting insights into cultural differences. It should be considered however that investigating different research setting might require additional or different approaches to support the investigations.

3. Extended research into other subject domain
The conclusions on principles and characteristics described in this thesis are based on the sample of interactive science courseware. However, different subjects have different requirements and different contexts. Thus, it may be worthwhile for future research to study interactive courseware for other subjects to determine whether the principles, characteristics and components established in this research project would be effective and appropriate to them.

4. In-depth study on multimedia components
Future work might also investigate individual user preferences towards multimedia components further. For example it might investigate design characteristics of video and animation in order to ensure the effectiveness and appropriateness of its use in interactive science courseware and other subjects.

5. The appropriateness of additional guidelines and proposed framework
This research project has proposed additional design guidelines and a new framework for developing the Malaysian Interactive courseware. Future research could be carried out to investigate how these have been applied in practice and measure their impact on courseware development and on the software produced, as well as the comparative extent of uptake. Or future research could evaluate the benefits of the new proposed framework and additional
guidelines by conducting in-depth surveys of the developers—particularly the designers in the developer team.

Overall, it is hoped that this research project will encourage other researchers in Malaysia to conduct further research on the software development process and to take a holistic approach that includes the perspectives of the courseware developers as well as end-users and is mindful of relationships between them.

8.5 Conclusion

In the context of e-learning, interactive courseware provides new opportunities and mechanisms for teaching and learning to students and teachers. The process of developing interface design for interactive courseware is an important activity that requires careful consideration throughout the development lifecycle. The feedback received from the courseware developers, school principals, teachers and students in this research project has contributed to the understanding of this process.

Two main lessons have been derived from this study. Firstly, the study shows that courseware developers have not fully implemented the existing guidelines for designing interactive courseware due to budget and time constraints, lack of skill in the development team, lack of authority to make decisions in the design process, assumptions about end users and context of use. Hence, the Malaysian Ministry of Education needs to take actions on reviewing the cost requirements of the design and development process as well as the tender process, increasing consultations with end-users, and facilitating effective relationships between stakeholders. With the Ministry in control of the decision-making process and the technical ability sitting with the courseware developers, both parties are actively involved in the development process, yet teachers are not involved even though they are responsible for implementation and this needs to be addressed, as does the integration of expertise and the facilitation of stakeholder relationships.

Secondly, the courseware developers must become aware of the importance of ascertaining contextually specific end-users’ needs, because this understanding impacts on the capacity to produce effective interface design, which in turn impacts on the level of courseware uptake as well as learning engagement. Designers in the development team also need to gain in-depth
understanding of the role and theory of interface design (particularly the principles, characteristics and components) as well as instructional design strategies in order to improve the quality of the courseware.

From these lessons, it can be concluded that the main problems with the interactive courseware of the Malaysian Smart School Project occur because the courseware developers fail to fully implement the guidelines and to determine the needs of their clients from the very beginning of the development process. At the same time, the Ministry of Education also neglects to seek the views of teachers and students who are the end-users of the interactive courseware. They also fail in to provide adequate facilities to support implementation in a truly effective way.

The main conclusion of this study is that it is important for all stakeholders – the Ministry, courseware developers and teachers – to be engaged as collaborators in the development process. Close cooperation and clear communication between all stakeholders in the design and development process is necessary because active participation among stakeholders in the development process can significantly improved the performance of future interface design for interactive courseware.

By providing a new direction for the development of effective interface design that includes extended principles to ensure courseware usability, this study has extended knowledge about the implications of designers’ and users’ conceptual differences, demonstrated the broad potential of the methodological approach that has been applied, and provides a tool that exemplifies how this new knowledge can be implemented in the design process.

By conducting a comprehensive comparative analysis, including a contextual analysis of the international literature and the Malaysian government guidelines, a content analysis of the existing interactive courseware, observing end-users of the interactive courseware, and subsequently interviewing the courseware developers, this research project has extended the scope and findings of prior studies on interface design for interactive courseware. It has also produced additional outcomes including extended interface design principles that suit the Malaysian context, and a new framework for establishing and supporting key relationships and ensuring end-user involvement as stakeholders in the development and evaluation process. This proposed framework can be used as a new foundation for the future
development of interface design for courseware and will help to reduce the gap between the design of interactive courseware and the reality of students’ experiences with it. Above all, it is anticipated that this will lead to an improvement in educational courseware and, consequently, its uptake in Malaysia.
References


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Appendix 1

Malaysian ethic approval letter to conduct research in Malaysia

Application to Conduct Research in Malaysia

With reference to your application dated 8 October 2008, I am pleased to inform you that your application to conduct research in Malaysia has been approved by the Research Promotion and Co-Ordination Committee, Economic Planning Unit, Prime Minister’s Department. The details of the approval are as follows:

Researcher’s name: NORFADILAH BINTI KAMARUDDIN
Passport No. / I. C No: 750605-06-5126
Nationality: MALAYSIAN
Title of Research: “AN ANALYSIS OF INTERFACE DESIGN WITHIN MALAYSIA EDUCATIONAL COURSEWARE: IMPACT ON ENGAGEMENT AND PARTICIPATION IN TEACHING AND LEARNING SCIENCE IN PRIMARY SCHOOL”

Period of Research Approved: SIX MONTHS

1. I would like to draw your attention to the undertaking signed by you that you will submit without cost to the Economic Planning Unit the following documents:

   a) A brief summary of your research findings on completion of your research and before you leave Malaysia; and
   b) Three (3) copies of your final dissertation/publication.
Appendix 1 - continue

Malaysian ethic approval letter to conduct research in Malaysia page 2

4. Lastly, please submit a copy of your preliminary and final report directly to the State Government where you carried out your research. Thank you.

Yours sincerely,

[MUNIRAH ABD. MANAN]
For Director General,
Macro Economic Section,
Economic Planning Unit.
E-mail: munirah@epu.gov.my
Tel: 88882800/2818/2658
Fax: 88883798

ATTENTION

This letter is only to inform you the status of your application and cannot be used as a research pass.

C.c:

Ketua Setiausaha,
Bahagian Penyelidikan Dan Pendidikan Dasar Pendidikan,
Kementerian Pelajaran Malaysia,
Ara 1-4, Blok E-8,
Kompleks Kerajaan Parcel E,
Pusat Pentadbiran Kerajaan Persekutuan
62604 Putrajaya
Appendix 2

Approval letter from Malaysia Ministry of Education (MOE) on the list of primary Smart School

APPROVAL TO CONDUCT RESEARCH AT PRIMARY SMART SCHOOL

With reference to your application, I am pleased to inform you that your application to conduct research at Primary Smart School has been approved by the Ministry of Education. The detail list of the Smart School are as follows:

1. Sekolah Rendah Putra Jaya (1), Selangor - Primary (New school)
2. Sekolah Rendah Putra Jaya (2) Selangor - Primary (New school)
3. SK Tanjung Lalang, Temerloh, Pahang - Primary (State school)
4. SK (F) Palong 5, Gemas, Negeri Sembilan - Primary (State school)
5. SK Kg. Pagi, Ulu Tembeling, Pahang - Primary (Remote school)
6. SK Kg. Kenang, Sg. Siput (U), Perak - Primary (Remote school)

You are be advised to have an early approval from each of School Principal before entering school.

Lastly, please submit a copy of your preliminary and final report directly to the State Government where you carried out your research. Thank you.

Yours sincerely,

(MUNIRAH ABD. MANAN)
For Director General,
Macro Economic Section,
Economic Planning Unit.
E-mail: munirah@epu.gov.my
Tel: 88882809/2818/2958
Fax: 88883798
Appendix 3

Consent Letter for the school principals

RESEARCH CONSENT FORM (PRINCIPAL)

AN ANALYSIS OF MALAYSIAN COURSEWARE FOR PRIMARY EDUCATION: The Impact of Interface Design Upon Engagement and Participation in Teaching and Learning Science Courseware

ANALISA TERHADAP PERISIAN KOMPUTER PENDIDIKAN RENDAH DI MALAYSIA: Kesan pembahagi reka bentuk program diatas pengurusan dan penglibatan dalam pengajaran dan pembelajaran sains.

Researcher Contacts

NORFADILAH KAMARUDDIN  Dr. JILLIAN HAMILTON  Dr. JI YONG PARK
PhD Candidate  Principal Supervisor  Associate Supervisor
+617 31385610 (Australia)  +617 31385480 (Australia)  +617 31385928(Australia)
+6012 3488324 (Malaysia)  ig.hamilton@gcut.edu.au  jyong.park@gcut.edu.au
kamaruddin@student.gcut.edu.au

Statement of Principal Consent

I ______________________ (Name of School Principal / Teacher) have read the information presented in the information letter about the research being conducted by NORFADILAH KAMARUDDIN and I agree to have this study take place at __________________ (school or classroom). By signing below, I understand and agree to the following:

- All information collected during this study will be shared only amongst researchers and school principal and be securely stored at Queensland University of technology for five years.
- I understand that if I have any additional questions, I can contact the Researcher.
- I understand that I can contact the QUT Research Ethics Officer on +617 3138 2340 or ethicscontact@gcut.edu.au if I have concerns about the ethical conduct of the project.
- I agree to allow the school children in my school to participate in this project. It will be the child’s name will not be used at any time in reporting or use of information collected. Participation is completely voluntary and the child can withdraw from the study at any time.
- I understand that the project will include audio and video recording. There is not PHYSICAL risk the child as a result of participating in this study.

Principal Name: KAMARI BIN MOHAMED USOH

Signature:

School official Stamp’s: KAMARI BIN MOHAMED USOH
Guru Besar
Guru Besar
2K UKTP Sungai Rattang
27070 Jerantut, Pahang D.M.

Date: 09.02.2010
Appendix 4

Approval letter from Malaysia Ministry of Education (MOE) on getting sample of interactive courseware

Norfadilah kamaruddin
PhD Candidate
Creative Industries Faculty,
Queensland University of Technology
Brisbane, Australia

Puan,

SAMPLE of SMART SCHOOL COURSEWARE FOR SCIENCE SUBJECT UNDER MINISTRY OF EDUCATION MALAYSIA.

With reference to your application date 28 January 2009, I am pleased to inform you that your application has been approved by us.

1. In approving this application, I would like to draw your attention that you need to bring a letter of approval to conduct research in Malaysia by the Economic Planning Unit (EPU), Prime Minister’s Department, MOE when you come to collect the sample of courseware at Education Technology Division.

3. Due to the government procedure, you are also need to submit a copy of your final dissertation to us when the study complete.

Thank you.
Your sincerely,

(DR. MASNAH ALI MUDA)
Director of Education Technology Division
Ministry of Education Malaysia
Appendix 5

Consent Letter for the courseware developers

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AN ANALYSIS OF MALAYSIAN COURSEWARE FOR PRIMARY EDUCATION: The Impact of Interface Design Upon Engagement and Participation in Teaching and Learning Science Courseware

Researcher Contacts

NORFADILAH KAMARUDDIN
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+617 31385619 (Australia)
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Dr. JI YONG PARK
Associate Supervisor
+617 31385926(Australia)
luyong.park@qut.edu.au

---

Statement of consent

I have read the information presented in the information letter about the interview session being conducted by NORFADILAH KAMARUDDIN. By signing below, I am indicating that:

- I have read and understood the information document regarding this project.
- I have to answer any questions to my satisfaction.
- I understand that if I have any additional questions I can contact the Researcher.
- I understand that I am free to withdraw at any time, without comment or penalty.
- I understand that I can contact the QUT Research Ethics Officer on +617 3138 2340 or ethicscontact@qut.edu.au if I have concerns about the ethical conduct of the project.
- I agree to participate in the project.
- I understand that the project will include audio and video recording.

Name

NORHALIZAH UJANG

Signature

Company

PINTAR MEDIA SDN. BHD.
(423746-X)
E-10-4, Jalan SS 15/4G
Subang Square
47500 Subang Jaya, Selangor
Tel. : 03-5635 8672
Fax. : 03-5631 1352

Date 19th May 2009
Appendix 6

QUT ethic approval

Dear Mrs Norfadilah Kamarudin,

A UHREC should clearly communicate its decisions about a research proposal to the researcher and the final decision to approve or reject a proposal should be communicated to the researcher in writing. The Approval Certificate serves as your written notice that the proposal has met the requirements of the National Statement on Research involving Human Participation and has been approved on that basis. You are therefore authorized to commence activities as outlined in your proposal application, subject to any specific and standard conditions detailed in this document.

Within this Approval Certificate are:

* Project Details
* Participant Details
* Conditions of Approval (Specific and Standard)

Researchers should report to the UHREC, via the Research Ethics Officer, events that might affect continued ethical acceptability of the project, including, but not limited to:

(a) serious or unexpected adverse effects on participants; and
(b) proposed significant changes in the conduct, the participant profile or the risks of the proposed research.

Further information regarding your ongoing obligations regarding human based research can be found via the Research Ethics website http://www.research.qut.edu.au/ethics/ or by contacting the Research Ethics Coordinator on 07 3138 2340 or ethicscontact@qut.edu.au

If any details within this Approval Certificate are incorrect please advise Research Ethics within 10 days of receipt of the certificate.

Research Ethics Officer
(on behalf of the Chairperson UHREC)

Date: 27-1-2007

Category of Approval: Human non-HREC
Approved Until: 23/01/2012
Approval Number: 0900000006
Project Title: An analysis of Malaysian courseware for primary education: the impact of interface design upon engagement and participation in teaching and learning science courseware
Project Chief Investigator: Mrs Norfadilah Kamarudin
Other Project Staff/Students:
Dr Jilton Hamilton, Dr Ji Yong Park

Experiment Summary:
Evaluate learning experiences through the current courseware and the development of practical guidelines for future courseware development to ensure a more learner engaging and high quality learning experience.

Participants:
Approximately 5 educational courseware developers, 3 principals, 10 teachers and 230 students

Location/s of the Work:
Smart State Schools (Malaysian Ministry of Education), Kuala Lumpur, Malaysia

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Appendix 6- continue

QUT ethic approval page 2

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University Human Research Ethics Committee

HUMAN ETHICS APPROVAL CERTIFICATE

NHMRC Registered Committee Number EC00171

Conditions of Approval:

Specific Conditions of Approval:
No special conditions placed on approval by the UHREC. Standard conditions apply.

Standard Conditions of Approval:

The University's standard conditions of approval require the research team to:

1. Conduct the project in accordance with University policy, NHMRC / AVCC guidelines and regulations, and the provisions of any relevant State / Territory or Commonwealth regulations or legislation;

2. Respond to the requests and instructions of the University Human Research Ethics Committee (UHREC);

3. Advise the Research Ethics Officer immediately if any complaints are made, or expressions of concern are raised, in relation to the project;

4. Suspend or modify the project if the risks to participants are found to be disproportionate to the benefits, and immediately advise the Research Ethics Officer of this action;

5. Stop any involvement of any participant if continuation of the research may be harmful to that person, and immediately advise the Research Ethics Officer of this action;

6. Advise the Research Ethics Officer of any unforeseen development or events that might affect the continued ethical acceptability of the project;

7. Report on the progress of the approved project at least annually, or at intervals determined by the Committee;

8. (Where the research is publicly or privately funded) publish the results of the project in such a way as to permit scrutiny and contribute to public knowledge;

9. Ensure that the results of the research are made available to the participants.

Modifying your Ethical Clearance:

The University has an expedited mechanism for the approval of minor modifications to an ethical clearance (this includes changes to the research team, subject pool, testing instruments, etc.). In practice this mechanism enables researchers to conduct a number of projects under the same ethical clearance.

Any proposed modification to the project or variation to the ethical clearance must be reported immediately to the Committee (via the Research Ethics Officer), and cannot be implemented until the Chief Investigator has been notified of the Committee's approval for the change / variation.

Requests for changes / variations should be made in writing to the Research Ethics Officer. Minor changes (changes to the subject pool, the use of an additional instrument, etc.) will be assessed on a case by case basis and minor approval may be granted subject to ratification at the subsequent meeting of the Committee.

It generally takes 7-14 days to process and notify the Chief Investigator of the outcome of a request for a minor change / variation.

Major changes to your project must also be made in writing and will be considered by the UHREC. Depending upon the nature of your request, you may be asked to submit a new application form for your project.

Audits:

All active ethical clearances are subject to random audit by the UHREC, which will include the review of the signed consent forms for participants, whether any modifications / variations to the project have been approved, and the data storage arrangements.

End of Document

RM Report No, E691 Version 2
Appendix 7

Inform Letter for the school principals

PARTICIPANT INFORMATION for SCHOOL PRINCIPAL

AN ANALYSIS OF MALAYSIAN COURSEWARE FOR PRIMARY EDUCATION: The Impact of Interface Design Upon Engagement and Participation in Teaching and Learning Science Courseware

Researchers

NORFADILAH KAMARUDDIN
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Dr. JILLIAN HAMILTON
Principal Supervisor
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Description

This project is being undertaken as part of PhD project for NORFADILAH KAMARUDDIN from QUEENSLAND UNIVERSITY OF TECHNOLOGY (QUT) as to fulfil the requirement of the programme. The purpose of this project is to review the current problems of the Malaysian educational courseware in terms of effectiveness interface design characteristics and its impacts on learner interactions. It also investigates and defines the learners’ needs in terms of facilitating quality learning experience through courseware. The research outcomes are expected to result in the development of a practical guideline for courseware development by presenting a set of principles for the effective design of courseware based on integrating the stakeholders’ needs in terms of creating a quality learning experience in courseware.

Participation

- Your school and your student’s participation in this project are voluntary. If you do agree to participate, you and your students can withdraw from participation at any time during the project without comment or penalty.
- Each student who’s agreed will participate in classroom observation that would be arranged for a time convenient to class schedule on different days and would take about 30 minutes to 1 hour in classroom. Each session will involve audio and video taping of your child engaged in learning activities.
- To ensure the students and teachers do not feel distracted or uncomfortable during the observation process, a teacher will be present at all times, the researcher will be unobtrusive and will not participate in classroom activities. The researcher will stay at the back of the classroom and will not interrupt or participate in activities but simply observe them from a distance while close-up use of the courseware and screen will be recorded using a video camera. This will minimize interruption of activities and distraction. With your permission, the non participant observation will be tape-recorded to facilitate collection of information, and later transcribed for analysis.
- Students will be given clear guidelines on the length and limits of their involvement, as well as a briefing on how the research and their contribution will benefit students in the future.
- Each student who is agree to participate in the classroom observation will be interviewed after the classroom observation to facilitate the data gathering from the classroom observation. This session will involve the students responding to the researcher’s questions. To reduce anxiety, this session also will include the teachers. However, to prevent any problem, all interviewees’ comment will be kept completely anonymous and may decline to answer any of the interview questions they do not wish to answer and may terminate the interview at any time.
- You would like to assure you that this study has been reviewed and received ethics clearance through the Office of Research Ethics at the Queensland University of Technology (QUT).

Expected benefits

It is expected that this project WILL benefit your student in term of creating a quality learning experience towards courseware by increasing student interactions.

Risks

The students and the teachers might feel uncomfortable during the observations, due to the presence of a non-teacher (the researcher) in the classroom. The students and the teachers also might be feeling distracted during the follow-up interview. However, there is NO PHYSICAL RISK beyond normal day-to-day living associated with your participation in this project.

Confidentiality

All comments, information and responses are ANONYMOUS and will be treated CONFIDENTIAL. The audio/video recordings are to be verified by the participants prior to final inclusion and the researcher will dispose of the recordings after the contents have been transcribed. The transcription of data recordings will be kept in a secure location for 5 years time. The names of individual persons are not required in any of the responses.

Consent to Participate

I would like to ask you to sign a written consent form (enclosed) to confirm your school agreement to participate.

Questions / further information about the project

Please contact the researcher named above to have any questions answered or if you require further information about the project.

Concerns / complaints regarding the conduct of the project

QUT is committed to researcher integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Officer on +617 3138 2340 or ethicscontact@qut.edu.au. The Research Ethics Officer is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Yours sincerely,

NORFADILAH KAMARUDDIN
Appendix 8

Inform Letter for the courseware developers

AN ANALYSIS OF MALAYSIAN COURSEWARE FOR PRIMARY EDUCATION: The Impact of Interface Design Upon Engagement and Participation in Teaching and Learning Science Courseware

Researcher Contacts

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Description

This project is being undertaken as part of PhD project for NORFADILAH KAMARUDDIN from QUEENSLAND UNIVERSITY OF TECHNOLOGY (QUT) as to fulfil the requirement of the programme. The purpose of this project is to review the current problems of the Malaysian educational courseware in terms of effectiveness interface design characteristics and its impacts on learner interactions. It also investigates and defines the learners’ needs in terms of facilitating quality learning experience through courseware. The research outcomes are expected to result in the development of a practical guideline for courseware development by presenting a set of principles for the effective design of courseware based on integrating the stakeholders’ needs in terms of creating a quality learning experience in courseware.

Participation

- Your participation in this project is voluntary to participation in this study. If you do agree to participate, you can withdraw from participation at any time during the project without comment or penalty.
- The interview would take about 30 minutes to one hour, and would be arranged for a time convenient to your schedule and you may decline to answer any of the interview questions you do not wish to answer and may terminate the interview at any time. With your permission, the interview will be tape-recorded to facilitate collection of information, and later transcribed for analysis.
- To prevent any problem, all interviewees’ comment will be kept completely anonymous.
- I would like to assure you that this study has been reviewed and received ethics clearance through the Office of Research Ethics at the Queensland University of Technology.

Expected benefits

It is expected that this project WILL benefit you in term of producing a good quality of educational courseware by improving the development process.

Risks

There is NO PHYSICAL RISK beyond normal day-to-day living associated with your participation in this project. However it is possible that your may be feel uncomfortable with certain of questions that will be asked by the researcher. There is a small possibility that you may choose to say things that your peers, employers or users might criticized, however the researcher will be assured that data given is non-identifiable.

Confidentiality

All comments, information and responses are ANONYMOUS and will be treated CONFIDENTIALY. The audio/video recordings are to be verified by the participants prior to final inclusion and the researcher will dispose of the recordings after the contents have been transcribed. The transcription of data recordings will be kept in a secure location for 5 years time. The names of individual persons are not required in any of the responses.

Consent to Participate

I would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate.

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Yours sincerely,
NORFADILAH KAMARUDDIN
# Appendix 9

## School Principal Questions

### School Background

1. **Does your school have computer in all classrooms?**
   - [ ] Yes  [ ] No

2. **Does your school receive any computers from the Ministry of Education?**
   - [ ] Yes  [ ] No

3. **Does your school use the interactive courseware provided by the Ministry of Education?**
   - [ ] Yes, please proceed to section A
   - [ ] No, please proceed to section B

### SECTION A (by answering YES)

1. What subject(s) is/are the interactive courseware used in common?
   - .................................................................

2. Please describe how you most frequently make use of interactive courseware?
   - Daily  [ ] Weekly  [ ] Monthly  [ ]

3. An average, how many hours per week the interactive courseware been used in classroom?
   - .................................................................

4. Can you describe in what ways your school has experiences with the interactive courseware at your school?

5. Does your school have teachers who are skilled in using interactive courseware?

6. Does your school have a technical support person?

7. How about the computer other support facilities in implementing the interactive courseware. Does your school have enough computers?

8. How does the Ministry of Education support your school in interactive courseware implementation?

9. Do your teachers be involved in the development of the courseware?

### SECTION B (by answering NO)

1. Please describe any reason why interactive courseware are not been implemented at your school?
   - .................................................................

2. How does the Ministry support your school in implementing the courseware?

3. What kinds of teaching materials have your teacher most use in classroom?

4. Do your teachers be involved in the development of the courseware?

**Thank you for your respond and participant for this session.**

End session
## Appendix 10

Sample Questions for Teacher

<table>
<thead>
<tr>
<th>Topic relate to the following areas:</th>
<th>Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part 1 - Discussion Topic:</strong> Demographic information of the teachers</td>
<td>1. How many years and months you in this present school?</td>
</tr>
<tr>
<td></td>
<td>2. How long you be experiencing with this interactive science courseware?</td>
</tr>
<tr>
<td></td>
<td>3. Can you describe about a classroom situation in which you had to apply the interactive courseware?</td>
</tr>
<tr>
<td></td>
<td>4. When was the last time you used the interactive courseware?</td>
</tr>
<tr>
<td></td>
<td>5. In your opinion, have your teaching methods changed because of the presence of this interactive courseware</td>
</tr>
<tr>
<td></td>
<td>6. To the extent that you’ve used interactive courseware in your teaching, has it saved you time or taken more of your time?</td>
</tr>
<tr>
<td><strong>Part 2 - Discussion Topic:</strong> Involvement in development process and user testing</td>
<td>7. Have you ever been involved in any development project before, whether it is school project or a MoE (Ministry Of Education) project?</td>
</tr>
<tr>
<td></td>
<td>8. What experience do you have on testing the interactive courseware?</td>
</tr>
<tr>
<td></td>
<td>9. Would you be willing to attend, participate and help the developers or MOE in the development of interactive courseware? Can you tell me in what ways or any participation technique that you prefer?</td>
</tr>
<tr>
<td><strong>Part 3 - Discussion Topic:</strong> Interface design principle and characteristics</td>
<td>10. What do you think of the mix of graphic or video or audio and animation presented in this interactive courseware. Is it helpful to you?</td>
</tr>
<tr>
<td></td>
<td>11. When you look at this courseware, what appeals to you?</td>
</tr>
<tr>
<td></td>
<td>12. Which part of this courseware have you found most interesting?</td>
</tr>
<tr>
<td></td>
<td>13. What kinds of problems have you experienced with this interactive science courseware in the classroom?</td>
</tr>
<tr>
<td></td>
<td>14. What improvements would you recommend for the interactive science courseware?</td>
</tr>
</tbody>
</table>
Appendix 11

Focus Group Discussion – topic and questions
This questionnaire was made as an example guide. The actual questions slightly varied according to the various scenarios.

Date: ___ / ___ / ___
School: __________________

Introduction
Hello, my name is NORFADILAH KAMARUDDIN. I am conducting a study about interface design for interactive courseware. I want to get some ideas about your experiences as a student in the classrooms where interactive courseware is used. In deep, I want to know: (1) How do you used it and how did it help your learning process, (2) What was the good and not so good component used you saw, (3) What else can be done to enhance the uses of interactive courseware in the classroom from your perspective of view.

First, we will talk about the interactive courseware that you was used just now. Tell me anything that you think really impact you. Therefore, I am also interested in hearing your experiences on use of interactive courseware in any of your classes.

<table>
<thead>
<tr>
<th>TOPIC 1</th>
<th>Routines and user attitudes related to the interactive courseware</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Before this had anyone in this group participated in any focus group discussion?</td>
</tr>
<tr>
<td>2.</td>
<td>Where do you normally use the interactive courseware?</td>
</tr>
<tr>
<td>3.</td>
<td>Do you find any differences when you use interactive courseware compared to the printed book?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TOPIC 2</th>
<th>Effectiveness of components</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>What are the things in the interactive courseware that you used just now encourage you to use the courseware more? (Showing the screen of interactive courseware that containing of pictures and text to the students):</td>
</tr>
<tr>
<td>2.</td>
<td>Do the (images/text) help you to understand the topic that you learn just now?</td>
</tr>
<tr>
<td>3.</td>
<td>How it helps you? Can you tell me? (Showing the page of interactive courseware that containing of animations to the students):</td>
</tr>
<tr>
<td>4.</td>
<td>Did you think the animations explain something?</td>
</tr>
<tr>
<td>5.</td>
<td>How it works on you?</td>
</tr>
<tr>
<td>6.</td>
<td>How about others components?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TOPIC 3</th>
<th>Principles and characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Do you feel that you get enough information about the subject when you use the interactive courseware?</td>
</tr>
<tr>
<td>2.</td>
<td>Do you understand on the feedback given by the interactive courseware?</td>
</tr>
<tr>
<td>3.</td>
<td>Are you found anything that make you confuse while you use the interactive courseware?</td>
</tr>
</tbody>
</table>
# Appendix 12

## Developer’s interview questions

<table>
<thead>
<tr>
<th>Topic relate to the following areas:</th>
<th>Questions</th>
</tr>
</thead>
</table>
| **Part 1 - Discussion Topic:** Company history and profile | 1. How long has your company been involved in this field, and how much courseware has you developed?  
2. What are the roles of people in your production team and company management in relation to the courseware development? |
| **Rationale:** To determine the history and extent of company involvement in courseware development of *Smart School Project.* | |
| **Part 2 - Discussion Topic:** Development Process | 3. Can you describe the steps that your production team take in the interface design and development process of this courseware?  
4. Does your production team follow any standard design process in developing the interfaces for the science courseware?  
5. Is there any person in your development team that has been trained thoroughly in interface design? |
| **Rationale:** These questions will determine how the courseware was developed and the priority of interface design in this process. | |
| **Part 3 - Discussion Topic:** Design Guidelines | 1. Do you follow any guideline in developing your interactive courseware?  
2. If YES, have you followed government guidelines?  
3. If NO, did you follow other, alternative guidelines and why?  
4. Was your company provided with interface design guidelines from the government to develop this science courseware?  
5. Was your development teams satisfied with these guidelines? What are the reasons for this? |
| **Rationale:** These questions are to collect information on the current guidelines that developers use in their courseware development. | |
| **Part 4 - Discussion Topic:** Interface design principle and characteristics | 1. Is there any part of the government guidelines /your own guidelines on the interface design that is difficult or problematic to implement? If there is, any reason for this, please explain.  
2. Has this courseware been structured consistently to make the interface design acceptable by most end-users?  
3. What do you consider the role of interface design to be?  
4. Do you think that interface design is an important aspect of the development process compared to other aspects?  
5. When is the interface designed in your process? |
| **Rationale:** These questions gauge the developer’s understanding of the role of interface design components in providing effective learning experiences | |
Appendix 13

Sample of developers’ interview transcript

<table>
<thead>
<tr>
<th>filename: IMTEQMOV02F.avi</th>
<th>Date &amp; Time: 29 May 2009, 11.00am – 12.15am</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewee: Project manager</td>
<td></td>
</tr>
<tr>
<td>Tool: video recorder</td>
<td></td>
</tr>
<tr>
<td>Company: IMPAK TEKNIK SDN BHD</td>
<td></td>
</tr>
</tbody>
</table>

1. Company History and background
   How long has your company been involved in this field?
   We mostly involved with Pusat Perkembangan Kurikulum (PKK) and other ministry project such as INTAN, MIMOS and Bahagian Buku Teks. Under Ministry of Education, they have 3 departments which are Pusat Perkembangan Kurikulum (PKK), Bahagian Teknologi Pendidikan (BTP) and Bahagian Buku Teks (BBT). So far, we have been working with MOE for almost 7 years.

   How much is the courseware had been produced within this time?
   We have 2 projects from Bahagian Buku Teks (BBT) for subject Mathematics and Science. This project was not a MOE project since we got the project from our vendor who produced the text books. Nowadays, most of the text book will come with CD activity based. This CD was prepared by us and we involved with this development for 5 years ago.

   We are awarded a direct MOE project by the PKK and BTP. We developed primary Science for year 2 and 5 and also Secondary level, which is Form 5 for the PKK. With BTP, the project running by phases. It’s including Form 1, 2, 3 and 4. So far we only involved for 3 phases (2, 3 and 4). What I can say is, we been involved for all level in Secondary School. It’s hard for us to determine the total lesson which had been produced. Because we received a project for different subject and standard. However, I can say that it’s more than 100 lessons been developed.

2. What are the roles of people in your production team and company management in relation to courseware development?
   Normally, how many person/people involved in this production work and who are they?
   Basically here, we are by department. We have Project Manager, Instructional Designer, Graphic Designer and Multimedia Programmer. These 4 people are the main person that must be in the production. The team size may depend on the value and workload quantity of the project. Beside these 4 main persons, we also have an additional people involved which are subject matter expert and illustrator. Sometimes, we also need media, voice talent, photographer and language editor. But what I can say is, as an average for Ministry of Education project, all together, the workforce not more than 15 people. To give you the specific workforce is very difficult since it’s depending on the project requirement. Sometimes, we only have the team leader in the office and others task will be outsourcing. So, what I can conclude that the quantity of people who are involved in the project are depending on the time frame, company budget and project value.

   You been mentioned about outsourcing. What is normally being outsourced?
   A lot of things actually. Audio, photograph, video, etc. But then, as I mentioned just now, it’s depends on the requirement for that time. Sometimes we also outsource the graphic works.

   Is it means that this company does not have any specific interface designer for the courseware?
   Yes! We do not have a specific interface designer because the project is change several times. Therefore, most of our graphic designer was been trained to be more flexible. They can be a graphic designer and at the same time as interface designer.
Can you explain further about this?
In our company, graphic designer has been trained to understand about graphic principles and instructional design principles so that they can work as interface designer. The important things and what we need is our graphic designer must be able to read the storyboard and understand the whole concept. That’s enough to prepare all the artwork.

And one more thing, we normally are based on the MOE requirement for the interface design since only the MOE committee will approve the graphic user interface. We have to study their requirement and proposed to the MOE based on their requirement even though the requirement itself not very details enough. Then, we give an input based on this. The most important is just to make the interface become user friendly. However, the approval is still come from the MOE committee. So far, our graphic designers are able to fulfil the entire MOE requirement in term of graphical user interface.

You are mentioned that your designers are capable to fulfil the MOE demand; Does the designer of your company have attended any specific training about the interface design courseware before?
If specific training, there are no one involved or attend. However, so far our graphic designers are capable to do the work which elated with the production of interface design. And we believed on their background history. Most of them were graduated in design field.

3. Can you describe the steps that your production team commonly take in the interface design and development process of this courseware?
There are a lot of productions steps in producing the courseware. Either by CD-rom or direct online, which means, online web. For MOE project, we only produced the courseware by using CD-rom as a platform. Normally, when we received an approval to produce a courseware; Project Manager will handle the project. As explain earlier the process is the same. Received the requirement, review the document, preparing the storyboard and proceed with the prototype. Finally we do the testing.

Do your company have any standard process or follow other standard in producing the courseware?
Currently we are following the generic model ADDIE which is mean Analysis, Development, Design, Implementation and Evaluation. Each phase will be details. Like other company, example instructional designer already analyse the task and then they pass to other department.
In this company, our instructional designer will analyse the courseware from the beginning until the end together with other designer’s i.e. graphic designer base on their scope. We didn’t simply past the tasks to other department for them to continue the works. They will seat together to discuss from the analysis phase until the end of process.

What is the common problem you are facing during making this courseware?
You mean any problem that we are facing? As a developer, we don’t have a problem. Some more we deal with lots of people. For this Ministry’s courseware, impossible to say that no problem at all. As I said earlier we only prepare the design, but the approval is by MOE. Do you understand?

Do you think that the process of making the component of interface design is the hardest phase?
To me it is too subjective. For me it’s not too hard. The reason is in the process of courseware production, there are certain levels. For example, inside the education system there is level 1 to level 5.

What do you mean by level?
This is refers to level of learning capability. Actually we also refer to the multimedia level of courseware itself. This means, it’s referring to level of interactivity or courseware movement. So, generally the level of difficulty in the process of interface development is average. Not too hard and too easy. If we follow by logic, interface design itself has their specific section. For example, we take navigation design requirement. Sometime we no need to add anything because the screen bar, exit button and etc is already standard.
Do you prepare the storyboard before start the project of design phase?
Yes. We will do the storyboard after we received the project. Actually, before we start with any project we must build the storyboard first then follow by design and others. The reason is if we didn’t do the storyboard, how we are going to submit to MOE. They need to see the storyboard and we need to get approval for every lesson.
Now we take an example for interface. Usually project manager will prepare the storyboard together with instructional designer. So this is considered as a guide for our designer to do their work or task.

How is it helping your production?
 Normally, storyboard is a guideline to designer and programmer. I mean the placement of the button, where should go, NEXT or BACK. If on generic screen it’s to be YES or NO. The reason is designer need to know everything on this. But then inside the storyboard which was prepared by our instructional designer, all the details about the courseware was explained. Either we need the animation or not and etc.
We are also using the storyboard as our landmark for us to get a clear picture on the courseware that we produced. So it’s means without the storyboard we can’t simply start the development or design.
Let me tell you. Based on this storyboard we developed lesson mapping. In lesson mapping we prepared everything including learning strategies, learning objective and so on. Then we start produce the prototype. At this stage, we already found the subject matter expert in order to get the perfection of the courseware. Sometime, they asked us to make a change on the storyboard such as title or any graphic images which they do not agreed. Then from there we will start on lesson design. So during that phase we actually already in process of development.

Can you tell me is the company practice the user testing process on each courseware which been produced?
For multimedia yes we have. When the lesson is complete usually we will do the in-house testing. For graphic part, they have their own set of testing before they pass it to the instructional designer. Instructional designer will do the testing and checking for the whole lesson based on the storyboard. Instructional designer also will meet MOE committee together with graphic team representative.

Who will be the judges to check or prove that the courseware is successfully design before it’s can be used by student?
Usually we send it to the ministry officer. They will be the last person to made a check on the courseware.

4. Does your company being provided with specific guideline by Ministry in the process of making interface design component?
We just have the tender document. So far that’s the only thing you can call a guideline. For me it’s just a starting guideline. The reason is because after that we will always have a review process with MOE. You need to buy the tender document you know. So for us, if the tender document does not exist we still can produce the design based on our previous experience and our capability. We are the developer for interface educational courseware and we know the basic requirement for the courseware. So why should bother on that. Some more the project is based on tender. So every single developer needs to fight each other in order to get the project. With very brief information, do you think you can produce a good quality of courseware? You can’t is it? So you must be more creative. In simple word we have to make our own initiative. But when we always do MOE project, we already familiar with their requirement and know what they like or don’t like. Remember that just now i told you that every single lesson must go through with the content approval from MOE. So during this review process, there are still lots of changes and how are we going to follow their guideline. During review session, the people who involve are the school teachers which invited by MOE. These teachers will give a feedback during the review session. Easy to say it’s not documented in the guideline for what they want actually.
Do you think the guideline become part of the process of making interface design courseware component?
(Laugh) for the early stage, either you like or not we have to follow the guideline but when we already familiar with MOE style some requirement can be pass over. Means that different project is a different tender document. So that is why at early stage we have to follow the guideline. When we meet MOE for several times, it will change automatically.

Do you think that the guideline is helping your company to produce the interface design courseware component?
Hard to say. Actually the company must have a skill to extract the information from MOE especially during review session. Content of approval may give more input during that session. So, for a new company it is quite difficult for them the produce the courseware based on the guideline because they are not familiar with it. So i can conclude that for new developer it’s very difficult but for experience developer it should be no problem.

Have your company satisfied with the content in the guideline? Can you explain?
We have our own reserve (Big laugh). To us when we work with the MOE project, our objective is to give the best to the student. Means that, how to fulfill student requirement from the courseware and also to accomplish the MOE’s needs. Problem is always there but when we have an objective, we try to overcome everything and mostly we absorb all. Back in mind, client is always right. They pay us for the project so we can’t do or say much. Actually there are two parties involved. Sometime client is okay but then maybe the developer got a problem. In our experience with MOE, we still success to overcome them and their requirement. To us, we have to understand each other. We had tried to outsource the task for instructional designer but then its really create a problem. Since we are the person who have a meeting with MOE and understand their requirement therefore in house instructional designer is the key person for the successful of courseware performance.

5. If possible, what is the thing in the guideline that you required to modified or replace?
Any part in the guideline that been prepared by the Ministration to your company at this time was difficult or in-relevant to be used?
For me animation and video.
Why?
For the first video we received from client, usually quite difficult for us to fulfill their needs. Means beyond our skill (laugh). For example, we do a project for government and to be use by all student, so all the copyright we must have. Means that all the courseware produced shall be government property. When they request very specific requirement such as we have to show the real life of the particular thing which is difficult for our designer to provide or visualize. So that is a problem. We cannot simply take other people job, so we have to do a little bit study on that. Meet the expert on the particular thing. We have done shooting and so on. It was same happen to the static image as well. So this is the problem because we need to deal with the third parties. So I think we should considered also either the MOE requirement was logic or not.
As long as we can fulfill their requirement, we proceed the work until we cannot do it and then we explain to them. But sometime they did not accept. For them, since they give us the project so we have to fulfill the requirement as per their instruction. Even the MOE’s requirement is a high quality but they are not very sensitive on certain aspect such as system requirement.

What is the thing that been stressed by your company to ensure the successfullness of the courseware and easy to be used by end user?
KAY: the thing that we really taking seriously is the functionality of the courseware. It’s including the placement, the layout of the interface and then the presentation. The important is how user friendly it is.
How consistent is your courseware design produce so that it is easy to use by all users?

KAY: Actually MOE have their own specific template. I think you can get it from the tender document. We are needed to maintain the consistency of the presentation. For example, from icons, colours and style of screen layout. Since the tender already show the requirement for layout, so for that we always make sure that the courseware we develop must used same set of colour scheme that can be applied for all lessons. Usually we used that. The changes only on the visual part. The rest is same.

Did your interface design courseware providing an efficient response to the end user when they use it?

KAY: we must prepare this entire thing. If you look into our own courseware (she show the courseware), we provide everything for the end user such as Indicator, tool kits, short cut button and etc.

Ok, thank you for your respond and participant for this session.

You are welcome