DESIGN AND DEVELOPMENT OF LEARNING MATERIAL WITH THE TEN STEPS TO COMPLEX LEARNING: A MULTIPLE CASE STUDY

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LIST OF ABBREVIATIONS

CBI – Computer-based Instruction

DDR – Design and development research

SPM – Sijil Pelajaran Malaysia

TSM – Ten Steps Model

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DECLARATION

To the best of my knowledge and belief, I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. I confirm that this thesis has not been submitted for a degree at any other university.

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ABSTRACT

This study is an example of design and development research involving the design and development of learning material using the Ten Steps to Complex Learning model or TSM. It seeks to answer the key question, what is the value of the TSM? It does this by asking: What is TSM?; How does TSM work?; Is TSM useful?; and What are the contexts that need to be considered in adapting TSM?. TSM is a prescriptive instructional design model comprises of ten design steps needed in designing instruction. The ten steps are the expansion from four design components; learning task; supportive information; procedural information; and part-task practice; that derived from the 4C/ID model. TSM emphasises designing instruction for complex learning that promotes transfer of learning.

In order to explore TSM, the model was used in developing learning material for three different topics using computer-based instruction as a medium of instruction. The study involved three different contexts, meaning that a multiple case study approach was adopted. The cases covered different higher education institutions in Malaysia and involved Interface Design, Injection Moulding, and Web Programming. The three cases enabled an exploration of the value of TSM by reflecting on the experience of design and by the gathering of the perspectives of learners and lecturers on the learning materials. Each case involved a mixed method data collection procedure that comprises of interview with the lecturer who taught the subject; online survey (Case 1: 16 items, n=17 and 18 items, n=6; Case 2: 17 items, n=21; Case 3: 18 items, n=15); Facebook feedback (in Case 1), open-ended

questions (in all cases); observation, and document analysis. Each case study was examined with direct reference to the TSM whereby the process of reflecting on action that build up the knowledge about TSM and how it works in practice were recorded in a design log. The mixed methods enabled data triangulation and provide an in-depth exploration of TSM.

From the reflection on the three cases studies, it was found that, TSM is a procedural model and could be categorized as product-oriented model. TSM works by breaking down the competencies or complex skills into learning task and structuring the content of the subject matter. TSM also was found useful in terms of focusing on content and learning task but was weak in considering context. The study suggested TSM should be used flexibly and designers should consider the content and curriculum, placement of media and learner readiness, they should also be aware that design takes place in a wider ecological context. These findings provide the basis for a model of design. This study not just brings value to the field by describing the use of TSM but also raises wider issues about design in general. Design is not solely about following procedures but is shaped by social cultural context. Designers need to ask the right key questions of where and how the learning takes place as well as who the learners are.

CHAPTER 1: INTRODUCTION

1.1 What is this thesis about?

This thesis is about the process of designing and developing instructional materials for three different subject matter. It does this by presenting an in-depth exploration of van Merriënboer's Ten Steps to Complex Learning model (hereafter TSM), an approach to designing instruction that focuses on complex learning. The main value of TSM is its focus on learning tasks and how these tasks work as the backbone of instructional design. My exploration of TSM is carried out through multiple case studies (n=3) in which TSM was used for developing instructional materials. These cases enabled this study to investigate the strengths and weaknesses of TSM when used for this purpose. This study brings value to the field by describing the usability of an interesting, emerging model and in the process, raising wider issues about design in general.

1.2 Why carry out this study?

Personal interest. I started developing an interest in instructional design while working as a multimedia designer and later as a content developer. Working with a development team, our design tasks were based on the storyboards from the instructional designer. We worked in phases, and every design produced was presented to the client and stakeholder(s) in order to gather their feedback. The design process was iterated until the project was completed. Within the

development team we encountered different kinds of subject matter often outside of our area of expertise and in which we did not have a natural interest. Having a multimedia academic background, I trusted that technology was a powerful medium to deliver instruction, whether via computer based instruction, web based training or technology enhanced learning. However, I felt there was a gap in my understanding of how content or subject matter should be formulated into teaching and learning material that enables the transfer of knowledge among learners in different contexts.

Learning transfer. In my own experience of developing material for teaching and learning, I learnt that there were issues on learning transfer in which learners felt there was a gap between what they learnt from the module or instruction and what they were expected to do in reality. In general, it could be seen that some learners could not integrate the knowledge and skills received from the module and employ them in a real task. This implies that they did not acquire the level of knowledge and skills that permit transfer of learning (Kirschner and van Merriënboer, 2008). Having to said this, there were also other factors that might contributed to this such as learners background, learning environment and how the teaching and learning material was designed.

Transfer of learning has long been discussed among scholars in Malaysia and many approaches have been used to achieve it (Yusmarwati, 2010; Azmi, 2011; Ahmad et al., 2011). Transfer of learning is one of the elements in evaluating the effectiveness of a module or instruction (Irmawati and Siti Aisyah, 2013). There are various approaches to designing modules or instruction, and many users adopt and adapt the approach based on its suitability and applicability to the

context. For example, (Yusmarwati, 2010) used a hybrid approach that combined collaborative and metacognitive strategy in designing, developing and implementing an instructional module. This approach enabled the learners to achieve transfer of learning. However, I realised that there was not much of a focus on the design of the content or on the learning task design used in the module or instruction, and it was especially lacking in material on how to break down the content and learning task intelligently.

Instructional design model. Upon coming to England, my interest in this area further developed around a proposal to look at designing and developing technical training using virtual reality. With this interest in mind, I started to explore literature on instructional design models, and came across the 4C/ID (four components to instructional design) model by van Merriënboer. The four components in this model are also referred to as the blueprint components, comprising Learning Task, Supportive Information, Procedural Information and Part-task Practice. 4C/ID focuses on training for complex cognitive learning, which van Merriënboer saw as emphasising the transferability of new skills. van Merriënboer later elaborated on the 4C/ID model in TSM. TSM is a prescriptive model because it sets out the steps of what needs to be done in designing instruction; the 4C/ID model is a descriptive one because it describes the four blueprint components.

The systematic approach of TSM offers a high degree of fidelity in terms of tasks and content breakdown. This was part of TSM's appeal to me, in that it seemed to provide a blueprint for understanding how to break down the content of subject matter. Culturally, I was not attuned to learner participant models and

although I was aware of other approaches, it was of particular value that TSM took content seriously; this helped me to think about the actual material that had to be taught, as the model seemed to provide a blueprint for the instructional material. In addition, TSM dealt with one important contextual area: complex learning. I can see the potential that this model offers in designing content and developing instructional material that support transfer of learning.

What further study needs to be done? My interest in TSM led me to review the literature in relation to the model. Some research had been undertaken; however, there was little evaluation of the model and how it worked in practice. Some studies had used the model, for example in the context of designing educational games, technical learning, and virtual learning (see Enfield, 2012; Kwaku Sarfo and Elen, 2005; Nadolski, Kirschner and van Merriënboer, 2006). However, their main focus was on the product rather than the process of design.

I felt there was a need to conduct a study with a focus on the design process in order to fill that gap, as most learning technologists focus on the technology rather than design. Technology should provide an opportunity for learners to experience tasks and integrate knowledge, skills and attitudes in new ways. It is easy for the instructional designer to be overwhelmed with what technology can offer for learning, when what is actually needed is to intelligently break down the learning tasks and content to make learning more accessible regardless of the technology being used. van Merriënboer's model seems to offer some pragmatic solutions to designing instructional material. However, I felt there was a need to explore the model by replicating the design process in order to understand how the model can best be used across wider contexts.

1.3 What did I do?

Two pilot runs have been conducted prior to this study, using different instructional design models. The two case studies involved instructional material through different design approaches.

Pilot Case 1, Courseware, involved designing a learning material for a technical subject, Streaming Media. This was aimed at learners in a private higher education institution in Malaysia. The case used the Bergman and Moore model as its design approach, and follows every phase as defined in the model: Analysis, Design, Develop, Produce, Author and Validate.

Pilot Case 2, Website, entailed developing a website that provides information about studying abroad that is being provided to tutor trainees in a public university in Malaysia. This case adopted Rapid Prototyping as its design approach, and the design process begin with a low fidelity prototype which then went through an iteration process. These experiences heightened my understanding of the strength and weaknesses of an iterative versus a linear approach, and increased my experience of using different methods. The experience gained from these pilot studies was used later in my case studies for this thesis. For example, I learned that there was a need to use a designer log as a method besides interviews and product evaluation questionnaires.

Based on my experience in the pilot run, I planned and conducted case studies that focused on designing and developing instructional materials (product) for three different subject matters, using TSM. The intention was to reflect on the

model use through three different cases. The cases were: Case A – Interface Design; Case B – Injection Moulding; and Case C – Web Programming. These cases involving complex learning in which computer based instruction and mobile learning was used as a medium of instruction. The case studies were conducted at three different higher education institutions in Malaysia with learners whose courses focused on technical and vocational training approach, in particular with Case Studies 2 and 3. The initial objective of technical vocational training is to prepare learners with skills that could help them to enter the workplace. In Malaysia, as in many countries, vocational programme is often aimed at learners who do not do well in secondary school and may be perceived as the poor relation of the education system.

Case Study 1 was conducted in a private college in Malaysia. The Principles of Interface Design was chosen as the subject matter, selected from within a wider module on Interface Design. The main focus of this topic was to teach the learners about the principles of interface design and how to apply them in designing and developing multimedia based products, for example a mobile application, courseware or website. Computer-based instruction was chosen as the medium for delivery.

Case Study 2 was about Injection Moulding Defects and took place in one of the technical colleges in Malaysia. The topic was taken from an Introduction to Injection Moulding module and covered the skills of identifying defects in plastic products and finding solutions to overcome and prevent these defects. The instructional material for this case study was accessed using mobile devices.

Case Study 3 was conducted in another technical college in Malaysia. PHP Programming was chosen as the subject matter from the Web Programming module. The focus of this study was on developing programming skills that used PHP syntax. Learners accessed the material via desktop computers.

Within these studies the focus was on using the model and exploring the design process itself rather than the evaluation of products, although of course, the two were interrelated. By carrying out the three case studies, I was able to compare and contrast TSM across different contexts and I could introduce an adaptive element. Thus, the case studies served the overall purpose which was to explore whether TSM was useable, useful, and adaptable. This research poses the overarching question: **What is the value of the Ten Steps Model?** Sub questions are:

- What is the model?
- How does the model work?
- Is it useful?
- What are the contexts that need to be considered in adapting the model?

1.4 Methodology and method

This study is a design and development research that has interest on the TSM and its adaptability in designing learning material. This study was developed based on the approach of pragmatic inquiry and action-oriented elements. In order to explore TSM, multiple case study was used. It emphasises the role of TSM in designing and developing learning material for three different case of

subject matter. This has put me in the position of taking on the dual roles of both researcher and designer. This adds an unusual dimension to the study because while using TSM as a designer, I was also reflecting on the design process as a researcher. Being in this dual role position meant that a design log was crucial as a means of recording my reflections about the design process and my relationship with the subject matter. The log was kept in an unstructured form to allow flexibility in gathering data. It is important for me to say at the outset that I had no experience of or familiarity with TSM before carrying out this study.

Aside from the design log, I used interviewing as a research method. I interviewed the lecturer during needs assessment and during the evaluation of the instructional material. I also interviewed a sample of learners from each case study in order to ascertain their perceptions of the material they were using. Evaluation of the material also involved surveys and observation. Surveys were distributed to the learners to gather data on how they felt about their learning and the instructional material itself. I was able to directly observe the use of the material in Case Studies 2 and 3; in Case Study 1, I had access to a video recording from my colleague as I was unable to be on site.

1.5 Guide to the thesis

This thesis is a structured investigation of the use of TSM within three case studies, and is divided into eight chapters.

Chapter 1: This chapter has introduced the reader to the research background, and has explained why I started this study and my initial interests that steered my

focus toward TSM. It has further covered my dual role as researcher designer, the methodology and case studies, and methods used.

Chapter 2: This is the literature review. It discusses key concepts associated with the study including design and development research, instructional design models, discussion about 4C/ID and TSM, educational technology and ICT research, and technical education in Malaysia.

Chapter 3: This chapter covers the methodology of the study. It explains the methodology and methods and my role as researcher and designer. It also explains the type of case study that was adopted, and how it fitted the purpose of the study.

Chapters 4, 5 and 6: These chapters tell the story of each case study: Case Study 1: Interface Design; Case Study 2: Injection Moulding; and Case Study 3: Web Programming. The case studies are reported in such a way as to show the design phases including the needs assessment, design and development, and evaluation of the instructional material. Each case study is followed by my reflection on the design process, how TSM was adapted and what I learned from each case.

Chapter 7: This is the discussion chapter which covers my reflections on what I learned from using TSM and the four research questions of this study - hat is the model? How does it work? Is it useful? What are the contexts that need to be considered in adapting the model? - are addressed.

Chapter 8: This chapter summarises the thesis. It suggests any limitation which was not covered in this research and how the study can address any potential to be expanded in future research.

CHAPTER 2: LITERATURE REVIEW

2.1 What is this chapter about?

This chapter offers a narrative literature review structured around design and development research, instructional design models, educational technology and design, the 4C/ID model and TSM, and complex learning.

2.2 Design and Development Research

Design and development research (DDR) is a systematic research practice which has been growing in popularity in the field of instructional design technology. Also known as developmental research, DDR is defined by Richey and Klien as "*the systematic study of design, development and evaluation process with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern the development*" (Richey and Klien, 2007 pg. 1). Design and development research is focused on (i) research that involved evaluating design theories; and (ii) research that involved product development and evaluation. It provides a pragmatic type of research to design, test and validate theory through practice. The knowledge claimed from this research are generalizable or contextually specific.

Richey addressed six areas in instructional design research: learners and the learning process; learning and performance context; content structure and sequence; instructional and non-instructional strategies; media and delivery

system; and designers and design process (Richey, Klien and Tracey, 2011). Richey and Klien view design and development research as being of two separate types; (i) product and tool research, and (ii) model research. These two subdivisions are summarised in Table 2.2-1 below. Product and tools research could be further divided into product development and tool development. Model research, meanwhile, focuses on model development, model validation, and model use. This shows the range of approaches available, especially in the field of design and development research.

My own study is particularly focused on model use (Type 2), drawing on comprehensive design and development projects (Type 1). Through these two approaches (Type 2 and Type 1), it offers opportunity for in depth exploration of TSM which led to addressing the overarching research question: **what is the value of the TSM for designing and developing instructional material?**

Table 2.2-1 Clusters of Design and Development Research (Richey and Klien, 2007, p.8)

Design & Development Research	
Product and Tool Research (Type 1)	**Model Research (Type 2)**
Comprehensive Design and Development Projects: • Instructional Products and Programs • Non-instructional Products and Programs	Model Development • Comprehensive Model Development • Development of Model • Component Processes
Specific Project Phases • Analysis • Design	Model Validation • International Validation of Model Components

• Development • Evaluation	• External Validation of Model Impact
Design and Development Tools • Tool development • Tool use	Model Use • Study of Conditions Impacting Model Use • Designer Decision-Making Research • Designer Expertise and Characteristic Research

As described by Richey, doing DDR does not have to be about solving problem but it emphasises relevant studies that could contribute to usable knowledge for practitioner and to inform practice. As the study focuses on instructional design, I will now walk through the literature on the types of model put forward to explain the process involved in instructional design.

2.3 Instructional Design Models

The field of instructional design can be viewed from many different perspectives and there are many definitions in the literature. Branch and Kopcha described instructional design as *"an iterative process that involved planning outcomes, selecting effective strategies for teaching and learning, choosing relevant technologies, identifying educational media, and measuring performance"* (Branch and Kopcha, 2014, p.77). Smith and Ragan defined instructional design as *"the systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources, and evaluation"* (Smith and Ragan, 2005, p.4). Instructional System Design (ISD) is also used as a term, for example Seels and Richey who

define ISD as *"an organised procedure that includes the step of analysing, designing, developing, implementing and evaluating instruction"* (Seels and Richey, 1994, p.129). Most of the literature avoids over complicating the search for definitions and refer to the Association of Educational Communications Technology (AECT), by which instructional design is defined as "*a systematic approach to the design, production, evaluation and utilisation of a complete system of instruction, including all appropriate components and a management pattern for using them"* (Association for Educational Communications and Technology, 1997, p.172).

Although there seems to be inconsistency of terminology in defining the term, it is clearly seen that these terms have the elements of analysis, design, development, implementation and evaluation. This has served as the basic backbone of many instructional design models from the outset of may authors (see also Dick, Carey and Carey, 2013; Morrison et al., 2012). It could also be said that these models could be mapped to the generic instructional design model known as ADDIE.

2.4 ADDIE model

The field of instructional design has its origins in the formation of a group of researchers to design and develop training programmes for military services (Reiser, 2001). Through the perceived success of these programmes, psychologists began to view training as an instructional system design (ISD) that consisted of analysis, design, development, implementation and evaluation procedures (ADDIE). There is no direct reference as to where and who invented ADDIE but it developed as an umbrella to capture the major process of ISD

(Molenda, 2003). Somehow ADDIE evolved and influenced some of the early work on instructional design and this influence continues today.

In general, the first phase of ADDIE, the analysis phase, is a process of identifying the possibilities of a performance gap. Secondly, the design phase consists of verifying the desired performance and an appropriate testing method. Thirdly, the development phase entails generating and validating the learning resources. Fourthly, the implementation phase involves preparing the learning environment and engaging learners with the resources. Lastly, the evaluation phase involves assessing the quality of the instructional product and of the process involved in its implementation (Branch, 2010a). Branch described the ADDIE model as an effective tool to create efficacious learning resources, as it served as a grounded framework for any design situation. The phases in ADDIE abstract the essence of instructional design process hence make it more holistic and easy to be applied (Crawford, 2004). This is particularly true for instructional design since most of the phases in any instructional design models share the same structure as those in the ADDIE model.

2.5 Other instructional design models

A long tradition of refinement and at times step change can be seen in the work of those revisiting instructional design models (see Gustafson and Branch 2002; Edmonds, Branch, and Mukherjee 1994; Andrews and Goodson, 1980). In drawing attention to the size of the field, Andrews and Goodson identified 40 models and explained that one of the reasons for this large number was researchers' preferences for creating new models rather than using those that

already existed. This has led to an uncoordinated research effort. Andrews & Goodson suggested it is impossible to use one grand pattern that can be utilised under all circumstances, but that too many models have led to confusion and a waste of resources.

Instructional design models offer a structure for how to approach an instructional design problem. Models help designers to visualise a problem and break it down into manageable units. These models have changed over time as the field has altered its views about learning. For example, there is in modern study a greater focus on the learner's learning pace, the complexity of the content, and the range of media used to deliver the instruction. However, choosing appropriate models is challenging given the sheer number of models available. Gustafson and Branch have grouped the models based on taxonomy: *classroom oriented*, *product oriented*, and *system oriented*. This taxonomy helps to identify which models best suit the conditions of instruction (Gustafson and Branch, 2002). For example, the Morrison, Ross, Kalman and Kemp model is better suited for designing instruction in a classroom setting because some of the steps are intended to be carried out in a face to face classroom setting. Meanwhile, the Bergman and Moore (1990) model is suitable for designing instruction products, particularly those that use technology as a medium, because it comprises steps to develop instructional products. Since the focus of my research is design and development of instructional products, models that belong in the product category will be discussed below.

Models in the product category. The models highlighted by Gustafson and Branch as sitting within a product-oriented category are *Bergman and Moore, The de*

Hoog, de Jong and de Vries, Bates, The Nieveen, and *Seels and Glasgow*. These models were categorised as product-oriented by Gustafson and Branch based on four key assumptions: (i) the instructional product is needed, (ii) something needs to be produced rather than selected or modified from existing materials, (iii) there will be considerable emphasis on trying out and revision, and (iv) the product must be usable by learners with only "managers" or facilitators, but not teachers, available (Gustafson and Branch, 2002). In my cases, a lecturer was present when the learning through the material took place, which varies slightly from these guidelines. I reviewed a number of these models in more detail and further added a later model, the Isman model (Isman, 2005), to my review process. It was difficult to choose which later model to consider, but I based my judgement on the desire to look at a model that was being used to govern the design and development specifically of instructional products such as computer-based instruction, web-based learning or mobile learning.

2.6 Bergman and Moore Model

The Bergman and Moore model (Bergman and Moore, 1990) was chosen as part of my model review because it focused on managing the process of designing and developing multimedia products, an area closely related to my research scope. This model was not so popular, or at least was less cited, in the literature, probably because it did not propose a learning theory or appear to be concerned with learners. Looking at the steps in this model as compared to others, it functions as a linear model. The Bergman and Moore model can be adapted for a variety of more recent high-tech interactive instructional design products

(Gustafson and Branch, 2002). It contains six design activities: *analysis*, *design*, *development*, *production*, *authoring* and *validating*. The output from each phase provides the input for the next. The strength of the model is that it provides a checklist of what type of design documents or design artefacts should be expected. Even though the phases and components of the model are structured generally in a linear manner, one should have the common sense to review each phase before moving to the next phase.

Table 2.6-1 Bergman and Moore model components

Phases / Design Components	Design Activities
Proposal	Analysis of user, task, and content
Design	Sequencing the major segments and defining treatment
Development	Preparing documents needed for the production such as storybooks (storyboards), audio scripts, shot list, art and graphics, and a database for managing the production
Production	Transform the information from a development component into its respective medium such as video sequence, sound effect, graphic and text.
Authoring:	Integrate the media produced in production components to become a completed product. This includes doing coding, testing, and tuning.
Validation:	Comparing the finished product with the original objectives of the multimedia project in order to make sure the finished product has met the target audience or assessment standard.

2.7 de Hoog, de Jong and de Vries Model

This model was developed in 1994 and served in the development of simulations and expert systems. It is based on a non-linear approach (de Hoog, de Jong and de Vries, 1994) is the model is product driven, involving the procedures of development methodology derived from Boehm's spiral model for computer software development. It was aimed at addressing weaknesses in the waterfall model, in particular its linear assumption. This model by contrast was intended to support a non-linear approach, with sub products which could be developed separately. The sub products could be divided into two parts: *local development* and *global development.*

Local development follows a spiral approach. The spiral is based on axes consisting of *specificity*, *compliance*, *quality*, and *integration*. Even though it is stressed that the development progress should be consistent from one partial product to another, it is could be expected that the interval between the axes can also be uneven. However, if it very inconsistent, this indicates that there is a problem in the development process.

Global development refers to *conceptual model, operational model, instructional model, interface model,* and *learner model*. Operational and conceptual models relate to what we want the learner to know or master at or by the end of the training or instruction. The instructional model involves instructional measures for the learners that include formulating a hypothesis and carrying out specific assignments, whereas the learner model refers to information about the learner that can be used to activate the instructional measures. The interface model

contains information between the simulation and learners, such as graphic objects and other elements that allow interaction between learner and the simulation. Global development works in an iterative manner.

This approach has value but appears overcomplicated. There are too many phases which make it difficult to differentiate the function of each component, especially when there are two phases with sub components running.

2.8 Nieveen Model

The Nieveen model was published in 1997 and used to develop educational materials for schools including lesson materials and courses in Holland (see (Nieveen, 1997). In general, it could be said that this model has the same structure as the generic model, ADDIE, although with an extensive use of formative evaluation. This model has an iterative element whereby the design documents at the beginning of the phase undergo several changes until they reach the completion stage. The quality of materials is the validity test of the model.

As with ADDIE, the process of designing the materials starts with preliminary research on learner needs and ends with summative evaluation. The development process includes nested processed with their own analysis, design and formative evaluation. The design activities involved in the first level of the development process include creating and evaluating design specification. The second level involves development and evaluation of materials by an expert, perhaps (but not necessarily) the subject matter expert. The third level assumes that the material is

already prepared (as the result of the first level) and a test run is conducted. Finally, in the fourth level of the development process, the materials are completed and a small or large group test is conducted. This process is followed by summative evaluation.

The model has the potential to be implemented at a micro level since it requires the involvement of learners and subject matter expert in the development process. The iteration process allows for in-depth exploration leading, in theory, to a high quality of materials.

2.9 Seels and Glasgow Model

As seen in Gustafson and Branch (2002), this model was developed in 1998 in the context of project management and consists of three design phases: *needs analysis and management, instructional design and management,* and *implementation and evaluation management* (Seels and Glasgow, 1998). The first phase of this model emphasises the analysis of needs and planning. Design activities in this phase involve *needs assessment, performance analysis* and *context analysis*. The second phase focuses on instructional design and involves six design activities: *task analysis, instructional analysis, objective and test analysis, instructional strategy and delivery system, materials development,* and *formative evaluation.* These six activities work iteratively. The second phase is only considered complete after a certain level of satisfaction in formative evaluation is gained. The third phase is mainly related to management tasks such as creating support, preparing training materials, and providing training to users.

The model is different than the previous three as it emphasises project management. Probably Bergman and Moore have the same flow within their model; however, this does not focus as thoroughly on the design documentation as does Bergman and Moore. In structure, it is a step by step model and is a good example of its kind but has limited relevance to the context of my study.

2.10 Isman Model

Isman's model (see İşman, 2005) focused on planning, developing, implementing, evaluating and organising learning activities. The aim is to develop instructional activities that not only motivate the learners but also allow them to become active learners. Thus, it aims to help them to reflect on their own learning experience and become autonomous. The model consists of five major phases; *input*; *process*; *output*; *feedback*; and *learning*. The design activities involve in the major phases are described in table below:

Table 2.10-1 Isman model's phases and design activities

Phases/ Components	Design Activities
Input	Identify needs; identify contents; identify goals / objectives; identify teaching methods; identify evaluation materials; and identify instructional media.
Process	Test prototypes; redesigning of instruction; teaching activities
Output	Testing; analyse results
Feedback	Reverse instruction
Learning	Learning

The model can work like a nested process because one can still go back to previous phases and redo the activities if necessary. The input phase is about analysing needs, learning objectives and designing learning activities, or as İşman says, *'what to teach'* and *'how to teach'*. Based on the input gathered, the designed instruction is tested in the process phase which is also referred to as prototype phase. The activities in this phase include redesigning the prototype based on learners' feedback. Isman's model places greater emphasis on learners' feedback i.e. learner needs, how to deliver those needs, and the redesign of the prototype based on formative feedback. The output phase involves testing and analysing the product. This testing is based on measuring the ability of the learners to exhibit skills, knowledge and attitudes in relation to the learning objectives. Unlike other models that normally end at the evaluation phase, the Isman model adds on a learning phase to cross check the accomplishment of learning goals and objectives, in which teachers make sure that the learners have learned what they are supposed to learn from the learning material.

According to İşman, the model can be used to design and develop a variety of instruction, for example instruction that can be used by teachers or independently by learners. It may seem that this model is classroom oriented rather than product oriented, but at least one study has been done using it in relation to instructional products (Alias, DeWitt and Siraj, 2013). The model looks like a flexible model in that it is not over complicated. The learning phase seems to be its particular strength as it brings the instruction into context and tests how the two complement one another. However, its flexibility seems to make the model less focused on the task and content breakdown.

2.11 Comparison of the model

A comparison of the models discussed above is set out in the table below, which shows each model's phases and components.

Table 2.11-1 Comparison of models

ADDIE	Bergman & Moore	Nieveen	Seels & Glasgow	Isman
Analysis	Analysis	Preliminary research Analysis	• Problem Analysis • Task Analysis • Instructional Analysis • Objectives and Tests	Input
Design	Design	• Design • Design Specifications	Instructional Strategy and Delivery System	Input
Development	• Develop • Produce	• Global materials • Partially detailed materials	Materials Development	Input
Implementation	Author	Complete Materials	Implementation and Maintenance	Process
Evaluation	Validate	• Formative Evaluation • Summative Evaluation	• Summative Evaluation • Formative Evaluation • Feedback and Interaction	Output, Feedback, Learning

In table above, I compare the models and show that they all have routes in ADDIE but offer different levels of iteration, complexity and context. It is also clear that there are models which are too general for my purpose and some which

are too specific. This differentiation gives different angles on the usefulness of the model in design. In relation to the table data, TSM does not fully match the ADDIE process; rather, it focuses on the analysis and design phase and has a unique focus on tasks and content breakdown. van Merriënboer and Kirschner (2013) suggest that TSM may be employed within a broader ISD context in order to cater to other phases that are not covered in TSM itself. It can also be assumed that there may be a need to integrate some iterative design into the process to better suit the actual project as it goes.

Based on the model comparison, it could be said that models generally can be viewed from two perspectives; linear and non-linear. Linear models are often characterised as systematic and are sequenced logically. The design components describe in each model cater to different purposes but relate to each other in the sense that the output from one design component produces input for the next (Nixon and Lee, 2001). For example, as described earlier, the Bergman and Moore model which consists of six design phases can be viewed as linear, since the design activity of each phase is the input for the following phase. It is a product-oriented type as it is applicable to the production of interactive multimedia products. This model consists of phases that are comparable to the ADDIE model.

Likewise, Bates (2005) offered a systematic approach based on the ADDIE model, although it was not developed with technology in mind. Instead it primarily focused on developing open and distance learning courses. Linear models offer advantages as they provide a simple and accessible way to break down the complexities of the design process (Gustafson and Branch, 2002).

However, a disadvantage of the linear approach is that it can consume greater time and resource when employed (Nixon and Lee, 2001). For example, users' involvement is mostly emphasised at the end of the design process, and may be missed during trying out the prototype. Thus, a great deal of effort may go into designing a product which ends up not satisfying the users. A further disadvantage is that even though it may seem that each of the design components are well sequenced, they cannot be completely practiced as discrete steps in "real world" situations because design is always context influenced.

Unlike their linear counterparts, non-linear models appear to have characteristics of iterative design process and most are characterised by a series of product evaluations with the involvement of users throughout the development process. Rapid prototyping is central to many models, though the prototypes might not be the final product, the design activity allows further investigation of the problem which leads to refinement and solution (Nixon and Lee, 2001). Rapid prototyping involves the production of a low fidelity prototype which can be later evolved into a high-fidelity product as a result of user feedback. Rapid prototyping makes iteration practical and more efficient (see Tripp and Bichelmeyer, 1990; and Roytek, 2010).

The iteration design process allows flexibility in design and development and a better fit with users' needs, as discussed in de Hoog, de Jong and de Vries (1994) earlier. However, there may be some limitations with iterative models. While they seem to offer rapid design solutions, in reality the process of gathering feedback is often labour intensive (Tessmer, 1994); coordination is difficult across design teams, especially in mass production contexts, and they require

strong interpersonal skills and demand a strong design experience (Tessmer, 1994; Tripp and Bichelmeyer, 1990). In worst case scenarios, the iterative process might be a never-ending process of assessing user feedback. Moreover, a key question is the extent to which the user is a reliable guide to product design. Gaining user feedback is democratic, but does the user really know the full range of available products and solutions?

2.12 Educational Technology and Design

Research into design models has been stimulated by the use of media and technology, and computers in particular (Alias and Siraj, 2012; Neo and Neo, 2009; Hashim, 1999; Hammza, Omar Ibrahim Massoud, Daw and Faryadi, 2013; Kirschner and Gerjets, 2006; Downey, 2011; Li, Gu and Chen, 2010; Chien and Chang, 2012). In its relatively short history, we can see how technology has influenced teaching and learning. Over time designers have experimented with drill and practice, computer aided learning, and computer based instruction. With the internet, new approaches were made possible including web based training, Moodle, CSCL, MOOCs, Web 2.0 and Web 3.0. As technology evolved, there was renewed interest in immersive learning environments such as augmented reality and virtual reality (Chuah, Chen and Teh, 2011; Ausburn and Ausburn, 2004). The use of technologies stimulated creative discussion about pedagogy as our understanding and views about learning evolved. However, traditional ways of viewing learning were still useful; for example, drill and practice was associated with behaviourism, and CSCL could be associated with social constructivist pedagogy. Debate will go on about the use of computers and technologies in

learning, but it is undeniable that there are opportunities that benefits learners, some of which could be seen in my case studies. Some of the key benefits are access to a mix of media, access to learning beyond the classroom, simulation of real life contexts, and access to motivational ideas.

Access to a mix of media: text, graphics, sounds, animation and video. Using these mixed media, designers can illustrate and model difficult concepts and complex processes by using graphics and animation. For example, animation could be used to teach complex, abstract and dynamic concepts (CAD) in electrochemistry which can be delivered through computer based instruction (Othman, Matthews and Secombe, 2005). Through animation learners can observe the changes within an event which are difficult to explain verbally in the classroom. The use of animation is significant involving mathematical or scientific subject (Mayer and Moreno, 2002). Other than animation, graphics have proved to be useful in representing tacit knowledge such as a multimedia networking topic, as their use increases learners' performance and encourages a shorter learning time (Reisslein, Seeling and Reisslein, 2005). Having said on the opportunity to have access to media as the benefits of integrating technology in learning, this brings another opportunity i.e. promoting learning engagement. The use of multimedia such as animation and graphics help in promoting learning engagement. It enable learners, for example to see the practical application of concept of statistic, helped learners with understanding the concept of statistic and addressed negative attitude towards statistic (Neumann, Neumann and Hood, 2011). Regardless on any subject matter, multimedia brings opportunity to present content efficiently.

Access to learning beyond the classroom. Learners are able to interact and engage while learning through computers and technology even when the teacher is not present. Virtual learning environments such as Moodle and MOOCs allow users to access content and designers to update content 'anytime' and 'anywhere' (de Freitas, Morgan and Gibson, 2015). One of the enabling elements in learning beyond the classroom is interaction. More traditional computer-based instruction allowed for interaction to occur by automatic feedback. This was improved by dynamic display and allowing learners to provide input and click on-screen objects (Gibbons and Fairweather, 1998). Through this, learners are enabled to replay an animation whenever they need to by using mouse interaction, and can read the information (text) at the same time (Kablan and Erden, 2008). Thus, learning could be enriched by presenting many forms of media to learners and allowing them to control the information presented at their own pace. Learners are also able to receive automated feedback by learning through computer and technology media, for example through learning activities and quizzes. Beyond automated feedback, learners are also able to receive peer feedback through synchronous and asynchronous forums within platforms like Moodle and MOOCs. Although there have been arguments about the credibility of unmoderated peer assessment in providing feedback, methods to evaluate peer assessment are available (Suen, 2014). All this encourages learning through computers and technology to extend beyond the classroom.

Simulation of real life contexts. In a situation where the ideal learning context may be costly and unsafe to access in real life, a controlled learning environment could be designed to support learning. Chwen and Seong developed a 3D virtual

learning environment for car driver instruction (see Chwen and Seong, 2005) Learning benefits from such a medium as it provides representational fidelity, i.e. realistic replication of environment and smooth display of view changes and object motion, and learner interaction i.e. embodied actions including view control, navigation and object manipulation (Dalgarno and Lee, 2010). Through virtual reality, learners can be exposed to a greater and richer learning experience such as being able to experience outer space (Chen, Yang, Shen and Jeng, 2007). Even within a conventional setting, the application allows the user to stay active during the learning process as it permits the user to navigate and interact with the learning environment (Lau and Chen, 2010).

Motivational idea. Underlying a lot of claims round technology in learning is the assumption that learners using computers and technology are confident in their use and find it natural to use them. Since computers and technology supports a mix of media, their impact has proved positive towards learners' motivation, for example helping to reduce mental effort and increase learners' performance (Kablan and Erden, 2008) which later increases their motivation. Besides that, through exposure to and use of mixed media learners are rendered more positive towards the use of computer-based instruction (Reisslein, Seeling and Reisslein, 2005).

However, there are some difficulties and limitations on the use of technology. These include cost, the technology will not appeal to some learners, the possibility of the teacher's role being sidelined, and the fact that access may be limited.

Cost. The development of all computer supported material is high as it requires a lot of resources. Particularly in the case of advanced technology such as virtual reality it may requires specific equipment such as head mounted displays and 3D gloves. As such, budget is crucial when considering using technology in teaching and learning (Hanson and Shelton, 2008). Even the use of a very basic technology such as freeware requires that more time be spent planning, designing, developing and evaluating the material. Sometimes the quality can be compromised due to these constraints, and this does not add value to the process of teaching. Besides budget, in certain situations, a dedicated development team is required in order to meet certain standard of quality in producing an instructional product (Barrett and Blackledge, 2013). The team may be difficult to manage and some people in the team might not know what to do or vary in terms of knowledge and skills. This means that a team member must learn how to manage. When it comes to high end development, the requirement for a technical expert adds yet more cost to the process.

Technology will not appeal to some learners. As much as computers and technology are generally appreciated, they will not appeal or be appropriate to some learners. For example learners with special needs such physical disability have limited access to some activities in computer-based learning environments as compared to learners in general (Lidstrom, Granlund and Hemmingsson, 2012). Some learners will hold a strong preference for face to face interaction rather than computers and technology. We are assuming that learners broadly like technology and are skilled at using it; in practice, they may find it quite difficult and a challenge

The teacher role may be side-lined. This may be a problem stemming from design in which the learners and the material are standalone and nothing is asked from the teacher. It might also be that teachers do not see their role as being at the computer to assist learners. This could be seen especially if the teacher is new to a particular application or indeed new to technology in general. This is made more of a problem if the teacher is not curious about technology and is not open to changes (Keengwe, Onchwari and Wachira, 2008). Integrating technology in classroom becomes challenging, even impossible, without teacher involvement. This is a drawback, as in a face to face environment educators have the opportunity to adapt what they are saying and how they are saying it based on feedback as they continually monitoring how the learners are behaving. Computers and technology might appear to enable more personalised routes to learning, but they lack the instant adaptation that a face to face educator can achieve. The is aligned with the study carried out by Saunders and Gale, in which face to face teaching was seen as prioritised by most learners even thought they were offered exposure to a virtual learning environment. It was found that learners were concerned that while the VLE could improve the learning experience they did not want it to reduce the time during face to face teaching (Saunders and Gale, 2012). Although computers could offer progression that could lead learning from one point to another, there are limitations.

Access may be limited. For example, learners may be in an institution where computers and facilities are limited. The computers available might lack the specification required to run programs without freezing and creating a frustrating experience, or they may be unable to support high end applications such as

virtual reality. In addition, some learners might have limited access to computers, other devices and the internet outside of the classroom, which will limit their ability to access the material as a standalone resource. With these external barriers, it is almost impossible for technology integration to take place (Sang, Valcke, Braak and Tondeur, 2010). The external barriers (see Ertmer, 1999) need to be resolved first before considering technology in an institution, something that can be seen especially in developing countries. For example, one of the factors that influences the acceptance of e-learning in developing countries is good access to the internet (Bhuasiri et al., 2012) but such access is often restricted. Thus, it is important to be aware of limitations in planning to implement instructional materials and processes using computers and technology in an institution

It could be said that there are both many opportunities and difficulties in the use of computers and other technology in the design and development of education technology. in the review of literature given in this chapter demonstrates that design is an important consideration, but all the problems of design need to be viewed within the wider context of the limitations and opportunities that computers and technology could offer. It is not necessary to choose a high cost medium such as virtual reality, as teaching and learning could also be effectively designed through a low-cost medium such as PowerPoint (See Knowlton and Simms, 2010). What matters most is the question of how teaching and learning may benefit from computers and technology, and how it can best be delivered through such a medium considering the opportunities and limitations.

2.13 4C/ID model and Ten Steps to Complex Learning model

Initially, the author of TSM developed the Four Component Instructional Design or 4C/ID model which emphasis integrating and coordinating skills. It helps to promote complex learning mainly in technical domains (van Merriënboer and Kirschner, 2013). The researchers then continued to develop in the area of non-technical domains such as policy analysis, patent information, and information search (van Merriënboer and de Croock, 2002). However, some practitioners thought it difficult to adapt the model. The argument was that the four main design components did not provide enough guidance to help them to systematically use the model in designing instruction (van Merriënboer and Kirschner, 2013). van Merriënboer described the 4C/ID model as analytic-descriptive in nature, with a stress on cognitive-psychological learning and the link between design components and the learning process. TSM meanwhile is described as prescriptive in nature, providing an extension of the 4C/ID model that offers steps that makes it more practicable to be adapted.

The second version of the model provides a systematic approach to design instruction for complex learning that can be understood by practitioners and inexperienced designers as well as teachers. It is more directed at people interested in vocational and training programmes that involve developing complex skills (van Merriënboer and Kirschner, 2013). The similarity of these two models, and also their strength, lies in the four main components: *learning task*, *supportive information*, *procedural information*, and *part-task practice*. Each of the design components described in TSM can be associated with the components in the 4C/ID model, as illustrated in the table below.

Table 2.13-1 4C/ID Model and TSM

Components of 4C/ID	Ten Steps to Complex Learning (TSM)
Learning Tasks	1. Design learning tasks 2. Develop assessment instruments 3. Sequence learning tasks
Supportive Information	4. Design supportive information 5. Analyse cognitive strategies 6. Analyse mental models
Procedural Information	7. Design procedural information 8. Analyse cognitive rules 9. Analyse prerequisite knowledge
Part-Task Practice	10. Design part-task practice

van Merriënboer refers to the designing of the learning task as the heart of the blueprint (van Merriënboer and Kirschner, 2013). *Learning task* refers to the whole task practices provided to the learners. These are sequenced *(sequence task classes)* for increasing levels of difficulty, beginning with a fully-scaffolded task working to a non-scaffolded task. Learners will work on the task up to a certain level until they have achieved an acceptable learning performance based on the *set performance objectives* that have been established. The whole tasks are basically development of constituent skills, comprising recurrent and non-recurrent aspects, that can be achieved as a result of completing the task. The learning task should therefore be designed in a way that requires learners to engage with the whole task which will help to develop a concrete schemata among learners (van Merriënboer and de Croock, 2002). There are strategies that can be used to design such tasks; these will be discussed in the next section.

In order for the learners to carry out the learning tasks, they need to be supported with relevant information or content. In this model, the relevant information refers to *Supportive Information* and *Procedural Information*. Supportive information is that which help learners to perform the non-recurrent constituent skills of the learning tasks such as problem solving and decision making (van Merriënboer and Kirschner, 2013). The information is the type that would normally be referred to as knowledge or theory, generally presented in books or during lectures, which helps to connect learner's prior knowledge and the new things covered in the learning tasks. This information is made available to the learners while they carry out the learning task. The design of supportive information requires one to *analyse the cognitive strategies* of how the learners solve problems in the learning task domain and in what way the domain has been organised *(mental models).*

Procedural information refers to 'just-in-time' information provided to learners when they need it. It covers information that helps learners to perform recurrent constituent skills (recurrent aspects) of the learning task as well as part-task practice. This type of information typically contains step by step instruction that enables learners to perform the task, and is normally presented to them in the form of a manual reference, help section in a program, or by an instructor (van Merriënboer and Kirschner, 2013). Procedural information requires learners to perform tasks in a similar way within different kind of problems; thus, it is expected that the way of performing the task will be the same when performing the learning task. According to van Merriënboer, procedural information is provided to the learners in the first learning task of an instruction and then slowly

fades away as learners develop their skills from performing the task. Designing procedural information requires the designer to analyse cognitive rules and prerequisite knowledge. *Analysing cognitive rules* identifies the condition-action pairs that enable experts to perform routine aspects of tasks without concious effort, whereas *analysing prerequisite knowledge* refers to what experts need to know in order to apply the condition-action pairs correctly.

Part-task practice is an additional task provided to learners at the end of the instruction programme. It is similar to the learning task in that it aims to help learners to automate the cognitive schemata that strengthen the routine aspects of performing the task. It enriches the learning task and is never meant to replace the learning task itself (van Merriënboer and Kirschner, 2013). Van Merriënboer suggested that the concept of drill and practice using computer-based instruction fit the purpose of part-task practice in order to provide enough practice to learners.

2.14 Ten Steps to Complex Learning model and Instructional Materials

There are different kinds of strategies available in designing and presenting the three main components of TSM, the learning task, supportive information and procedural information. These are described below.

Learning task. There are many types of strategies that could be used to design the learning task. The choice as to which is appropriate depends largely on the intended learning outcome that learners are desired to achieve, and on the level of difficulty the designer wishes to embed in the learning task. As will be seen

later in this thesis, some of the adopted strategies for learning tasks in the three cases are described in Table 2.14-1. Besides these strategies, there are others such as imitation task, reverse task, and non-specific goal task (see van Merriënboer and Kirschner (2013, p.64)).

Table 2.14-1 Strategies for learning task

Strategies	**Description**	**Level of support**
Worked-out example task	This task refers to a learning task that provides learners with a case study in which learners are able reflect on the solution given in the case.	High
Imitation task	This task refers to a learning task that combines worked-out example task and conventional task in which learners need to identify the analogy of the solution given in the task (worked-out example) and use it to map a new solution.	Medium
Completion task	This task refers to a learning task that provides learners with a partial solution and requires learners to study that partial solution, identifying the missing steps and coming up with a complete solution.	Medium
Conventional task	This task refers to a learning task that has no guidance and support; learners are required to find the solution independently.	Low

Supportive information. Since supportive information normally involves content or theory, there are various ways to present it depending on the type of content or theory to be presented to learners. As described by van Merriënboer, there are different kinds of content that require different strategy and methods

for viewing and presenting them. Table 2.14-2 describes the types of content and their correlating strategy.

Table 2.14-2 Strategies for supportive information

Type of content	Description	Example of strategies
Conceptual model	Type of information that consists of concepts that describe objects, events or activities.	• Compare and contrast a set of similar ideas
Structural model	Type of information that describes how objects, events or activities for reaching certain goals are related to one another. It helps learners to predict behaviour.	• Explain the relative location of elements in time or space • Rearrange elements and predict effects
Causal model	Type of information that consists of how objects, events, or activities affect one another. It helps learners to interpret processes, give explanations and make predictions.	• Make a prediction of a future state • Explain a particular state of affairs

Other strategies include modelling examples; these involve providing the mental process of how a professional or expert solves a problem, and learners are able to study and reflect on how the expert dealt with the problem, for example by viewing a video recording of an expert baking a cake or a demonstration of a CPR procedure. Besides the modelling example, a case study could also be used as a strategy.

Procedural information. Since procedural information involves the just-in-time information needed to carry out a learning task, this information falls into two

types. The information could be presented by providing rules, or through a step-by-step guide that helps learners to apply the reccurent aspects of a learning task. Besides rules, crucial prerequisite information needed by learners in order to apply the rules correctly should also be provided.

2.15 TSM and Instructional Materials

In addition to the discussion of product oriented models and my research interest in instructional materials, it is important to acknowledge the relationship of these models with computer and technology as a medium in designing instructional materials. The rapid growth and development of computer based instruction products is due to the emergence of technology. Most technology-based research to date is related to advanced computer application (Richey and Klien, 2007) and it will most likely expand further in the future (Gustafson and Branch, 2002). This in many ways explains the variety of models found across the literature, as mentioned earlier. Different settings might require different product-oriented models as support. Therefore, it is important to identify models that are fit for the development of multimedia product. It is also important to recognise the need to be more detailed in designing the blueprint for the development of computer-based instruction. The emphasis should be placed on the main design components: learning task, supportive information, procedural information, and part-task practice (Merriënboer, Clark and Croock, 2002).

TSM does not cover the actual development part of designing learning material because it is task and content specific. This means the designer must be especially thorough in selecting appropriate media to support the content in the instruction.

The process of choosing the media takes place after the process of designing the blueprint. According to Merriënboer, Clark and Croock (2002) design implementation, time available, and learners' characteristics often become the factors that most influence the process of media selection. They suggest that there is a need to find another suitable instructional design model that can provide guidelines around media selection. Even though the four main design components are related to each other, they sit within different categories of the learning process and are supported by different kinds of media. Merriënboer, Clark and Croock suggest a real or simulated environment to support learning tasks, which include problem-based, case-based or simulation-based tasks. As for the supportive information, they suggested the use of books and lectures, probably due to the nature of the information as covering knowledge-based content. Procedural information, they suggested, is best supported by a manual, online help system or pop-up menus whenever the learners need it. Finally, part-task practice could be supported by drill and practice with computer-based media supporting it.

2.16 Research carried out using the model

To better understand the model, I revisited some of the studies done in relation to TSM and 4C/ID. Initially my search was broad simply using the keywords "Ten Steps to Complex Learning" and "4C/ID". This revealed a high number of studies which used TSM or 4C/ID or an adaption of either. As it is the interest of my study to explore how TSM or 4C/ID can be applied in designing learning materials with computers and technology as the instructional medium, I began to

narrow down my search to look purely at studies done within the scope of technology and design as these carried greater relevance. These studies are organised around two main contexts, technology and non-technology as seen in the table below.

Table 2.16-1 Research of 4C/ID and/or TSM in relation to technology context

Author	Focus	Methods	Context	Findings	Media	4C/ID / TSM
(Kwaku Sarfo and Elen, 2005)	Powerful learning environment (PLE) Particular focus on use of ICT	Experimental	School in Ghana / classroom Subject: technical building drawing	The experimental group was able to achieve a higher outcome than the control group. However, the use of ICT was not significant.	Computer/ drill and practice	4C/ID
(Nadolski, Kirschner and van Merriënboer, 2006)	Effect of the number of phases (breaking the whole task into phases) and driving questions on both task performance and task efficiency	Experimental	Dutch Universities Subject: Law (Sophomore)	A lower number of phases in learning to solve complex whole tasks led to both higher performance and greater efficiency. There were no differences between the conditions for transfer task performance and efficiency.	Computer / virtual multimedia program	Learning tasks and supportive information
(Melo and Miranda, 2015)	Investigates the effect of two instructional approaches (4C/ID versus conventional) Focus on learners' knowledge-acquisition and transfer of	Survey/ experimental	Private school Subject: physics, electrical circuit	Result shows that the experimental group performed better than the control group on the knowledge acquisition test and in a learning transfer test. The learners also perceived a lower cognitive load in the transfer test, and the learning	Computer based instruction	4C/ID

	learning			environment developed with the model proved to be more efficient compared to the conventional approach.		
(Huang and Johnson, 2009)	Design guidelines to attain specific game characteristic that employed 4C/ID model	-	-	No findings as this was a concept paper		4C/ID
(Lukosch, van Bussel and Meijer, 2013)	Design framework for a vocational education application of gaming simulation	-	Vocational education Subject: mechatronic construction	No findings as this was a concept paper	Game based	4C/ID

Table 2.16-2 Research of 4C/ID and/or TSM in relation to non-technology context

Author	**Focus**	**Methods**	**Context**	**Findings**	**4C/ID**
(Hoogveld, Pass, Jochems and van Merriënboer, 2001)	Compare the effects of web-based training in an ISD approach to WBT in an experience based approach on resulting design behaviour of teacher trainee	Experimental	Polytechnic Subject: Teacher training	Results show the model approach effectively supports the teacher in designing learning task.	4C/ID
(Hoogveld, Paas and Jochems, 2003)	This study trained teachers in using an ISD and compared the effectiveness of its application within two groups, individual or a team.	Survey/Experimental	Teacher trainee/ designing learning task	The results show that only low individual achievers could profit from the collaborative design work. There was no advantage for high individual achievers.	4C/ID
(Lim, Reiser and Olina, 2009)	Investigates the effect of two instructional approaches (whole task vs part-task) and learner prior knowledge (lower vs higher) on learner acquisition and transfer of a complex cognitive skill	Survey	School Subject: computer training (teacher training)	Result 1: whole-task group performed better than the part task group on skill acquisitions test and transfer test. Result 2: no significant interactions between levels of prior knowledge and skill acquisition and transfer. Result 3: learners in the whole-task instructional approach did not have	4C/ID

				more positive attitudes towards the instruction than learners in the part-task instructional approach. Result shows that the whole-task group performed better than the part task group on skill acquisitions test and transfer test.	
(Barnes, Wiebe and Branoff, 2011)	Effects of worked examples on CAD performance	Experimental	College Subject: Foundation to Engineering Drawing		4C/ID

Research focus. The studies above show a range of different focus areas, working from how instruction is designed in a learning context and the technology used to support the instruction, narrowed down to strategies and components of the model. For example, Barnes, Wiebe and Branoff (2011) focuses on a worked-example strategy in designing a tutorial video, based on the 4C/ID model.

Methods. Most studies were experimental studies, which is understandable as the studies investigate the impact on learners from a learning perspective. One study that suggests the use of qualitative data to further understand how the intervention affects the learning process from the learners' perspective (Melo and Miranda, 2015). The relative absence of qualitative data was a weakness and there were opportunities to enrich the findings with first hand reported experiences. This could give an in-depth view of the learning process and an indication of other elements that could help to improve the transfer of learning which are not covered in quantitative data. Qualitative data can help to crystallise how the model affects learning strategies, particularly in relation to the design components offered in the model, Learning Task, Supportive Information, Procedural Information and Part-task Practice. There was comparatively less discussion from the perspective of design or pedagogical aspects in the process of designing and developing the instructional materials discussed above.

Context. These studies also show that the model could be implemented at any level of education from a school to a university setting. The subject matter in the studies is mostly technical and involving skill development that includes engineering, physics and technical drawing. This shows a gap in the research as to

whether the model could also be adapted for other subjects such as computer skills and concept based topics.

Based on the literature, there seem to be specific areas of interest in relation to the model. One of the earliest is the theoretical aspect and the possible grounding of the model in cognitive load theories, problem-based learning and complex learning. The literature then evolved to explore the effectiveness of the model in supporting teachers in designing learning tasks (Hoogveld et al., 2001). Although the study placed an emphasis on comparing two approaches, Instructional System Design (ISD) and Experience-based Design Conditioned (EXP) in training teachers on instructional design behaviour in web-based training condition, the 4C/ID model was used in the ISD group training. It appears to be the ISD within 4C/ID group training that supported teachers' instructional design strategies; however, it could be debated as to whether the ISD training approach was the main influence on the result, or whether the teachers found that the 4C/ID model worked better for them in designing instruction thus influencing the result. The later study further expanded this point by using the ISD training approach and comparing the effectiveness of the approach in two groups, individual and team (Hoogveld, Paas and Jochems, 2003). Although it focused on comparing the two groups, similarly to the Hoogveld study (Hoogveld et al., 2001) it uses the 4C/ID model as the instructional design model in the training. There was less discussion about the experience of the participants in regard to the 4C/ID model.

Besides the interest of exploring the effectiveness of the model in supporting teachers in designing learning tasks, other areas of interest for this literature

review include a study on designing and developing computer-based tools to support designers in designing and evaluating competency-based programs (de Croock, Paas, Schlanbusch and van, 2002).

I also came across a study that investigates the effectiveness of a powerful learning environment (PLE) by adopting the 4C/ID model in designing instructional materials for a technical subject, building drawing at a technical secondary school in Ghana (Kwaku Sarfo and Elen, 2005). The study compares three learning groups: regular teaching method as a control group, and two experimental groups; 4C/ID PLE with ICT, and 4C/ID PLE without ICT. ICT in the study context is computer-based instruction that focuses on activities such as matching, multiple choice questions, and typing the correct response. Meanwhile, the group not using ICT used conventional tools in classroom such as flash cards, a chalkboard, pencil and paper for the same activities as the group with ICT usage. Although, the result of the experimental group indicates that the use of ICT helps to promote learning and develop technical skills among participants, it appears that there was not a significant difference in results between the learning group that used ICT and the learning group that did not use ICT, even though both adopted the 4C/ID model. The authors of the study proposed some explanations for this result which included the design aspect of the instructional materials including missing animation and sound in the drill and practice, a lack of computer literacy among learners, and the probability of the learners engaging in other activities instead of practising the instructional material during the designated time (this can be connected with user readiness as mentioned in the discussion chapter). This being said, the context of using ICT

in the study may need to be generalised in relation to other studies because the study focused on using a computer to deliver drill and practice to support part-task practice, which is only one of the components mentioned in the model. Thus, there is significant evidence to suggest for further investigation into the uses of ICT or technology related materials in regard to other components in the 4C/ID model.

In regards to the different kinds of technology and testing for other design components in the 4C/ID model, one example from the literature considered is a study that used a multimedia practical application as a platform in teaching law (Nadolski, Kirschner and van Merriënboer, 2006). This study adapted multimedia practical materials that teach learners how to prepare a plea, and work from two design components in the 4C/ID model, supportive information and whole task practice (learning task). Within this multimedia practical, the supportive information component was in the form of video examples of expert lawyers conducting a plea and pleading a case, and the judicial procedure of preparing a plea. A virtual coach was also used in this multimedia practical application as a support to learners in carrying out tasks given to them. A study conducted by Melo and Miranda (2015) on the use of digital learning environments that adapted the 4C/ID model appears to show evidence of its effectiveness in developing high level of efficient instruction. The result of the study indicates that learners are able to develop skills related to electrical circuit problem solving. In general, learners that received instruction developed with the 4C/ID model has a higher level of instructional efficiency for knowledge acquisition and transfer of learning as compared to learning in the conventional way. This result

was consistent with Kwaku Sarfo and Elen (2005). The conventional means of learning in this study refers to lecturing and exercises using PowerPoint and a blackboard as well as other tools such as pencils, paper and calculators. However, it is questionable whether the positive results were primarily influenced by the instructional medium (digital learning environment) used in the instruction or whether they were due to the pedagogical strength of the model that supported the instruction in the experiment group. It was also not discussed how the digital learning environment was perceived by the learners in the experiment group, although the content and the digital application was validated by an expert panel.

Besides the technologies discussed above, there were also research interests in adapting the 4C/ID model in the context of educational game design (Huang and Johnson, 2009; Enfield, 2012; Lukosch, van Bussel and Meijer, 2013). Huang and Johnson's (2009) and Lukosch, van Bussel and Meijer's (2013) papers were more related to conceptual studies that propose a design framework based on the 4C/ID model in designing educational games. However, there are no further empirical studies found to support the idea in the concept paper.

2.17 Complex Learning

Complex learning as described by Merriënboer and Kirschner involves *"integrating knowledge, skills, and attitudes by coordinating qualitatively different constituent skills, and often transferring of what is learned in the school or training setting to daily life and work settings"* (van Merriënboer and Kirschner, 2013, p.2). It is based on the premise that in a fast-changing society we are confronted with many new kinds of knowledge. A complex approach requires one to learn new sets of skills and

transfer them to practical contexts. Richey, Klien and Tracey (2011) described complex learning as activity that focuses on integrating learning goals and multiple performance objectives that comprise tasks of a particular job or in life. The term is not widely used, though other writers have of course investigated contexts which resemble a complex learning context and have called up educational approaches such as inquiry learning, problem-based, and learning by doing (van Merriënboer and Kirschner, 2013). For example, de Jong et al. (2012) associated inquiry learning and collaborative learning in designing complex learning via technology-enhanced learning environments. In their study, technology-enhanced learning was used because it affords the user the ability to manipulate content (inquiry learning) and share content within the learning environment (collaborative learning). In ensuring transfer of learning, a learning by design approach was also used in the study that required learners to create products. Through this approach, de Jong et. al proposed that learners are able to transfer what they have learned by creating products. This study shows how the researcher viewed complex learning and used it in their context. Nevertheless, complex learning may vary in different context. Be that as it may, the focus remains on promoting teaching and learning through learning tasks that centre on real life tasks.

In relation to TSM, the four main components in the model are claimed to support complex learning. The learning task is important in designing instruction for complex learning, and may vary from a simple to complex task, requiring different instructional methods. Unlike a simple task, a complex learning task

stimulates learners' cognitive systems to provide a solution; this is naturally not fixed and varies from one context to another.

There are three methods in designing complex learning tasks: *variety of practice*, *guidance* and *feedback*. However, it is important to consider the aspect of low-expert learners and high-expert learners in designing the complex learning task, because different strategies generate different impact for each type of learners. For example, in considering the variety of practice, providing practice in a random order will encourage learning and increase transfer of performance for high-expert learners. Conversely, the same strategy is less effective for low-expert learners because more practice time is required in order to achieve a certain level of performance (Van Merriënboer, Kester and Paas, 2006). Therefore, it is crucial to consider learners' prior knowledge when designing practice for the learning task.

At the beginning of this study, there were conflicting ideas as to the meaning and use of the term complex learning in general. It was unclear how to define the levels of simple and complex tasks for a particular content or subject matter in the case studies. Does the level of complexity for the learning task depend on the complexity of the content, or on the amount of effort required of the learners in carrying out the task? Does the task get harder the more complex it becomes? And can the tasks be designed and delivered to learners using technology as a medium, for example computer-based instruction? It was proposed that complex content could be delivered through the use of software tools. Scaffolding in the context of complex learning refers to the guidance given to learners while carrying out rich learning tasks (van Merriënboer and Kirschner, 2013). Using a

computer as a medium for scaffolding benefits learners if it can represent the complex content in such a way as to help learners to understand and interact with the content in a more manageable way.

Abrami (2001) discussed research on using technology for knowledge construction as a result of interacting with the content developed through technology. However, to what extent do the features supported by technology help to support complex learning? Or does the choice of medium not matter as long as the task is well designed to promote learner engagement to integrate knowledge, skills and attitude? It is the attempt to use technology to scaffold learning that will be investigated in this study.

2.18 Summary

This chapter provides an idea of design and development research as a way to approach this study, in particular how the outcome of this study will contribute to the knowledge in the area of instructional design. It later outlined an overview on the generic instructional design model, ADDIE, overview on other models and its comparison emphasising on instructional design models in product category. It then followed by overview on educational technology and design looking at how research into design models has been stimulated by the use of media and technology. At the end, this chapter described the 4C/ID model and later drawing attention to the model adopted in this study, the TSM. It described the strategies associated to the main components of TSM and its relation to the design of instructional material. Overview on other study that has been carried

out using TSM and 4C/ID, the gap found and how the implementation of the model could support complex learning were also discussed.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 What is this chapter about?

This chapter discusses the overall research methodology that underpins this study, and the challenges that arose from my engagement in the dual role of researcher and designer. It provides a detailed account about the research purpose; research paradigm; my dual role position, the type of case study and how multiple case studies were undertaken relevant to this study; the description of the three case studies; the pilot runs; and the methods used in this study.

3.2 Restating research purpose

My overarching research question is, **what is the value of the van Merriënboer's Ten Steps Model for designing and developing instructional material?** The research explores the use of this model in designing learning material for three different kinds of subject matter. In particular, my study combined elements of product development and model evaluation. Although most research on instructional design models is not specific to a particular product's development, it is possible to conduct model research while carrying out product development (Ross et al., 2008, p.740).

The most important characteristic of my study is that it describes and reflects on my design practice in the development of instructional material. As was seen in

Chapter 2, research carried out using this model tended to focus more on impact on learning, and there was less discussion of reflecting on the design process itself. There was a gap in the literature on how the model works in practice. This study provides an opportunity to present an in depth, insider-outsider perspective on the model, looking in particular at values and shortcomings. The action focused nature of this study influenced my methodology and methods.

3.3 Research Paradigm

A research paradigm could be defined as the researcher's belief, their alignment with a research tradition, and how it influences the way the research is or needs to be conducted. Merriam identifies four major paradigms: *positivist, interpretive, critical and postmodern* (Merriam, 2009).

According to Merriam, positivists believe that reality exists and can be observed; the world is stable and social phenomenon which can be measured. *Positivist* studies are normally associated with experimental research or quantitative research. The knowledge developed with a positivist approach is characterised as 'scientific'. In the field of instructional design and technology, the positivist tradition is well established in product development research, or Type 1 research (as seen in Chapter 2). For example, Kwaku Sarfo and Elen (2005); Nadolski, Kirschner and van Merriënboer (2006); and Melo and Miranda (2015) employed experimental methods in regards to the 4C/ID model in their studies. These studies basically compared outcome and performance between groups based on interventions that were designed using the model.

Interpretive studies lie at the other end of the epistemological spectrum and are often associated with 'qualitative' research. Model research or Type 2 research (as seen in Chapter 2) in the instructional design and technology field tends to be qualitative (see Rowland, 1992). In his study, Rowland studied four experts and four novice designers' processes in which their decision-making was coded and analysed while completing a task in designing instruction for industrial training. Giving these examples, some researchers have opted to follow an interpretive tradition in product development (Type 1). Such researchers include Corry, Frick and Hansen (1997) who employed multiple qualitative research methods such as in-depth interviews, field observations, and the think aloud method. Interpretivists believe that reality is socially constructed and that there are multiple realities out there; for example, they consider that there are many interpretations form a single event. This means the interpretive researcher needs to engage with the subjective meaning of 'social actors' or the people in their study.

The interpretive researcher needs to be aware that different people will have different perspectives, and that these perspectives are 'snapshots' in time and may change. This implies that the same instructional design models may be interpreted differently and there is no one model that will work across every context. The interpretation is constructed through understanding an individual's subjective meaning of their own experience. The individual might be the designer, a subject matter expert or a learner depending on the research focus.

The *critical* researcher shares much in common with the interpretive researcher, but draws on several additional ideas such as feminist theory, critical race theory,

and critical ethnography. They seek to critique and challenge, to transform and 'empower'. My work aims to be critical by examining the claims made for instructional design models and weighing up competing evidence. However, I am not drawing on Critical Theory as such in this study.

Finally, Merriam described post-structural or *postmodernism* as distinct from the three other paradigms. Postmodernism was influenced by interpretive and critical research and argues that as there is no absolute truth, the researcher can only write subjective narratives about events and understand that social agreement is often cohesive. Again, this study is not a postmodern account, but I do want to be critical by considering the subjective nature of the data gathered in this study.

A further paradigm not discussed in Merriam but widely adopted is that of pragmatic inquiry. Pragmatic inquiry is action-orientated research that seeks to address the impact of challenges and problems on practice. The epistemological bases of pragmatic inquiry are that knowledge about something emerges through action, and reflection on action. Much action research can be defined by reference to pragmatic inquiry. This is because action research involves planning, acting, observing, and reflecting while doing design and development. Although action research is associated with pragmatic inquiry, pragmatic inquiry is a broader concept than simply action research. For example, design based research (Brown, 1992) is an approach to inquiry which is action oriented but not specific to solving problem of practice. Although Brown described her research as design-based research, the research context that influence Brown's definition of design-based research was based on her intervention in designing instruction for

a classroom setting, whereby she viewed the classroom where she taught as her laboratory, the site of implementation for her intervention.

My study was conducted under the conditions that the context (subject matter and participants) and each problem that arose in each case study was systematically studied with direct reference to the TSM, while I was designing and developing the learning materials. Participants' feedback based on the experience using the learning material was carefully examined, and helped to refine the learning material in the iteration cycle. Each condition for each case had its unique characteristics which had to be taken into account in planning the study and refining the methods of collecting and analysing the data gathered. In addition, I needed to constantly recheck my design reflection with regard to the TSM. With the perspective afforded by this process, I was able to learn best from my own practice and applied what I have learned.

These paradigms give a useful insight into how research may be carried out. They help to show how a researcher can approach their research, and how it is underpinned by ontological and epistemological standpoints. Paradigms dictate the methodology and research design (Sarantakos, 2005), but in practice, researchers often do not fit into one tradition. They borrow assumptions from different fields, and it is very rare for a researcher to be a complete interpretivist or positivist, for example. All researchers understand that people see the world differently, but most are prepared to accept that there are associated patterns which can be described and explored. Many researchers tend to be pragmatic in that they make use of the tools available and fit them around the context that can be accessed and methods that work in that context.

The approach taken to this study could be labelled as pragmatic. As such, my orientation is towards 'pragmatic' inquiry in that I wanted to make best use of what methods and tools I could access in conducting this study. This is because, as a result of challenging my design practice in regards of adapting the model, I approached this study from the perspective of a practitioner. Pragmatism suggests the idea that knowledge evolved as a result of transaction between agent and environment (Hammond, 2013). In this study, the knowledge generated was based on design experience with the participants rather than by theorising on the model concept. Although the TSM was used as a guideline, each design decision during the design and development process depended on what was appropriate with regard to the context of the subject matter and feedback from the participants.

An example of this pragmatic approach lies in the use of different methods depending on what I wanted to find out and the data gathering opportunities available. Therefore, in order to explain participants' perceptions and to gain better insight of the use of the model, multiple methods were employed in order to inform this study. In particular, I used design logs, interviews and surveys. The conducted interviews, designer logs and surveys enabled me to examine my initial assumptions about the model in use, and to answer research questions as described earlier in Chapter 1. I considered each case study to be unique, and these unique cases illustrate and demonstrate the design process more clearly than an approach simply based on accepting theories and principles laid in the literature.

Although I found aspects of action research helpful in analysing my methodology, the study is not necessarily a piece of action research as a whole. While I have reflected on my own design practice in each design cycle, this study itself is not the study of a problem that arises from my own context. Rather it addresses the problem that arises from multiple cases with different context and participants. Unlike regular action research, I am one step removed from the context of this research in that my primary focus is on design evaluation rather than on deliberating the impact of the instructional materials on student learning. There was some evaluation conducted with the learners in regard to the learning materials at the end of the process; this is considered as a part of the iterative process of designing and developing the instructional materials. I believe the final evaluation of learning as a result of using instructional products is a study by itself, for which reason I chose not to go into depth in this study.

In drawing meaning from pragmatic and action oriented approaches for this study, I am borrowing assumptions from an interpretivist view. Many scholars when considering qualitative research seem to be in agreement that interpretive study tries to draw meaning and understanding from people's experience and views about their world (see Patton, 2002; Merriam, 2009; Cohen, Manion and Morrison, 2011; Yin, 2011; Creswell, 2007). The development of interpretivist philosophy arises from the critique of positivism. Interpretivism did not accept that principles of natural science were appropriate in researching human behaviour, and rejected the belief that human behaviour was governed by general universal laws (Cohen, Manion and Morrison, 2011, p.15). It considered that human beings think and reflect, and therefore influence the outcome of

situations. There are perhaps social agreements that allow knowledge to develop and society to inform study. Interpretivists argue that knowledge and meanings are the result of interpretations. In an interpretivist method of research, the world is normally understood from the human perspective while interacting with and experiencing certain situations or actions (Creswell, 2013). In interpretive study, personal beliefs and values inevitably influence understanding and judgement with regards to the subjective matter or situation.

Drawing on the interpretivist view as described in this chapter, I wanted to be sensitive to the different ways the lecturers and learners used and reflected on the instructional materials. Therefore, participants' perceptions and opinions were crucial in informing this study, as they provided insight into what was actually happening from their experience and how they perceived the world. Not only are voices of the participants critical to this study, but this study also draws on my subjective view in the dual role of researcher and designer.

There is less discussion focused on whether the researcher's view and experience has substantive value in gaining understanding from the study they have conducted. According to (Merriam, 2009, p.14), the researcher's understanding of a phenomenon is not as important as the participants' understanding. However, experience as an insider due to my design role means in this case that I was more involved in the study and I am a key 'research instrument'. My design log in particular is crucial to the study. This means I must explain my position as the researcher and my role in the design process. Each design decision made in relation to the learning materials was noted down as the design and development progressed, and was reflected upon. My perspective as designer and researcher

along with qualitative data will clarify the feasibility of the model adopted in my case studies. This helps the study to explore the strength and weaknesses of employing the model in developing instructional materials. As seen earlier, product evaluation was also important, and the feedback of participants allowed me to correlate my design with outcomes. Indirectly, this provided the opportunity to generate new knowledge from weighing up my subjective experience of design, the subjective experience of the participants, and providing trustworthy data in the study. Thus, it provides an in depth understanding of the process of designing and developing learning materials by adopting the TSM.

To sum up, interpretive research is fundamentally concerned with meanings and seeks to address essential features of shared meaning and understanding. However, I do not hold a fundamentalist interpretivist view because I believe that there is an environmental reality and various patterns evident in the natural world. There are social agreements and concepts that people agree on, which provide more or less valid ways to describe social phenomena. For example, each participant in the case studies had different views and experience of using the learning material developed for them. The variety of participants' reflections were likely influenced by the design experience they had with respective learning materials, or influenced by some other factor such as usability. This is at least in part the result of adapting the TSM in developing the learning materials. Thus, there are a lot of factors that could influence their interpretation.

I consider this study is grounded by interpretivist view in the sense of interpreting meaning from the reflections of both researcher and participants. The participants' view about the learning materials helped to reflect upon the

feasibility of the model. Their perception and experience might vary because it was influenced by their background and how they perceived their experience. This is a result of a pragmatic inquiry approach in the sense of conducting design and development research based on exploring the model, which is more akin to action based research. This is an essential point to address the overarching research question; *what is the value of the Ten Steps to Complex Learning model?* In conclusion then, I hold a pragmatic view, my approach is more towards action oriented study, and I am borrowing some interpretivist views in interpreting the data gathered from multiple methods in this study.

3.4 Dual Role

In design and development research, especially when it involves product or tool development, the researchers are often also the designers or developers of that product (Richey and Klien, 2007). Although some research in this category uses designers as participants (see Roytek, 2010; Rowland, 1992), this is not the case for this study, as I was engaged as the designer and the researcher simultaneously. Although the primary focus of my study was model use research, I was also reflecting on the design process of my own instructional products. According to Richey, this situation is not unusual and is in many cases unavoidable especially when the study involved product development. However, it has the potential to create methodological issues, a possibility of which the researcher needs to be aware.

As mentioned earlier, the nature of my study required me to play a part therein and to view the experience as a designer. Experience in this context could be

described as thinking, feeling or doing something (Johns, 2004). The process helped me to explore any issues that came up while designing and developing instructional materials for each case study. My thought or design decision while undertaking each design and development task was considered as an experience, and reflecting on those experiences has been valuable in this study. This reflection approach is readily summed up by Johns: *"being mindful of self, either within or after experience, as if a mirror in which the practitioner can view and focus self within the context of a particular experience, in order to confront, understand, and move towards resolving contradiction between one's vision and actual practice"* (Johns, 2004, p.2). Referring to Johns' typology of reflective practice, *reflecting on experience* and *reflection on action* are considered as doing reflection. He described *reflection on experience* as the practitioner's reflection on a particular situation after a certain event, which allowed the practitioner to learn from the event in order to inform future practice. *Reflection on action* was described as the practitioner stepping back from his position and reframed the practice situation in order to proceed towards a desired outcome. These two views are in line with my perspective on the dual role of researcher and designer in this study. I offer three types of reflection in this study:

- Reflection on my action as a designer. This reflection focused on the activity of designing and developing learning materials and working within TSM. It involved reflection with participants; the lecturers and the learners involved in each case study. Reflecting on my actions of doing design and development tasks allowed me to examine changes that

occurred during the iteration of each case and to then reflect back on the model adopted in this study.

- Reflection from lecturers' experiences encountered before and after their involvement in the design and development of learning materials. The experience prior to the commencement of the design and development of learning material occurred during needs assessment, while the experience after the commencement of design and development of learning material occurred after the evaluation with the learners was completed.
- Reflection from the learners after experiencing the learning materials. This occurred during the evaluation session with the learners. It involved learners' interaction with the material and learning task that they had completed.

My role in this study could also be viewed as participant-observer in a qualitative study (Richey and Klien, 2007, p.148). However, this may not be a normal case of participant-observer, as my involvement was that of a practitioner acting within the study, reflected on the design and development process of producing learning materials based on my interaction with the subject matter expert or the lecturer.

The key methodological problem arising from this study was that much of the data was generated by myself as designer, and by my interactions with lecturers and (to a limited extent) with learners. Playing a dual role in this study meant that my own positionality needed to be explored. Knowing that I was a novice and not an expert on TSM created a problem because I needed to learn about the model, which proved challenging. In my view, this part of the research had been

the most critical: to determine my positionality within the study, and to explore the experience and knowledge available within the field. Through my reflection within the cases, my views towards each differed greatly because of my own experience of teaching the subject (see in particular Case Study 1: Interface Design). However, to avoid the interference of personal preferences with the study, each design attempt was discussed with the subject matter expert (SME) at blueprint stage before proceeding with the development stage. With the attention given to the methods used for data collection as described above, the concerns around validity were reduced.

As seen in the Introduction and Discussion chapters, my past experiences, my knowledge of the field and gaps in that knowledge, my values and beliefs about learning, ideas and views about design and content of TSM and subject matter influenced the whole development of instructional materials for each case. Although my own position created challenges, it provided me an opportunity to experience how the model worked in practice. This view, that of an insider who is a novice regarding the model but feels that its theoretical foundation could support the Case Studies, indirectly provides an opportunity to develop informed practice. While Richey and Klien mentioned that it is not unusual for a researcher to be in this position, there was a possibility that my position would lead to validity issues in the study, i.e. researcher's bias. According to Merriam (2009), it is important to be aware of the possibility of researcher bias rather than considering it possible to eliminate that bias. In order to avoid bias, Richey and Klien suggested the use of multiple methods. These will be discussed later in 3.9.

3.5 Case Study

Case studies have been one of the most common and well-used approaches to educational research. A case study is described by Yin (2014) as a study that takes place within a context and is bounded by that context. They can be categorised into three types: *exploratory, descriptive and explanatory*. An *exploratory* case study is often appropriate for new situations and can help to identify research questions for subsequent study. A *descriptive* case study is one that sets out to present a narrative (giving voice) of a social phenomenon and might, for example, throw light on experiences that have been under-reported. An *explanatory* case study is one which often employs analytical frameworks to explain why certain events happened or did not happened. These three types are very useful; however, in practice they tend to overlap as no single study exclusively belongs to one particular type.

Stake viewed the case study as bounded, for example bounded within a study of a school or a classroom, and characterised the focus points of the case study format as *holistic*, *empirical*, *interpretive* and *emphatic*. *Holistic* refers to reporting on the relationship between a phenomenon and its context. *Empirical* refers to observations in the field of study. *Interpretive* refers to the researcher's goal of providing an account of viewing the case study based on their own interaction with the subject in the study. Lastly, *emphatic* refers to the researcher's reflection on the engagement with the subject in the study Stake (1995). Again, these foci are not exclusive as a single study may have elements of several or each.

Merriam is in agreement with Stake's and Yin's view that case study as a method is bounded within a system. Case study is viewed as being *particularistic, descriptive and heuristic*; *particularistic* emphasising the distinctive features of an event, program or phenomenon; *descriptive* indicating a study which is heavy on detail and engagement over time; and *heuristic* in the sense of illuminating participants' understanding of a phenomenon.

The typologies offered by Yin, Stake and Merriam are helpful; however, my study does not exclusively belong to any of these categories alone but, as can be seen in the table below, has elements of each.

Table 3.5-1 The ideas that foreground the study

Idea	**How it fits into the study**
Explanatory	The experience I undergo within the case studies allow me to come up with **explanatory** content. It is expected that at the end of this study I will have an increased knowledge of the processes I am undertaking and will be able to formulate an explanation, for example, of how TSM works in my practice, and the strength and weaknesses of the model. I would also consider this as a critical evaluation of the model to reveal its strength and weaknesses, and the advantages and disadvantages of adopting TSM in each case study. Regardless of any findings or feedback on the learning materials from the participants, there must be reasonable explanations provided which are valuable to inform practice.
Descriptive	This study includes descriptive elements because it carefully describes participants' experiences of using the learning materials and being part of the design process. By providing a detailed

	narrative account of those experiences, it helps to reflect on the feasibility of the model in regard to each case. This study also has emphatic elements because it includes reflection on my own engagement with the participants and subject matter in the study. My position as both designer and researcher enables me to provide a detailed account of my design reflections around the subject matter in regard to use of the TSM in designing and developing instructional materials. Although each of the subjects covered in the case studies differ greatly in terms of the content, this does not distinguish the way I approach each case. This is because I am following the steps as described in the model.
Exploratory	This study is exploratory because it begins with the rationale of knowing what TSM can offer to the process of designing and developing learning materials. While it was unclear at the outset what precisely would be determined through adoption of the model for the case studies, the study is being under taken with an open mind, accepting any possibilities as regards the direction this study might take at its conclusion, even if the initial assumptions regarding the value and usability of the model could be proved wrong. I believe there must be a reasonable explanation for any outcome.

3.6 Multiple Case

According to Yin, a multiple case could be in the form of either of two types: multiple case designs with a single unit of analysis, and multiple case designs with multiple units of analysis (Yin, 2014). Yin sets up a useful two by two matrix of the design of a case study. He considers single and multiple cases as both holistic and embedded. This study explores the use of the TSM across three case studies,

covering different learning environments and subject matter. As a case study, each was bounded within a system or context, and the focus of my interest was the design of learning materials and their use in learning. They showed the model at work and provide in-depth descriptions and process and allow readers to compare and contrast within their own context. This format offers a critical examination of the model in particular. It does not set out to show that the model is good in all circumstances; instead, it is aimed at allowing us to evaluate the pros and cons of the model. In this way, I will produce findings which are relatable to other practitioners.

My overall case study structure is easily seen as a multiple case design because it involved three case studies in different settings. It has some of the characteristic of a holistic case in that it is concerned with the general idea of the model. Within that, there are embedded units of analysis including the learners' evaluation, lecturers' perceptions, and reflection of the design process in regard to the steps taken in designing the learning materials. This makes it a hybrid of both holistic and embedded approach. In fact, it is extremely difficult to understand there is holistic approach which does not have embedded units of analysis, because each case is both holistic and are embedded.

Since this is a multiple case study design, the cases deal with different areas of subject matter - Interface Design, Injection Moulding and Web Programming - and are carried out in different contexts with different people. A problem evident in the literature is how to deal with multiple cases: should they be treated as distinctive, or should we try to integrate the three into one story? In this study, I found that there was significance in the sequencing of the cases. For example,

Case 2 was built in part from my reflections from Case 1 as I had learnt about. practical issues such as the speed of producing the materials, and theoretical issues regarding aspects of TSM that I was unaware of at the beginning. Carrying out three case studies in order gave me the opportunity to carry the insight of one case into the next. At the time, this was very helpful; however, there were limits on how extensively such a method could be used. This is because I needed to complete each case within a certain period of time, and for scheduling reasons the second case study had to be conducted before the full analysis of the first case could take place.

The range of content covered in the cases was a significant factor in providing the chance to explore the feasibility of applying TSM in different subject areas. However, each case was exploring the same research question and was concerned with elements of technical learning. I will present these cases one by one, but when it comes to discussing them further into the study, I will pull out themes across all three.

3.7 The Case Studies

The case studies were chosen on the grounds of subject matter and access. In terms of subject matter, they all concerned complex learning, which as seen in Chapter 2 refers to the ability of integrating knowledge, attitude and skills in performing a task. I saw all three case study contexts as complex learning because in order to complete a real world task, learners were required to integrate sets of knowledge and skills. For example, in order for learners to design an interface,

they are not merely required to apply the principles of interface design, but also need to be able to justify the reasoning behind their design work.

These cases were also chosen on grounds of accessibility. Getting access is deeply problematic in this kind of study, and has been one of the main factors that influenced the way it was conducted. I needed to get permission from the head of department in order to conduct the study at the institution, to be able to engage with the lecturers, to visit the technical workshop, to be able to conduct evaluation at the computer lab, to evaluate products and to engage with the lecturers and learners in helping in carrying out the evaluation. In Case Study 1, I had already known Miss H and upon her agreement to participate in this study, a formal letter was sent to the head of department to gain access. However, it was different for Case Study 2 and Case Study 3. Since I did not know the lecturer, a formal letter was sent to the head department and a lecturer was later assigned to help me with the study (see Appendix H). I felt that it was easy to conduct study if there was a good rapport especially with the subject matter expert (lecturer). Unlike in Case Study 1, Case Study 2 and 3 led to my being in the position of designing with people at the same time as conducting the research. Different institutions have different policies which restrict access. For example, in Case Study 1, I was able to record a video during the evaluation of the learning material with the learners, thus enabling me to easily gather observation data which is valuable to the study. However, in Case Study 2 video recording was not allowed which left me only with the option of jotting down observation notes while the evaluation of the learning material was taking place. Each of the case

studies conducted follow the same design procedure as in Figure 3.7-1. Each procedure was broken down based on the task as in Table 3.7-2:

Figure 3.7-1 Design procedure

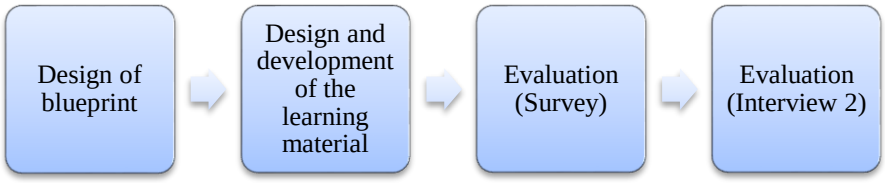


Table 3.7-1 Design procedure and its task

Design Procedure	**Task breakdown**
Design of the blueprint	• Needs assessment (interview with the lecturers) • Task analysis • Blueprint design: • Design learning tasks (sequencing learning task from simple to complex) • Design supportive information (analysing cognitive and mental models for the content of the subject matter). • Design procedural information (analysing cognitive rules and prerequisite knowledge for the content of the subject matter) • Flow chart and Storyboard
Design and development of the learning material	Technical details: • Developing the learning materials using authoring tools based on the flowchart and storyboard • Designing the interface, graphics, and animation • Integrating the interface and interaction using programming language
Evaluation (survey)	During the evaluation:

	• Briefing about the learning material • Learners were asked to try out the learning material including carrying out the learning task • Observation took place and field note were taken • Learners needed to answer an online questionnaire • Learners workings after carrying out the task were gathered
Evaluation (interview)	During the evaluation: • Lecturers were introduced to the learning materials • Lecturers were interviewed, to gain feedback and experience of trying out the learning material

The three studies were based in Malaysia and covered the topics detailed below.

Case Study 1 - Interface Design. This case study was conducted in one of the private colleges in central Malaysia. It involved learners aged 18-20 years old. The reason for choosing Interface Design as the subject was due to the nature of the subject having more a theoretical context rather than a technical context. As such, it provided an opportunity to explore the model in the context of complex learning that involved more abstract content. I had time constraints to consider and thus chose just one topic, Principles of Interface Design, from the syllabus; this decision was based on the information gathered during needs assessment. This topic required learners to be able to understand and apply the design principles in designing and developing an interface such as courseware or a website. The complexity of this topic was shown in that a student had to think of the best design solution that met what was required of the product they were developing. At the end of their learning, the learners were expected to have acquired a strong foundation of integrating the principles of interface design with

some technical knowledge of using specific authoring tools. Knowing that design in this context was subjective, this was not an easy task for the learners. It therefore required proper instruction in order to promote and develop those skills. In delivering the topic, the design components of the TSM were explored in designing and developing the instruction; the learning task. The medium that was used to deliver the learning material was computer-based instruction (CBI). The CBI was designed and developed based on the discussion (needs assessment) with the lecturer who taught the subject. The prototype was then evaluated by the learners and later with the lecturer in order to gain their perceptions of the learning material.

Case Study 2 - Injection Moulding. This case was conducted in one of the technical colleges in south Malaysia. Twenty learners were involved in the study. The subject matter was Introduction to Plastic Technology. The learners were following an introduction to the concept of plastic technology, including techniques for plastic processing, plastic materials and product defect. For the purpose of the case study, Product Defect was chosen. This topic gave an overview of types of product defects that the learners might encounter while handling injection moulding machines. Learners were expected to be able to identify the defects and also identify the factors that caused the defects.

This topic was complex as learners needed to identify the types of defect within a product and diagnose the cause for the defect before coming up with a solution. This knowledge and skillset is important in plastic product mass production. Furthermore, diagnosing any product defects requires critical skills in order to be able to assess the different possibilities for product defects. The medium used to

deliver the instruction was a mobile app. Learners were able to use it as a reference whenever required in the lab or outside the lab. The prototype was developed based on information gathered during needs assessment with the lecturer who taught the topic.

Case Study 3 – Web Programming. This case was conducted in one of the private college in south Malaysia. There were 21 learners involved in the study. The subject matter chosen for this case study was Web Development. I chose PHP programming as the topic because it required learners to combine the concept of programming (theoretical element) and the use of a web authoring tool (technical element) in order to develop a website. Programming for web development is a complex task that requires learners to be able to visualise the concept of programming (what the programming could achieve), as well as the logic behind it, in order to achieve a desired output. Through combining the knowledge of programming concepts with the skills of using web authoring tools, learners could transfer their problem-solving skills into different situation within web development. There might be several approaches which could achieve the same desired output, which made it more complex for learners. The medium used for this case was CBI. Learners were able to use the instructional material via this medium while carrying out the programming task which was also using a computer medium (Adobe Dreamweaver). The prototype was developed based on the information gathered during a needs assessment session, and was amended according to the feedback gained during an evaluation session. There were two iterations involved in this case.

3.8 Pilot Run

At the start of my study, I realised that while was aware of theories as to how design should take place, I had limited practical knowledge of instructional design. I wanted to get first-hand knowledge of design and the design process in a more holistic manner. I therefore conducted two pilot runs that employed two different design approaches, linear and non-linear, so that I could compare the implications of user involvement and how those approached reflect the task of doing design and development. The two pilot runs involved the process of designing and developing learning materials for two different content areas and two different instructional mediums. Pilot 1 involved designing learning material for a technical subject; Streaming Media, and was produced using LectureMaker authoring tools. This was aimed at learners in one private higher education institution in Malaysia. The pilot run used the Bergman and Moore model as a design approach and it followed each phase of the model: Analysis, Design, Develop, Produce, Author and Validate. Pilot 2 involved developing a website that provided information and guidance related to studying abroad for those in Malaysia considering it. The case adopted Rapid Prototyping as its design approach, and the design process began with a low fidelity prototype which was developed through an iteration process. The importance of conducting these pilot runs is discussed in the reflection below.

3.8.1 Reflection of pilot run: Needs Assessment

I adopted a semi-structured interview as a needs assessment in order to gain information on the current practice of the participant (lecturer). Needs

assessment provides the opportunity to learn about and understand the current teaching practice and problems faced in teaching and learning in this study. It also provides insight around the ways of delivering a topic and teaching and learning material used. Knowing the current state of affairs and what is required in the case would provide some ideas as to what kind of learning materials are suitable to fit into the situation. To this end, an online interview schedule was given to the participant before the needs assessment interviews was conducted. The schedule contains general questions that helped to generate in depth questions when the needs assessment interview took place.

I started by generating questions for the interview schedule which was given to the participants before the interview. The purpose of the schedule was to narrow down the topic to be covered during the main interview, a process which helped me to be more focused on identifying and developing questions for the main interview. The questions were sent to the participant as a Google form. The reason for using Google form was due to a lack of proximity between myself and the participant which prohibited a face to face meeting, and the difficulty of arranging a Skype or phone interview because of the participant's tight schedule. The questions listed in the online interview schedule were:

1. Please specify the subject or topic that you find it difficult to teach.
2. Please specify learning objectives of the subject or topic that you have specified above.
3. Please specify learning outcome of the subject or topic that you have specified above.

4. Please specify current mode of instruction delivery of the subject or topic that you have specified above.
5. Please specify current instructional media used in delivering the instruction of the subject or topic that you have specified above.
6. Please specify assessment methods used in delivering the instruction of the subject or topic that you have specified above.
7. Please explain problems arise in delivering the instruction of the subject or topic that you have specified above.
8. Would you consider a Computer Based Instruction as a tool in helping you delivering the instruction of the subject or topic that you have specified above?

After obtaining the participant's feedbacks from the online interview schedule, I started to generate questions (open ended) for the main interview. I generated five core questions as below:

1. Can you explain about the subject that you teach?
2. In the interview schedule, you mention the problem you encounter. Can you explain more?
3. Can you explain in detail how you conduct the class?
4. Can you explain how you design or sequence the content that you teach?
5. Which topic do you suggest that we can focus on for the purpose of this study?

Fundamentally, the two sets of question that I prepared for the interview schedule and the main interview focused on context. I wanted to explore the

participant's current teaching environment and practice, teaching materials, and methods of delivering the instruction. There were three types of context; *orienting context*, that emphasises learners and how they perceive learning; *instructional context*, which refers to the physical environment where the teaching and learning takes place; and *transfer context*, which refers to the chances of transferring knowledge and skills to new situations (Morrison et al., 2012). These contexts can affect every aspect of teaching and learning experience either for the lecturer or the learner. Thus, the generated questions were more or less constructed according to this paradigm. The information gathered from the interviews would justify whether the potential subject matter mentioned by the participant could be used as a case in this study.

I was also able to reflect on the way I had constructed the interview questions that were used in the pilot runs. These reflections fell into four categories: *structure of the question, sensitive subject, interview subject* and *data transcribing*.

Structure of the question. I found the participants in both pilots were unsure of some of the terms that I used in the questions asked in the interview schedule. Cohen, Manion and Morrison (2011) suggest that one of the factors that contributes to bias in interview is the participant's misinterpreting the meaning of what is being asked. To increase the validity of responses, therefore, some of the sentences need to be structured into simple language without changing the meaning of the sentence.

Sensitive subject. I had anticipated that there was a possibility that the interview might touch upon sensitive issues such as organisational problems in that

institution where the participants taught. The interview was trying to get the participants to tell me about their teaching practices and problems related to teaching and learning in that institution. I anticipated that the questions I asked may, at certain points, lead the participant to hide their views and refuse to expose private and confidential matters happening in the institution, or that the questions could potentially be asked in a way that might offended them.

Interview guide. I anticipated the questions might lead the participants to give different answers since this was an open-ended interview. Thus, there was a need to prepare some probable follow-up questions that might be required during the interview. Some of the questions asked were prepared in advance of the interview, and there were some follow up questions that newly arose as the interview took place. There were possibilities that the interviews might stray away from the main objective if the follow-up questions were not well prepared.

Transcribing the data. Unstructured interviews required more time for extracting the data as the participants were free to answer the open questions in their own way (Cohen, Manion and Morrison, 2011). Based on the data gathered from the interview, I recognised while extracting the data that an open-ended interview yields different modes of response from the participants. Even though it was easier for me since the interview was text-based, the answers were all scattered and it took me some time to classify the answers into themes.

In terms of designing the instructional materials, I learnt that there was a need to identify the anchor or key themes within the subject or topic that would unlock the task and help the learners to acquire the skills and the ability to transfer those

skills while carrying out a subsequent learning task. This is seen as particularly important in relation to TSM because the model places emphasis on the learning task as a driving force to learning. By identifying the main theme of the topic or subject, I was able to plan and design the possible learning task. For this reason, the question around identifying the key theme of the topic or subject was added to the interview in my case studies. With this information, I was able to brainstorm and come out with a design blueprint which would be useful for the next phase, design and development of the prototypes.

3.8.2 Reflection on pilot run: Design Log (what happened during the pilot run)

After getting information from the needs assessment for each pilot run, I began designing the prototypes. The chronological events that took place during the design and development phase of each pilot are summarised as below:

- Flow chart
- Storyboard
- Actual development using authoring tools

Design and development phase mostly involved the technical content related to producing the actual products. Without the design blueprint, it would have been difficult to imagine what could be put forward in the flow chart and the storyboard. Although most of the necessary information had already been gathered during the needs assessment interview, I felt that the involvement of the participants in this phase was crucial. This is because I needed to get constant feedback while doing design and development task. In this way, I was able to

ensure that what was visualised by the participants was depicted in the developed product. However, since I was adopting two different design approaches; linear and non-linear, this generated different design experiences which were valuable to the main study.

These experiences heightened my understanding of the strengths and weaknesses of an iterative versus linear approach in designing learning materials. Through the implementation of these pilot runs, I was able to gain experience of using interview methods to ascertain lecturers' views of the learning material developed in the pilot run. The most important input from conducting these pilot runs was my realisation of the significance of taking notes on every design decision that I made while doing the design and development for each of the learning materials involved.

I therefore used my experience from the pilot runs and decided to use a log book during the case studies, which I referred to as the 'design log'. This served as a log that described all the design activities that I experienced in each case study. There are several studies that discuss the use of a design log as one of the methods to record design and development processes, as cited in Richey and Klien (2007), but most of the studies engaged the designer as participant rather than allowing for engagement in a dual role of both designer and researcher at the same time. As there was no specific format for the design log, I referred to an example of using a design log from Powers (2008), in which he approached his case studies as a reflective practitioner. Powers used a design log to record his experience as a reflective practitioner in applying instructional design principles in designing online blended learning. Next, I will discuss the methods that were

used in this study, providing details of how the methods were adapted, the challenges and opportunity they offered to this study.

3.9 Methods

Since my approach to this study was pragmatic overall, many different methods were used, including interview, design log, and survey. However, in order to suit some constraints encountered during the actual case studies, document analysis and observation were also used. These methods were appropriate in order to answer the research question that was addressed in the Introduction chapter.

3.9.1 Interview Phase I

Interview (Needs Assessment). Interview is one of the more popular methods used in design and development research. In order to explore and have an in-depth understanding of information related to people's perception, experience and emotion, then either one of these types of interview could be implemented: *structured*, *semi-structured* and *open ended*. A structured interview is normally a high protocol interview with predetermined questions and answers. It could be said that a structured interview is a face-to-face session of an interviewee answering an administered questionnaire (Denscombe, 2010). Semi-structured offers less control over the questions and answers as compared to the structured interview. An open-ended interview offers a flexible and exploratory approach in which the interview could be conducted in a more conversational fashion (Merriam, 2009).

This study was preceded with formulation of a needs assessment that was conducted in between semi-structured and open-ended interview format. The purpose of the needs assessment was to gain understanding of the context of the subject matter, the lecturer's background and experience, issues and challenges, and the learners' background. Since I knew less about the context of each case study, I felt that the semi structured interview was more appropriate to my study and at the same time I wanted the interview session to be more flexible (open-ended) allowing me to explore in depth as I engaged with the lecturer.

Although the interviews were semi structured, I felt they had some open-ended elements since the interviews were conducted in an informal way, allowing the lecturers to use their own words and language. However, I was aware that there was a need to keep the session in line with the interview schedule and to be prompt in asking follow up questions as each interview took place. I was also aware that there was a danger of straying away from the main objective of the interview, i.e. to the informal manner in which it was conducted, but I wanted to maintain that informality as it gave the participants more flexibility and rendered them more willing to share their thought and ideas comfortably.

An interview schedule was also prepared beforehand and was used as a guideline during the interview (needs assessment) for each case study (see Appendix A). Knowing the current state of the context of each case study and what was needed, these interviews enabled me to gain some ideas on what kind of instructional materials were suitable to fit into the situation. Interview also assisted me in exploring in greater detail the context of the instructional environment and helped to identify any problems that existed within it. It

provided an opportunity to understand the lecturer's experience with the learners in order to better inform the designing of learning tasks as described in the TSM.

3.9.2 Design Log

In most design and development research, a design log or work log is used by designers and developers to keep a record of work-in progress at different stages in a project. There are some studies that used this method to record the designer's design work. For example, Forsyth (1998) and Jones and Richey (2000) employed work logs in their studies to record the designer's and developer's data as the design and development took place. There is no specific format for the design log or work log. Forsyth's format was more an open-ended approach which gives some flexibility to the participants. The format used by Jones and Richey is more a design task-based work log to record specific design activities. Either way, the work log or, as I refer to it in this study the design log is established as an appropriate method for recording design experience which is crucial in this study. The way in which the design log was employed in my study is in contrast to those mentioned above, as unlike in those studies, my design log was used to reflect on the design process that I experienced across the three case studies. It could also perhaps be called a researcher's diary as it contained my reflection on the dual role of designer and researcher.

Powers provides a good example of using a design log in his study. He recorded his experiences in a logbook using a simple narrative style and reflected on his three years of practice adopting an instructional design model to design online and blended learning. The reflections included what he can do, what he is doing,

what he should do, challenges he encountered, and the prototype development process (Powers, 2009). Based on his cases, I adopted the same approach in my study. Some of the reflections in my design log concerned my design practice of adapting the model for the context of each case study. These notes included:

- my **understanding** of the model
- the **strategies** of delivering the learning task, supportive information, and procedural information
- my **awareness** regarding my dual role position in relation to the study
- **organising** my design and development task in relation to the model systematically
- showing the **visibility** of the design process in each case

My design log was in an unstructured form to allow flexibility in gathering data and to comply with the TSM approach. It was also used to track the progress of materials development and to reflect on the relationship with the subject matter experts (SMEs), i.e. the lecturers and learners, as the study advanced. The communication between the SMEs in each case study was conducted online throughout the design and development process, and enabled discussion of the design and development of the learning materials, for example blueprint design, storyboard and content of the subject. The design and development phases for the three cases were conducted simultaneously to eliminate issues of time constraint. There were other issues that arose as the study progressed. These will be discussed further in relation to each case in the Case Study chapter. An example of my design log is also included in the Appendices.

3.9.3 Questionnaire survey

Questionnaires were distributed to the learners in order to gain evaluation data on the learning material. I then aimed to triangulate the data gathered using the three methods described in 3.9. The questionnaire was in a form of Likert-scale item with statements designed to gauge learners' perception of the knowledge, skills, attitude, and accessibility of the learning material (see Appendix G) The questionnaire was developed and checked by my supervisor in terms of language used and to ensure there were no overlapping questions. The questions covered in the survey were used to convey several dimensions. The dimensions were: knowledge, skills, attitude, and accessibility of the learning material produced in each case study (see appendix G).

3.9.4 Interview Phase II

At the end of the development period, the lecturer was interviewed to get their reflections on overall process of design and development of the learning materials as well as feedback on the learning materials produced. This was also conducted as an open-ended interview, in keeping with the previous interview approach. An interview schedule was also prepared (see Appendix B) and were altered to suit the three case studies as the interview took place.

3.9.5 Observation and Document Analysis

In conducting evaluation of the three case studies, surveys were used to gain feedback from the learners about how they perceived the instructional material given to them. The areas covered included how much the instructional material

helped them in understanding the topic, whether the instructional material helped to improve their skills, how confident they were to apply what they had learnt about the topic, and the accessibility of the material. However, a survey alone might be insufficient to provide answers to these inquiries. I realised there was a need to have an alternative source of data besides relying on the survey questions and the interview data alone. Observation and document analysis were employed for a deeper understanding of the learners and the context of each case study.

Observation. I was not able to be present during the evaluation of Case Study 1. This was due to travel costs and time constraints. The observation in Case Study 1 was therefore conducted by my colleague, a nonparticipant observer, who was present at the site while the evaluation of the instructional materials took place. She was given an observation list to guide her during the observation. She has a different area of expertise and did not know the subject matter, Interface Design, very well. In my judgement, her view was unbiased because the topic was not in her field of expertise, giving her a neutral position as observer Creswell mentioned the disadvantages of this approach, namely that as researcher I was not participating in the research and was unable to experience the observations. However, my colleague managed to video record the site during the evaluation, and while the data was not used solely because it was not a well-structured video observation, some of the clips demonstrated how the learners interacted with and responded to the learning materials. At the end, my colleague provided me with a report of her observation.

In Case Study 2 and 3, I was able to be on site when the evaluation took place and to conduct my own observation using a simple schedule with open-ended

responses. I created a sheet for each observation session to record what happened during the evaluation. The primary focus of my attention was how the participants accessed the material; for example, did they refer to the content (procedural information and supportive information) while carrying out the learning task, did they asked for my help to guide them and when they asked for my help, was it about the content or about technical aspects of the material? An example of the open-ended observation schedule can be seen in Appendix F.

Document analysis. Initially, document analysis was not part of my data collection strategies. However, after conducting the needs assessment in Case Study 1, I was able to access the syllabus and curriculum documentation of the programme. The documentation was useful as it gave crucial information about the topics covered in the programme. It was also valuable in identifying the topic for the case study, designing the learning task, and identifying the content for the supportive procedural information for the instructional material.

As described earlier, a design log was one of my methods used in this study. The data generated from the design log was solely written by me based on my reflection on the design process. As a result, there was a need to employ strategies to avoid personal bias. Richey and Klien suggested that one strategy to avoid bias data, especially for the dual role researcher, is to collect different type of data from different kind of sources. Therefore, besides the curriculum and syllabus of the programme, learners' assignments (based on the activity provided in the learning materials) were also used in this study. The answers and the assignments for each case were useful for me to reflect on the learners' responses towards the learning materials developed. Through these documents in addition

to those already mentioned, I was able to observe whether the transferability of learning occurred.

3.10 Summary

This chapter has given an overall description of the research paradigm and methods used in the study. It discussed how a pragmatic research paradigm with an action-oriented approach was seen more relevant to underpin this whole study. It also described the pilot runs, the challenges to the study and how it was useful to determine which methods were suitable to be used for this study. Besides this, it also describes the multiple methods, their challenges and opportunity, and how they were addressed to fit the nature of this research inquiry.

CHAPTER 4: THE CASE OF INTERFACE DESIGN

4.1 What is this chapter about?

This chapter explains the first case study. It describes the process of needs assessment; design and development of the instructional material; the evaluation of the instructional material; and what I learnt from the design process and the evaluation. The process is simply illustrated in the figure below:

Figure 4.1-1 The process of design and development of instructional material in Case Study 1

As mentioned in Chapter 3, the first case study was conducted in a private college in Malaysia. The study involved two cohorts of learners (n=17 and n=6), and the topic, Principles of Interface Design, was chosen from a module on

Interface Design. This topic focuses on teaching the learners about the principles of interface design that they will use in designing and developing multimedia based products, for example a mobile application, courseware, or a website. Computer-based instruction was chosen as the medium to deliver the instruction for this case study. It was developed using the Flash platform and functioned as a standalone programme. The various types of data collected for this case study are organised based on the phases involved, as per Table 4.1-1 below.

Table 4.1-1 Summary of the types of data collected based on the design and development phase in Case Study 1

Phase	Key Activity	Research Data	Main purpose
Analysis	Needs Assessment: Interview with Miss H	Interview	Scoping of the needs assessment
Design	Blueprint design Flowchart and storyboard development	Design log	Using the blueprint to design instructional material To design the flowchart and storyboard as a means for communication; Miss H to check the content and give feedback
Development 1	Prototype development	Design log	To develop instructional material based on the flowchart and storyboard developed in Design phase
Evaluation 1	Feedback from lecturer on the prototype	Interview	To understand what needed to be changed to improve the instructional material
	Observation	Video shots	To assess learners'

		Report from observer	interaction with and thoughts on the instructional material
	Feedback from learners	Survey (online) Facebook feedback	To gain learners' perception of the instructional material
Development 2	Prototype amendment	Design log	To record my reflection on the process of designing and developing instructional material
Evaluation 2	Observation	Video shots Report from observer	To assess learners' interaction with and thoughts on the instructional material
	Feedback from learners	Survey (online)	To gain learners' perception of the instructional material
	Documents analysis	Documents on learners' work or activity	To access learners' work or project on the Interface Design subject
	Feedback from lecturer on the prototype	Interview	To understand what needed to be changed to improve the instructional material

4.2 Needs Assessment

I began this case study by conducting a needs assessment exercise in order to understand the needs and the context of the learners and their study. An interview was conducted with Miss H, the lecturer who taught the subject. I contacted Miss H to arrange an interview; she requested that this took place at a café in Kuala Lumpur over a weekend, rather than during the week in the college. As the new appointed Head of Multimedia department, she was a little uneasy at

the thought of being interviewed during weekdays at the college because she was busy being new to the role.

As described in Chapter 3, I prepared an interview schedule (see Appendix A) and the schedule was designed based on the question used in my trial run. Some of the interview questions used during the needs assessment in this case study are shown in figure 4.2-1 below. However, I preferred to hold the interview in a conversational manner rather than a formal one.

Figure 4.2-1 Some interview questions asked during needs assessment

How did you deliver the subject? Is there any specific method that you used to teach the subject? What is the assessment methods that were used?

Knowing that this topic is theoretical in nature, was there any challenges you faced when delivering the topic?

How did the learners cope up with the topic? Did they have any problem in learning the topic?

Since I had developed a good rapport with Miss H prior to the interview, having previously conducted a trial run with her on the subject of Streaming Media, it was easy for us to connect during our first meeting for this case study. The purpose of the interview was for me to understand her current practice and subject scope. I started by explaining my role in this project; I then asked her questions about the subject that she taught, the strategies that she used, any challenges she faced while teaching, and so on. I observed the importance of maintaining a conversational approach as Miss H looked more comfortable with this. It is possible that this would have been a good point at which to expand the

conversation and gain more input from her. However, I was conscious of not wanting to stray away from the main questions that I had prepared. From the needs assessment, I was able to gain understanding of the **subject matter expert background, context,** and **valuable input for the case study.**

Subject matter expert background. Miss H had been teaching for about four years at the college and had a Master's degree in E-learning. She was knowledgeable about instructional design, but was not familiar at all with TSM as a concept. Prior to our meeting, Miss H had chosen the subject of Interface Design to be used as the subject matter for this research. She was teaching Interface Design during the current semester, but was not very sure of the topic or whether it was a relevant fit for the model that I was adopting. I was not in a position to choose the subject matter myself as the options were dependent on what Miss H was teaching during that particular semester. I was aiming to fit my study around the course academic calendar and therefore did not pursue any possibility of changing the timing of my involvement with the course and class.

Previously, as informed by Miss H during the needs assessment interview, the subject offered for the current semester period was supposed to be Instructional Design, but since the subject was not offered during that semester, the offered subject i.e. Interface Design was chosen. Miss H came across as very committed and interested in the research. Even though she had four years of experience teaching at the college, this was only her second-time teaching Interface Design, her first having been the previous semester. She stated that the subject was particularly new for her but she felt fairly confident of understanding the subject matter and had a positive attitude towards teaching it.

Context. Miss H began the interview by explaining the curriculum requirements of Interface Design. Interface Design was a theoretical subject comprising a lot of concepts about design including history, devices, and principles of design. The essence of the scheme of work is given in the title Principles of Interface Design. The topic covers 18 principles of how a good interface screen should look. Overall, the purpose of the scheme of work was to help the learners understand the meaning of each of the interface design principles and to make sure they were able to apply the principles in their projects. Since my case study required a complex topic, the Principles of Interface Design was seen as an appropriate choice. The complexity of this topic lies in the need for learners to be able to apply the various principles to designing the interface and to justify the rationale behind their design in relation to a project requirement. My assessment of the context for this subject matter fit into four areas: **methods of delivery, assessment, problem and challenges,** and **strategy used.**

- ***Methods of delivery.*** This subject was delivered through a series of lectures, followed by a final project at the end of the course. The learning material took the form of PowerPoint presentations which were given to the learners before each lecture. The content was presented in text supported with images. There was no tutorial for the subject, as learners were not taught how to use design software - it was assumed that they had acquired certain knowledge and skills about multimedia authoring, typography, and colour theory.
- ***Assessment.*** From Miss H's previous experience of teaching the subject, she had made some changes to the way the subject was delivered in

terms of the final project assigned to learners. Previously, the learners had been given a project that required them to design an interface for a website or multimedia application. In this semester learners were instead required to design an interface layout for digital devices. Learners also had to generate a mock-up of the digital device and collaborate with lecturers from the Product Design department. Miss H felt that the learners needed different exposure and perspectives on designing interfaces, and that this revised project format might provide the opportunity for them to learn something new about product design, as well as developing their creativity in implementing what they had learnt in the subject.

- The project given to the learners required them to integrate the interface design principles in designing the device's interface. However, there was no requirement for the learners to develop a fully functional interface. What was needed for the project was the layout of the interface which could be designed using design software such as Photoshop or Illustrator. Learners needed to print the layout and place the printed layout on the device. In order to meet the project requirements, learners need to provide a sketch of the digital device which would be used as a reference for the whole design process later. These sketches needed to be approved by Miss H before the learners could proceed to create sketches for the interface. Miss H also mentioned that learners were guided along this process and were allowed to consult other lecturers from Product Design department regarding material and product development.

- ***Problem and challenges.*** Miss H mentioned several challenges in delivering the topic, which could be broadly categorised under attention span, learners' educational backgrounds, and language barrier. On the first of these points, the learners were able to concentrate for the first half an hour of the class but typically lost focus half an hour into a lecture. This was especially noticeable when Miss H delivered a theoretical topic such as the Principles of Interface Design. There were 18 principles in total, meaning there were a lot of concepts that needed to be understood by the learners. In terms of education background, most of the learners who enrolled in the course were those who had not managed to get a place in a public educational institution due to insufficient grade results in the national examination, Sijil Pelajaran Malaysia (SPM), also known as the Malaysia Certificate of Education).
- According to Miss H, some of the learners came from different states and educational backgrounds, and some of them lacked English proficiency. Since English was their second language, this created a language barrier when the learners used English language learning material and the lectures were delivered in English. However, Miss H insisted on using English as she believed this was a form of a practice and a good way of exposing learners to English. Furthermore, it was the policy of the college to use English as a teaching medium since there were also international learners in some of the programmes. Some of the terms used in the topic, particularly around the principles, were confusing to the learners, some of whom were using Google translate as an aid. The difficulty with potentially translating the material was that in giving a

direct translation one might lose the meaning of the original source. Learners ended up memorising the principles without fully understanding the meaning of the principles in depth, and were not able to readily justify the rationale of their design work.

Figure 4.2-2 Excerpt from needs assessment interview (CS1.NA1.EX17–CS1.NA1.EX18)

> *"Learners did a lot of memorizing because there were too many terms in descriptions of the principles that were confusing to them. There were learners who actually confused the name of some principles with definitions of other different principles. And there were learners having difficulty relating their design to the principles that they already learnt."*

Figure 4.2-3 Excerpt from needs assessment interview (CS1.NA1.EX32)

> *"… there were too many principles and some of them [the learners] weren't even familiar with certain terms. For example, configurability. They need to understand the meaning of the word and to relate the definition to the definition of the principle itself in relation to designing an interface, so this is complicated for these learners. It could be said that it is a bit too much for them especially with their prior education background"*
>
> From needs assessment interview: Na.Ex.32

- ***Strategy used.*** Besides lectures, Miss H used discussion to engage the learners, and there would be discussion in the class every time she covered a new topic. She also posed questions that related to subjects that the learners had covered previously, in order to help the learners to recall their prior knowledge. This questioning promoted class participation, and Miss H believed that participating interactively in class would promote learners' thinking and confidence regarding speaking in

public. One of her assessments was class participation which constituted 10% of the overall assessment to encourage learner participation. However, according to Miss H, not so many participated. And the same learners tended to be the ones who responded during discussion.

Valuable input for the case study. During the needs assessment interview, I gained some important input for the case study including ***subject matter topic, relationship to TSM; preferences on the instructional material;*** *and* ***design tools.***

- ***Subject matter topic***. Based on the needs assessment interview, it was confirmed that the subject matter for the case study was "Principles of Interface Design".
- ***Relationship to TSM.*** I was also able to gain some input in relation to the TSM concerning Procedural Information and Supportive Information. To recap, procedural information covers 'just-in-time' information or recurrent aspects of the learning task. In this case study, I established that information on *Design Steps*, *Typography* and *Colour Theory* would function as procedural information. In contrast, supportive information covers non-recurrent aspects of the learning task. The supportive information in this case study referred to the *18 principles* of interface design. As for the issues and challenges identified in the interview, they raised some inquiry into the best or most proper strategies for delivering the content. These strategies would form the approach that I used in delivering the 18 principles which had been a problematic part of the topic for the learners.

- ***Audience for instructional material.*** During my interview with Miss H we discussed the end user, i.e. whether the learning material should be designed for the lecturer to use in teaching to support the explanations she was giving, or as standalone material for the learners to use. My initial plan was to develop for lecturer use; however, in order to promote better transfer of knowledge, we agreed that we wanted to produce a self-paced instructional material for learners which they could use anytime and anywhere in order to enhance their learning. This would allow the learners to make use of the resource outside of the lecture period and therefore practice more. It was agreed by Miss H that self-paced learning would provide another learning option for the learners besides lecture notes. We also discussed the medium for the learning material. I suggested using Flash authoring tool as it allowed more flexibility in authoring compared to PowerPoint and LectureMaker (the authoring tool that was used for the pilot run). I was thinking of creating a drag and drop activity that required the learners to arrange an interface layout according to the principles.
- ***Design tool.*** At the end of the interview, Miss H asked a question about her role in this case study. Although I thought I had explained this at the beginning of the interview, Miss H. seemed confused about her role and indeed my role in the study. Reflecting on this, I realised that it was important to prepare a flowchart or a timeline for the subject matter expert so that. Miss H could see the overall process of how the study would commence. This would also help her to arrange the evaluation

session with her learners. The flowchart and storyboard were provided to Miss H during the first evaluation of the learning material.

4.3 Design and development 1

The process of designing and developing instructional material for this case study began with the assumption that there was no flexibility to change the learning objectives as specified in the curriculum. Thus, the design and development tasks were based purely on the learning outcomes given in the curriculum. I felt that I had to work from the textbook materials and lecture notes as supplied by Miss H in order to develop content for the chosen topic. Working with an understanding of the curriculum and the material given by the lecturer, I began designing the blueprint, adapted from van Merriënboer's blueprint. As seen in the table below, it covered the four main design components of TSM: (i) Design of the Learning Task; (ii) Design of Supportive Information, (iii) Design of Procedural Information; and (iv) Design of Part-Task Practice.

Table 4.3-1 Adaptation of TSM in Case Study 1

Four components	Steps in TSM	What is the strategy?	Descriptions
Learning task	Design Learning Task Develop assessment instruments Sequence learning task	• Worked examples • Completion task • Conventional task	I chose several strategies to design learning tasks ranging from simple to complex using a worked-example task, a completion task, and a conventional task. In this case study, a worked-example task refers to an example of good interface design that learners needed to evaluate; a completion task refers to learners providing a solution to improve an example of a poor interface design; and a conventional task involved learners' proposals for a design, based on a specification given. There was no development of an assessment instrument in this case study as it was based on the existing assessment used by Miss H. The tasks went in sequence from simple to complex. As learners proceeded from one task to another, the level of support and guidance decreased. Hence, learners were required to apply a greater level of autonomy as they carried out the tasks.
Supportive Information	Design Supportive Information Analyse Cognitive Strategies	• Conceptual model	Supportive information refers to information or theory that helped the learners to perform the learning task. In this case study, the supportive information possibilities were identified during the needs assessment, namely the 18 principles of interface design. The strategy chosen in presenting the supportive information was a conceptual model. Learners were provided with a list of principles, supported by an

	Analyse Mental Models		example of an interface design to support the explanation of the principles. This phase involved thinking of strategies to help learners deal with unfamiliar aspects of the learning task. Learners covered the 18 principles of interface design that they needed to allow them to perform the learning task. The 18 principles were presented directly to learners as information for them to study and apply while carrying out each learning task. One of the challenges about this topic was the expectation that learners would have difficulty in understanding the content, as indicated by Miss H, perhaps because the relationship between the 18 principles and its function within the task was not clear. In particular, I wondered whether the materials provided by the teachers were appropriate for the learners in terms of being a good match with their mental model. The list of principles would be difficult to remember and apply, and I felt there was a better approach to organising the principles if they were to act as a checklist for designing an interface. I realised that this was probably a problem of organising the principles and understanding how the principles differed in order for this checklist approach to be successful. I presented the 18 principles by giving each a definition and identifying its main characteristics. This was supported with a design case to help learners to see the relationship between the principles and a simulated design interface. Multimedia were used to support the presentation of supportive information, and I used images of interfaces and added interaction that allowed learners to drag and drop labels to the area where the principles were applied.
Procedural Information	Design Procedural	• How-to instruction	Procedural information refers to information presented to learners only when they needed it to perform routine aspects of the learning task.

	Information Analyse Cognitive Rules Analyse Prerequisites Knowledge	• Prerequisite information	In this case study, procedural information possibilities were identified during the needs assessment: firstly, steps in interface design for which a step-by-step instruction strategy was used; and secondly, prior knowledge or prerequisite information of the topic, for example knowledge of colour theory and multimedia principles. Procedural information was based on knowledge of the existing curriculum material. As such the topic dealt with a lower order of skills such as comprehension.
Part-task practice	Design Part-Task Practice	• Practice item	Part-task practice refers to additional practice given to the learners to help them retain knowledge and comprehend the topic. I added a multiple-choice question quiz for the learners to practice with. Although the material does not use state of the art of computer technology, it had a high degree of relevance for the learners because the subject matter was an area in which they would be assessed by examination.

Following the blueprint design was the development of flowchart and storyboard. These provided a convenient way to visualise the work. The storyboard and the flowchart were developed using Microsoft Office PowerPoint, which enabled a high-fidelity prototype. In this programme, I could use branching to visually demonstrate how the instructional material might look and explain the navigation structure, but of course with limited navigation. My interaction with a colleague, who has experienced in content development suggested that this was a cost-effective approach which was being used by instructional designers in Malaysia. Unlike my previous experience as a courseware developer, I worked in a paperless way. The storyboard and the flowchart were emailed to Miss H for her comments or changes. Given her busy role as the Head of Department, it took a few days for Miss H to reply with feedback on the storyboard and flowchart which I had emailed to her. The feedback basically covered the technical aspect, as seen in figure 4.3-1. The example of the storyboard and flow chart can be viewed in Appendix C.

Figure 4.3-1 Part of design log 23 March – 1 April

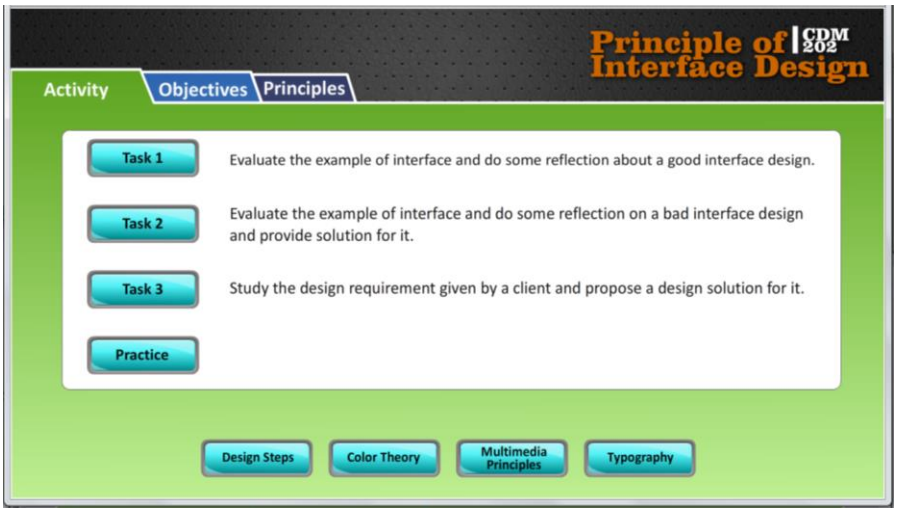
"Her comment was more on the technical aspect of the storyboard/low fidelity prototype".

"*So far looks okay. It's just on page 5 the button position is not the same as the rest and there is also no Home button. Other than that, it is okay*". I think I should have addressed more specific questions to invite her for an in-depth discussion".

Log date: 23 March – 1 April 2015

Based on the flowchart and the storyboard, I proceeded to develop the learning material using the software Adobe Flash. As seen in Figure 4.3-2, there were three learning tasks designed within this material. These learning tasks followed a strategy of *worked-out example*, *completion task* and *conventional task*.

Figure 4.3-2 Learning task used in the learning material

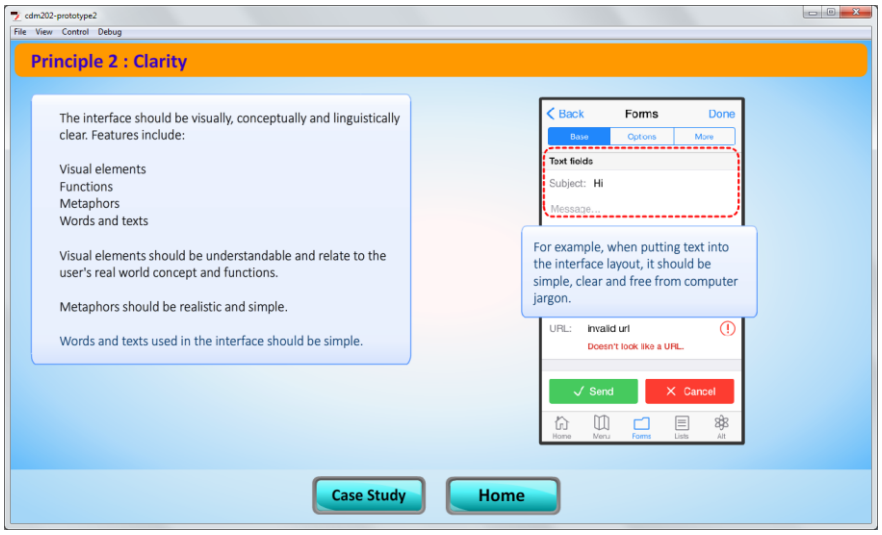


The supportive information for this case study comprised the 18 principles of interface design as seen in figure 4.3.3. The 18 principles were made Supportive Information as they were the concept and theory that learners needed to be able to differentiate and apply in carrying out the learning task. Learners needed to click on the principles button in order to access the information. There was no restriction on which principles they should learn first.

Figure 4.3-3 Supportive Information - the 18 principles

Figure 4.3-4 shows the explanation of each principle, supported with images. Learners can click on the case study button in order to carry out a simple activity associated with the principle.

Figure 4.3-4 Supportive information - Explanation of the principles



4.4 Evaluation 1

The evaluation of the learning material took place at the computer laboratory at the institution itself. Since I was not able to be there during the evaluation, I arranged for a colleague to observe and record a video whenever possible. Prior to the evaluation, I had given Miss H a briefing and guidelines of what should be done in terms of implementing the instructional material in the laboratory. I tried my very best to make access to the instructional material straightforward. The instructional material only need to be downloaded from my password-secured Dropbox and copied to each individual computer in the laboratory. Since I had converted the Flash file into an execute application, learners did not need to install the instructional material to run it. My intention was to evaluate the

content in the instructional material, rather than the implementation of the technical side of setting up the material. There were two types of data gathered during the evaluation: online survey, and Facebook feedback.

Online survey. For the survey, learners were asked to fill in an online questionnaire. The questionnaire consists of 16 questions in a Likert-scale form. As described in the Methodology chapter, the questions covered four domains; knowledge, attitude, skill, and accessibility. The accessibility aspect included questions about graphics, text and colour in the learning material. The language used was English, but during the evaluation some of the questions were translated by Miss H in order to help learners with English difficulties.

Table 4.4-1 Dimension and questionnaire items

Dimension	Question No.															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Knowledge	/	/	/													
Skills						/		/								
Attitude				/	/		/		/							
Accessibility										/	/	/	/	/	/	/

As seen in the table below and in other two cases later, the data was presented in percentages, the overall positive percentage referring to the total percentage of responses indicating *'strongly agree'* and *'agree'* for each question. From the survey,

it could be said the learning material was not well received by most of the learners. The learners were able to understand the topic, but at a low level and not to the extent they felt confident enough to explain and apply the principles of interface design. Some of the learners felt undecided and chose to respond neutrally to the most questions about their understanding of the topic (knowledge), their confident about the topic (attitude), and their ability to apply the knowledge (skills). My speculations as to the reasons for this included an understanding that learners may had difficulty with the language used in the material, since it was learnt from the needs assessment that English was one of the challenges to learning faced by the learners.

Although responses to question 12 showed that some learners find the material easy to use, it may have been that others could not comprehend the content given to them regardless of the ease of use of the material, and thus felt that a neutral position might be more sensible in describing how the perceived the learning material.

Table 4.4-2 Summary of participants' perceptions of instructional material (n=17)

Item	Statement	Agree (%)				Neither	Disagree (%)				
		Strongly Agree		Agree			Disagree		Strongly Disagree		% of +ve
		3	17.60	6	35.30	6	35.30	2	11.80	0	0.00
1	I understand the content presented in the learning package.	**9**				**6**	**2**				**52.90**
		2	11.80	7	41.20	3	17.60	5	29.40	0	0.00
2	I feel my understanding of some of the principle has increased.	**9**				**3**	**5**				**53.00**
		0	0.00	7	41.20	6	35.30	4	23.50	0	0.00

3	I understand better after trying out the activity in the learning package.	**7**				**6**	**4**				**41.20**
		0	0.00	5	29.40	7	41.20	5	29.40	0	0.00
4	I felt confident about designing an interface and making use of the principles covered in the instructional material.	**5**				**7**	**5**				**29.40**
		1	6.30	3	18.80	7	43.80	3	18.80	2	12.50
5	I felt confident about designing an interface after trying out the activity in the learning package.	**4**				**7**	**5**				**25.10**
		4	23.50	5	29.40	6	35.30	2	11.80	0	0.00
6	I know the steps taken in designing an interface.	**9**				**6**	**2**				**52.90**
		2	11.80%	4	23.50	6	35.30	4	23.50	1	5.90%
7	I feel confident about explaining the principles of interface design.	**6**				**6**	**5**				**35.30**
		1	5.90	5	29.40	8	47.10	2	11.80	1	5.90
8	I find design interface an easy topic.	**6**				**8**	**3**				**35.30**
		5	31.30	5	31.30	2	12.50	3	18.80	1	6.30
9	I felt happy when using the learning package.	**10**				**2**	**4**				**62.60**
		3	17.60	7	41.20	1	5.90	6	35.30	0	0.00
10	I understood how to use the learning package.	**10**				**1**	**6**				**58.80**
		2	11.80	7	41.20	6	35.30	2	11.80	0	0.00
11	I liked the appearance of the learning package.	**9**				**6**	**2**				**53.00**
		0	0.00	4	23.50	5	29.40	5	29.40	3	17.60
12	I found it difficult to use the learning package. **	**4**				**5**	**8**				**23.50**
		8	47.10	1	5.90	4	23.50	4	23.50	0	0.00

13	I think there is a need to use media such as animation or video in the learning package.	**9**				**4**	**4**				**53.00**
		4	23.50	4	23.50	5	29.40	4	23.50	0	0.00
14	I found the graphics used in the learning package helped me to understand the principles.	**8**				**5**	**4**				**47.00**
		4	25.00	2	12.50	5	31.30	5	31.30	0	0.00
15	I could read the text clearly while using the learning package.	**6**				**5**	**5**				**37.50**
		3	17.60	5	29.40	3	17.60	5	29.40	1	5.90
16	I liked the colour and design used in the learning package.	**8**				**3**	**6**				**47.00**

Facebook feedback. After they had filled in the survey, Miss H asked the learners to provide reflective feedback, via Facebook, of their personal experience when using the learning material. The Facebook feedback was not part of my plan but I was happy to see that Miss H had demonstrated commitment to this study through taking this initiative. The feedback was written in the existing class Facebook group which had been created by Miss H specifically for the Interface Design classes. The feedback was opened on 28 April 2015 and there were 17 comments in total. Some examples of the feedback are shown in the table 4.4-3.

Table 4.4-3 Some of learners feedback in Facebook

Item	Feedback	Area / Code
CS1.EV1.FB15	*The clip is a bit too fast, we literally missed the chance to look (read).*	Control
	A bit more attractive colour would be a blast.	Look and feel

	Add on a few more shortcut button.	Control
	Probably we need a playback during case study	Control
CS1.EV1.FB4	*Too fast...*	Control
	Need more button...	Control
	Need playback...	Control

I was able to triangulate the data gathered from the survey with the Facebook feedback. The feedback received from both was consistent as it concerned the elements and accessibility of the instructional material, the content, and attitudes towards the learning material. The accessibility of the instructional material was the most covered aspect in the feedback and covered timing of the presentation, multimedia elements, and interface theme. This will be discussed later in the Design and Development 2 section.

Observation. Since I was not able to be present during the evaluation, I had asked my colleague to observe the evaluation on my behalf. In my judgement, she had a less 'biased', more at a distance view because she had not been the hands-on designer of the material and might offer a more neutral position as an observer. Prior to the observation, she was given a checklist of the things to which she needed to pay attention. The checklist was open-ended observation checklist (see Appendix F) that was adopted based on McKenney's (as cited in Richey and Klien, 2007, p.117). During her observation, she recorded video of some of the sessions. While this was unstructured footage, some of the shots were useful as they showed how some learners dealt with the instructional material. This is shown in table 4.4-4.

Table 4.4-4 Some description on the recorded footage

Clip	Summary
CS1.EV1.mv_5314 (duration: 2:07)	The lecturer gives brief explanation about the research to the learners. She highlighted three main menus; the tab menu of "Objectives", "Principles" and "Activity". The lecturer also provides instruction on their role; what they need to do.
CS1.EV1.Mv_5326 (duration: 0:30)	The learner seems like spending a few seconds reading the text before navigating to case study screen. Then, the student tried out the activity (drag and drop).
CS1.EV1.Mv_5332 (duration: 1:19)	In this clip, the learners (two person) read the text and discuss about the content and try out the drag and drop activity. They seem to figure out why their answer is wrong by looking at the keyword in the content.

After the evaluation session, my colleague sent me the recorded video and a report of her experience during the observation via a Dropbox sharing folder. This was the easiest method due to the distance, plus for security purposes it was a close shared folder. The observations made by my colleague during the evaluation of the instructional material were consistent with the data I had from the survey and feedback, as shown by her report.

Figure 4.4-1 Observation report for evaluation 1

During the 1st observation, instructions were clearly delivered. As there were many learners from different levels (beginner, intermediate and expert), all of them did not start simultaneously. Some of them did not really understand the instruction and needed some time to digest, and needed close monitoring as their performance in English is just fair.

There were some of the learners who did not really read the matching text and simply dragged and dropped the text to the answer box. Some read properly and tried to match the answer.

However, there were also some learners asking how they were able to know whether their answers were correct or not. They also commented that the same questions were repeatedly presented even on different principles of the interface design.

Summary by observer during first evaluation

Interview. Miss H was also interviewed after the evaluation. The interview was done remotely via email, hence the guide in the interview schedule was altered to suit the medium. The questions were generated around some areas; the components of TSM adapted in the learning material, its usefulness, the presentation, and the pros and cons of the material (see Appendix B). Some of the interview questions are shown in figure 4.4-2.

Figure 4.4-2 Some of interview questions used in evaluation 1

What do you think about the task provided to the learners in "Activity"?

Does the additional link for example "Colour Theory", "Design Steps" help the learners to carrying out the task?

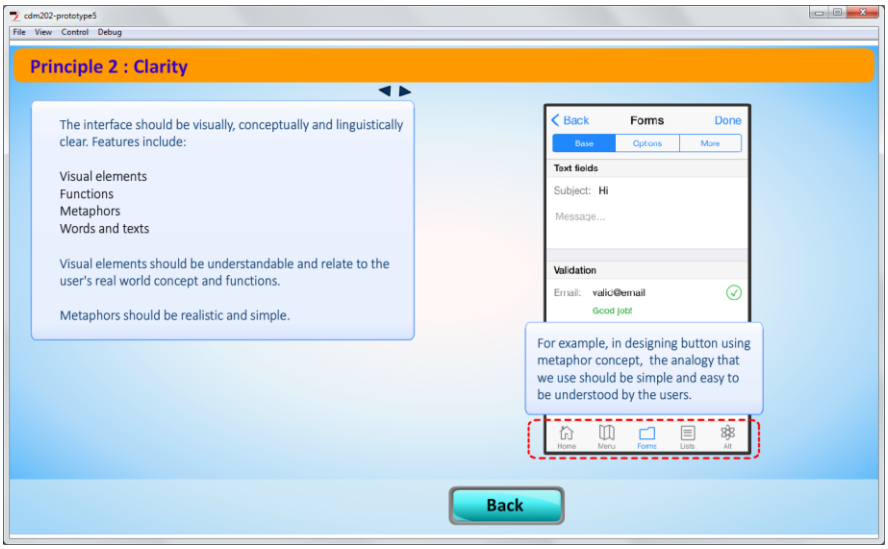
Do they need help and guidance while trying out the prototype?

4.5 Design and development 2

At this stage, the feedback was not what I had hoped and I began to realise that the learning material had not had the impact I thought it would. Perhaps because of my educational technology background, I tended to focus on how the product looked. I had focused on the technical aspects of the instructional material, but realised there was a wider context to the use of the product. In reflecting on the Facebook feedback from Evaluation 1, there were a few themes emergent. I addressed timing of the presentation, multimedia elements, and interface theme.

Timing of the presentation. The learners commented that they were not able to follow the presentation of the content as most of them took more time to read and understand the content than was given by the program. This was a concern raised in student Facebook feedback. Therefore, I added a control button in order to allow the learners to set their own pace. The button was designed in a form of an arrow that represented the *"Next"* and *"Previous"* screens. I considered this to be an appropriate option as there were only on average five screens for each principle. Via these buttons, learners would be able navigate through the instructional material in a self-directed fashion.

Figure 4.5-1 Updated layout for timing of presentation

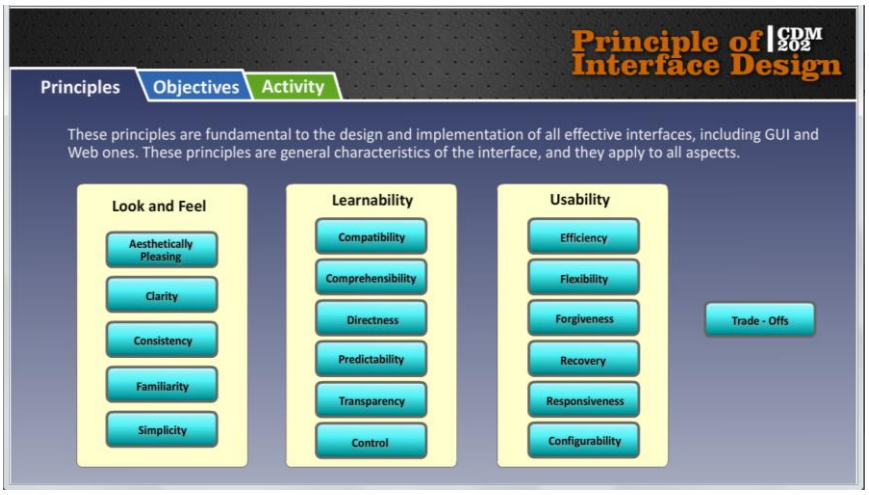


Multimedia elements. Some of the learners suggested having more graphics and animation to support the explanations; the use of audio and dual language options for the instructional material were also mentioned. However, I felt the graphics and animation that were already in use were sufficient and met the purpose of explaining the key concepts of the principles. Adding more of them would have overloaded the content. The suggestion to provide a dual language option for the instructional material was a good one, but I did not proceed with the changes as there were resource and time constraints. I would have required an expert to translate the content into Bahasa Malaysia. I could imagine this process would take quite some time as it is not easy to translate while maintaining the same meaning as in the English version. As I was working to a strict timeline (I had another two case studies to attend to), this would not have been practical to proceed with. Furthermore, at this point, I did not see that language was a major issue in the instruction. At the end, it turned out that language issue was a

critical one and in fact was one of the major factors as to why the learners found the instruction difficult to comprehend.

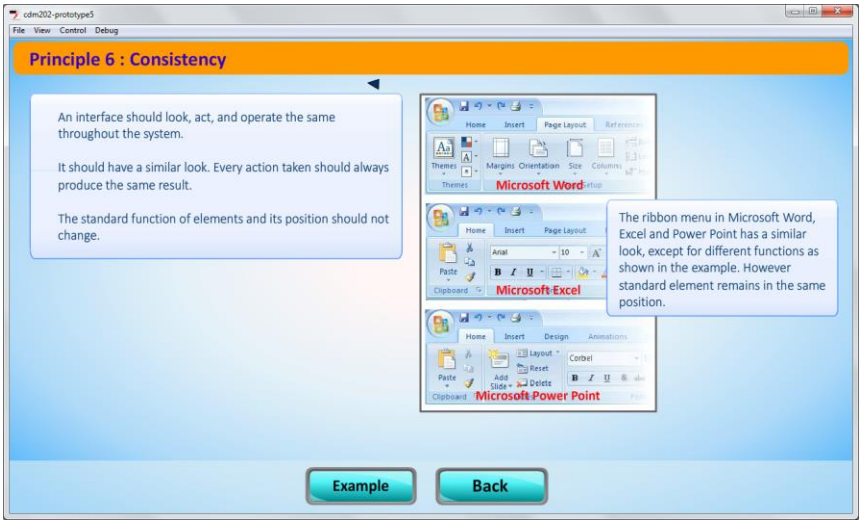
Interface theme and categorising the principles. Some of the Facebook feedback concerned the interface theme, including the colour theme used in the instructional material, font type and size, and the layout of the screen elements. I did not do a thorough overhaul because of the limited time and I saw these as minor issues which would not affect the learners' responses so markedly. However, I made some small changes including changing the background colour for the three tab menu for Objectives, Principles, and Activity. This was to better distinguish the differences between those menus. I did not make any changes to the background colour of other screens or to font type and size as I felt it already met the standard screen size presentation. I rearranged the principles interface and categorised the principles according to themes*: "Look and Feel", "Learnability"* and *"Usability"* (shown in Figure 4.5-2). I believed this would help to better match the learner mental model and enable them to see the relationship of the principles to the process of designing an interface.

Figure 4.5-2 Updated layout of the principles interface



In order to help learners to understand the function of each button, I changed the name of the button to a more user friendly one. For example, in the previous prototype a *"Case"* button was used; this was changed to *"Example"* as seen in Figure 4.5-3. Through understanding the function of each button, it was hoped that learners would find it easy to understand how to use the learning material and that this would indirectly increase the learnability of the material.

Figure 4.5-3 Updated layout of the principles interface



4.6 Evaluation 2

The exercise of Evaluation 2 was the same as Evaluation 1; however, the circumstances were different. The evaluation for the second round took place at the computer laboratory at the institution itself. I was not able to be there during the evaluation, and arranged for the same colleague as in Evaluation 1 to observe and record video whenever possible. Miss H was briefed and given a guideline of what should be done in terms of implementing the instructional material in the laboratory, and the instructional material could be accessed by downloading a Flash execute file from my password-secured Dropbox and copying it to each individual computer.

The learners involved in the second evaluation were from a different cohort. As this subject was offered during the short semester, there were only six people voluntarily enrolled for the course. Although the sample size was small, I was encouraged that there were other studies that used a small sample size in parametric tests (see Norman, 2010, p.628). The data gathered during this evaluation was again in the form of a survey, observation, and interview with Miss H. There was no Facebook feedback as in the first evaluation, so I added an open-ended question to the end of the survey as I found it useful for the evaluation. However, the feedback from the open-ended question received was not hugely helpful as three of the learners did not give their feedback, and the other three gave only short feedback that focused on the technical issues.

Online survey. There were changes to the survey questions whereby some of the questions were modified in terms of the wording, and two questions were

added to make up a total of 18 questions. The questionnaire still maintained the same dimensions as in Evaluation 1: knowledge, skills, attitude, and accessibility. Its purpose was to encourage learners to reflect on the instructional material.

As for the questionnaire items, the results were similar to the first evaluation. As seen in Evaluation 1, the data was presented in percentages, the overall positive percentage referring to the total percentage of responses indicating 'strongly agree' and 'agree' for each question. It could be seen that there were large number of responses in the neutral position. This suggests that the learners had not engaged sufficiently with the instructional material to be able to reach an opinion. I could sense that there was an issue with the content and the language used in the material or the context in which the product had been used.

Table 4.6-1 Summary of participants' perception on instructional material (n=6)

Question No.	Statement	Agree				Neither		Disagree				
		Strongly Agree		Agree				Disagree		Strongly Disagree		% +ve
		0	0.00	1	16.70	2	33.30	1	16.70	2	33.30	
1	I understand that interface design is a step by step process.	**1**				**2**		**3**				**16.70**
		0	0.00	1	16.70	2	33.30	2	33.30	1	16.70	
2	I understand the principles of interface design in real life settings.	**1**				**2**		**3**				**16.70**
		0	0.00	1	16.70	4	66.70	0	0.00	1	16.70	
3	I feel confident about designing an interface by following the step by step approach.	**1**				**4**		**1**				**16.70**
		0	0.00	2	33.30	1	16.70	2	33.30	1	16.70	
4	I can identify the strengths and weaknesses of my own designs.	**2**				**1**		**3**				**33.30**

		0	0.00	1	16.70	2	33.30	2	33.30	1	16.70	
5	I felt confident about justifying my design decisions.	**1**				**2**		**3**				**16.70**
		1	16.70	1	16.70	2	33.30	2	33.30	0	0.00	
6	I found interface design an easy concept.	**2**				**2**		**2**				**33.40**
		1	16.70	1	16.70	2	33.30	1	16.70	1	16.70	
7	The learning package developed my confidence in interface design.	**2**				**2**		**2**				**33.40**
		0	0.00	1	16.70	2	33.30	3	50.00	0	0.00	
8	I enjoyed using the learning package.	**1**				**2**		**3**				**16.70**
		0	0.00	2	33.30	1	16.70	2	33.30	1	16.70	
9	I liked the presentation of the content.	**2**				**1**		**3**				**33.30**
		1	16.70	1	16.70	1	16.70	2	33.30	1	16.70	
10	I liked the colour scheme used in the learning package.	**2**				**1**		**3**				**33.40**
		0	0.00	2	33.30	3	50.00	1	16.70	0	0.00	
11	The three tab menu ("Objectives", "Principles" and "Activity") was easy to use.	**2**				**3**		**1**				**33.30**
		1	16.70	0	0.00	3	50.00	2	33.30	0	0.00	
12	I was clear about how and where the buttons worked.	**1**				**3**		**2**				**16.70**
		0	0.00	1	16.70	3	50.00	2	33.30	0	0.00	
13	The graphics were helpful in understanding the topic.	**1**				**3**		**2**				**16.70**
		0	0.00	2	33.30	2	33.30	2	33.30	0	0.00	
14	The content was well organised.	**2**				**2**		**2**				**33.30**
		0	0.00	2	33.30	2	33.30	1	16.70	1	16.70	
15	The text was easy to read.	**2**				**2**		**2**				**33.30**
		1	20.00	0	0.00	1	20.00	3	60.00	0	0.00	
16	I liked the colour and design used in the learning package.	**1**				**1**		**3**				**20.00**
		2	33.30	1	16.70	1	16.70	1	16.70	1	16.70	
17	The drag and drop	**3**				**1**		**2**				**50.00**

	activity was helpful.											
		0	0.00	2	33.30	1	16.70	2	33.30	1	16.70	
18	The feedback was helpful.	**2**				**1**		**3**				**33.30**

Observation. As in evaluation 1, the same colleague acted as an observer for this evaluation session and was given the same observation guide to help her. During the observation, some video shots were taken and were shared in my Dropbox folder as with the first evaluation. She also provided a report of her evaluation. It could be said that her evaluation was conducted quite informally. Her observation raised issues of learner readiness for using the instructional material, which is shown in the figure below.

Figure 4.6-1 Observation report for evaluation 2

A student just opened the sections of the question and only observed the question without answering it when he was observed…

...he did not even mention to the instructor that he did not understand how to answer the question. His problems were only identified long after the session has started when the lecturer did individual monitoring…

… Some learners did not digest the notes and prefer to click, drag and drop the bar…

Interview. This interview with Miss H took place about two months after the evaluation. As I was going back to Malaysia to conduct the evaluation session for my second case study, I managed to set an interview at the college with Miss H during my visit. The questions during the interview were also based around the interview schedule (see Appendix A) but altered to the needs of the second evaluation. During the interview, I was able to access some of the learners' projects and Miss H showed me how learners had applied their knowledge in the project. I was also told that the learners had already finished the class and were

preparing for final examination. Besides that, I was able to gain feedback about Miss H's perceptions of the instructional material. One of the main concerns was about the way that the content had been presented to the learners.

In the interview, Miss H expressed that the format might not have been useful for her learners; she felt that the sequence of how the content was presented to the student should have been structured within a linear approach. She preferred that the concept of the interface be introduced first, followed by a learning task for them to practice what they have learnt from the concept presented earlier. Her preferences were based on her teaching experience whereby learners were normally given a lecture and learning material, followed by tasks for them to practice. Miss H saw the value of the approach but identified a problem for the learners. She believed it might be a bit difficult for the learners to adapt to it. The interview excerpt below illustrates this point:

Figure 4.6-2 Excerpt from the interview with Miss H (CS1.EV2.EX14)

I think it is ok so far. But I would prefer if the concept of the principles being introduce first, then followed by the learning task for the learners to practice. This way, they are able to relate what they have learnt.

Figure 4.6-3 Excerpt from the interview with Miss H (CS1.EV2.EX15)

This approach is okay but the learners might find it a bit difficult to learn through this approach. This is because normally they were given material first, like lecture notes, then followed by a practice task. However, I think this approach is okay. It encourages learners to think rather than accepting the content solely.

4.7 What I learnt

What are the obstacles of adapting the model in designing instructional material?

Using TSM was more complicated than I thought. TSM helped draw attention to the breaking down of learning tasks and structuring the content in this case study. However, with the variety of strategies to choose from for designing the learning task, supportive information and procedural information, it was confusing and time consuming. For example, I found it difficult to choose which strategy should be utilised to present and explain supportive information once I had decided that the 18 principles could be categorised as supportive information. As I focused my attention on the steps in TSM, I did not focus on checking the material given by Miss H. It turned out that the content itself was problematic in the senses that it was difficult for the learners to comprehend.

The models of learning. Since I adopted the TSM in designing the instructional material, the approach of presenting the learning task and content was different to what the learners were used to. TSM suggested the approach of learners integrating different kinds of information (received from supportive information and procedural information) while carrying out the learning task presented to them. In other words, it works by presenting the learning task to the learners first and at the same time enabling them to use information while carrying out the learning task.

In my judgement, the TSM approach has the same concept as problem-based learning whereby learners learn while solving a problem given in a learning task.

This approach however was different to the normal procedure for teaching and learning in a Malaysian classroom in which learners are normally presented with content followed by learning task. Perhaps the learners were expecting the same learning structure when they used my instructional material. This may be one reason for the disappointing feedback as seen in the evaluation.

How did TSM help in designing the instructional material?

Breaking down the learning task. Despite the obstacles discussed earlier, TSM was usable. I could follow the model to break down the learning task and structure the content. Besides, the model provided a blueprint in designing instruction. With different kinds of strategies available, it allowed me to scaffold the learning task and break it down from simple to complex.

Structuring content. In designing instructional material for complex content such as the Principles to Interface Design topic, TSM helped in structuring the content by categorising the content based on (i) supportive information, which is knowledge and skills that will be used by learners to solve different kind of problems in designing interface (the 18 principles), and (ii) procedural information which involves learners performing step by step skills and other prior knowledge needed in the process of designing interface (e.g. design steps and other prior topic such as colour theory and typography). These could be seen in section 4.3 of this chapter. Besides that, TSM also suggested a variety of strategies to guide in presenting supportive information and procedural information, which I found to be valuable.

Blueprint as tool. TSM provides a blueprint in designing instructional material in this case study. It asked you to provide; what are the task learners needed to do in order to learn the topic and what are the knowledge and skills needed by the learners in order to carrying out the task.

Other reflections that do not relate directly to TSM

This case study presented broader design problems that are worthy of consideration in designing instructional material. These other reflections are detailed below.

English as a medium. I recognised that one of the problems that occurred was due to the use of English as a medium. Even though the feedback from learners did not indicate directly that they were having problem with English, the difficulty they had in comprehending the content could be assumed to have at least in part derived from the difficulty they had with English. As mentioned in the needs assessment session, I felt English was one of the issues that most commonly affected the learners in this case study, especially when the type of content involved a lot of theory and concept. In this case, even though TSM helped to break down the learning task and structure the content, there was still a need to think of a better way to present the 18 principles that was easy to be grasped by learners without compromising or watering down the main point that is meant to be presented.

Limitation of the curriculum material. Dealing with the limitation of the curriculum caused me difficulty in designing the learning material. In reflecting

on the curriculum, I felt learners' ability to understand, analyse and apply the 18 principles was daunting which helped explain why the learning material was not well received. This is a general issue about design which is not covered in TSM. Given another opportunity, I would want to re-examine the idea that there are solutions for instructional design without taking account of ideas of learner readiness.

Limitations in the medium and media chosen. As seen earlier in this chapter, computer based instruction was chosen as the medium for the instructional material which provided the opportunity to use multimedia in presenting learning tasks and content. However, feedback and observation showed that during the evaluation there were learners who did not find the multimedia was enough and suggested the use of more multimedia elements in the instructional material. Although I understood the opportunities of media in computer based instruction, it is undeniable that learners have their own preferences.

Learners as participants. In this case study, the learners tended to focus on the cosmetics of the prototype rather than on the content. In the evaluation, most of the feedback and suggestions by the learners involved multimedia elements and the presentation of the content rather than reflecting on the content itself.

Learners' prior knowledge. Besides the instructional material, learners probably received knowledge from other sources for example the internet, self-reading or through peers. It is therefore difficult to determine whether the learning occurred purely because of the instructional material or because of any other external factors influence learning.

Learner readiness. Learners' readiness to use the prototype influenced their perception of and attitudes towards using the prototype. For example, they tended to click on buttons randomly rather than reading or trying to understand the content. Perhaps this was because the activity lay on the outside of learners' zone of proximal development.

4.8 Summary

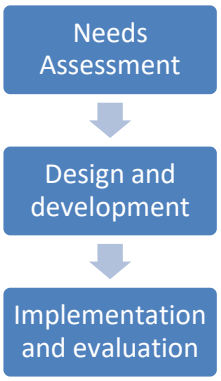
This chapter has given an overall description of the design and development process of the case study of subject matter Principles of Interface Design taken from a module, Interface Design. It was organized based on several phases that included needs assessment, two phases of design and development, and two phases of evaluation. Each process in the phases and its relation to other phases were described in detail. At the end of this chapter, what was learnt from the cases in relation to the obstacles of adapting the TSM and how did TSM help in in designing learning material as well as other reflections that do not relate directly to TSM were described.

CHAPTER 5: THE CASE OF INJECTION MOLDING

5.1 What is this chapter about?

This chapter explains the second case study, including descriptions of and discussion around the process of needs assessment; the design and development of the instructional material; the evaluation of the instructional material; and what I learnt from the design process and the evaluation. The figure below explains the basic outline of the process:

Figure 5.1-1 Design and development of the second case study



Case Study 2 was conducted at a technical college in South Malaysia and involved one class of learners (n=21). This case study was conducted concurrently with Case Study 1. As a topic, Product Defect was selected from a module on Introduction to Plastic Technology. The topic focuses on teaching the learners about types of product defects, and the learners were expected to apply their knowledge in identifying injection moulding defects and their causal factors. A Flash platform was used to develop the instructional material, which was

expected to be accessed as an app. The app was not made available to be downloaded openly in order to avoid any copyright issue. Furthermore, to remind the reader, this study was a design and development research, thus the app was still at the prototype stage. Therefore, the app was given to the learners in an app execute file and they needed to transfer the file to the folder in the mobile phone or gadget.

The key events for this case study are summarised in the table below:

Table 5.1-1 Summary of the types of data collected based on the design and development phase in Case Study 2

Phase	**Key Activity**	**Research Data**	**Main Purpose**
Analysis	Needs Assessment: Interview with Mr. S	Interview	Scoping of needs assessment
Design	Blueprint design Flowchart and storyboard development	Design log	Adapting TSM in the blueprint and using the blueprint to design the instructional material Designing and developing a flowchart and storyboard as a means for communication with Mr S to check on the content and provide feedback
Development	Prototype development	Design log	Using the flowchart, storyboard and blueprint to design the material

Evaluation	Feedback from Mr. S	Interview	To understand what needed to be changed to improve the material
	Feedback from learners	Survey (online)	To gain learners' perceptions of the material.
	Observation	Field notes, using an open-ended schedule	To assess learners' perceptions of the material

5.2 Needs assessment

In order to understand the context and background of the case, a needs assessment exercise was conducted with the lecturer who taught the subject, referred to here as Mr S. Prior to scheduling the initial meeting for needs assessment, I managed to make an appointment with the head of department. However, since he was not the person who taught the subject that I was intending to research, he introduced me to Mr. S. This needs assessment was held at the college and involved two sessions.

During the first session, I interviewed Mr. S in a conversational rather than formal manner, an approach based on my experience in Case Study 1. However, since I did not develop the same kind of rapport with Mr. S as I had done with Miss H, I felt there was a gap. In addition, the subject was not in the area of my expertise, and I felt there were so many things that I needed to explore. The questions were prepared based on the interview schedule seen earlier in Case

Study 1. It covered teaching methods and its processes, teaching and learning material used, assessment methods, the course structure including important topics covered, and challenges. Some of the interview questions asked during needs assessment in this case study are shown below.

Figure 5.2-1 Some of the interview questions used during needs assessment

From your teaching experience, what is the challenges that you faced or maybe the learner faced in learning the subject?

How did you approach the subject? What methods did you use?

What were your concern about the computer-based training programme (named XXX) given to the learners? Is it helpful?

The second session of the needs assessment entailed visiting the computer lab and injection moulding workshop. This was initiated by Mr. S since I did not have any experience of the injection moulding course. I was able to see demonstrations of the computer-based training programme that was used by the learners to learn about injection moulding which was conducted at the computer lab. This programme was basically a simulation program which allowed learners to get familiar with the control panel of an injection moulding machine, including the dials or buttons and the values to be entered in order to run the machine. This second session was more about observing how learners handled the injection moulding machine which was conducted in the moulding workshop. From both sessions, I managed to gain understanding of the **subject matter expert background, context,** and **valuable input for the case study.**

Subject matter expert background. Mr. S is an experienced lecturer who taught Plastic Technology. He had a Master's degree and had been teaching the subject for a long time. Unlike the first case study, I did not know this colleague before the interview took place and it therefore took a while to establish some rapport. However, after explaining about my study, he seemed to be more comfortable with the session. Mr. S was not familiar with TSM or even with the field of instructional design, but after my explanation he understood what this study was about. He did not decide which subject matter would be used for this case, instead wanting me to choose a suitable topic after I had had some experience about injection moulding from visiting the computer lab and injection moulding lab. He was very committed and willing to guide me in my understanding of injection moulding.

Context. Mr. S began the interview by explaining about the Plastic Technology diploma, a three year programme consisting of two and a half years of classes at the college followed by six months of training in industry. The curriculum structure was divided into three phases:

1. Semester 1: Theory – introduction to machine, materials, and basic technical skills such as AutoCAD.
2. Semester 2: Basic – introduction to basic plastic processing, computer-based training, and machine basics such as knowing machine parts and how to start the machine.
3. Semester 3: Advanced – how to start production, material and machine preparation, changing moulds, and troubleshooting.

According to Mr S, there was a lot to be covered within two and a half years' programme and the lecturer needed to select wisely what they thought would be useful for the learners as preparation to enter industry.

The subject matter chosen for this case study was Product Defect, which was taken from the Introduction to Plastic Processing Technique module. This was because it fit the characteristics of complex learning required for this study. Since the Product Defect topic required learners to be able to identify defect, analyse the cause of defects, and provide solutions to overcome defects, it fitted into the context of complex learning. This module was offered in Semester 1. From the needs assessment interview, it was understood that there were two essential areas of knowledge and skill that the learners needed to acquire: running the injection moulding machine, and troubleshooting the machine when there was a product defect. The computer-based training that the learners had already undergone covered the parameters and values needed to run the machine. The critical gap, according to Mr. S, was identifying the type of defect in order to offer a solution. Therefore, product defect was the main focus in this case study.

Contextual themes emerging from the needs assessment interview included ***methods of delivery and assessment***, and ***problems and challenges***.

- ***Methods of delivery and assessment.*** The process of teaching and learning began with the learners being introduced to the subject matter content in lectures, for example topics such as different kinds of injection moulding machines, type of materials used in moulding, and types of product defects. The teaching and learning materials used were in the

form of Microsoft Power Point slides, along with videos of injection moulding processes and how the machine worked. Then, with the knowledge acquired from the lectures, the learners were introduced to computer-based training that used a simulation approach. Since this was a technical college, the structure of the course was focused on technical and lab practice. The allowed time for practical lab sessions was four hours. However, the department normally scheduled two practical lab sessions into one day (4 hours + 4 hours) and ran the lab as if it was a real life production setting. This was because it took time to set up the machine, and scheduling two sessions in one day would also save costs. In terms of learning, each session offered a focus on handling the machine and gave learners an opportunity to experience production in a real setting.

- Learners were divided into groups of two, and two groups would work together to run the machine. By doing this, the learners would have more time with the machine compared to learning in a large group. During the practical labs, learners were given a job sheet that contained a task and instructions about what they needed to do. Learners would need to follow the instruction in order to complete the task on the job sheet. In order to be assessed, they needed to write a report at the end of the lab session. Learners had the opportunity to run the machine and produce marketable plastic products such as souvenirs. This offset the cost of materials and running the machine and gave a real life experience that motivated learners them as they learned the topic. Besides practical reports, learners were also assessed by examination.

- ***Problems and challenges.*** Challenges identified as being faced within the course were primarily around **anxiety and safety** and the **language barrier**. Most of the learners who enrolled in the programme had no experience in handling industrial machinery; according to Mr S, most of them had never seen any heavy-duty industrial machinery such as injection moulding machines. This was due to a lack of machine exposure when in high school. Thus, one of the purposes of the computer-based simulation used in the programme was to reduce the anxiety of learners around the equipment and to prepare them before they had real experience during the practical lab. According to Mr. S, the computer based simulation generally managed to reduce anxiety among first time learners, but not comprehensively as there was still a gap in terms of confidence in dealing with big machinery in a real practical lab, especially among female learners and learners who had no prior exposure at all to the machine. Practical lab sessions gave the learners more in-depth experience as compared to the simulation; however, it was crucial or them to acquire foundational knowledge about the machine parts and parameters before the actual experience took place, in order to reduce safety issues. In that respect, the computer based simulation helped to reduce safety issues when the learners were in the lab. In semester 4, learners mostly entered the advanced level of their programme and were trusted to handle the machine themselves with or without the lecturer's supervision. At this level, learners were given a job sheet which (according to the lecturer) was the same kind of job sheet that they would be using on a production line in industry. The ability to analyse

defects and identify what caused them, as well knowing which parameters on the control panel to adjust, was essential for the learners, but challenging.

- Another significant challenge faced by the lecturer was the language barrier, since most of the instructional materials for teaching were in English, including video and lecture notes. This was because most injection moulding machinery was made overseas made using English for its parameters and labels, and it was difficult to translate the technical terms into Bahasa Malaysia. However, since there was less exposure to English among the learners, this was a barrier to learning. Having said this, I am not sure how critical language was to the learning process as seen in Case Study 1.

Valuable input for the case study. From the needs assessment exercise, I managed to identify some useful input for this case study, including the ***subject matter topic for the study; its relationship to TSM; medium of delivery; language barrier;*** and ***knowledge about the course content.***

- ***Subject matter topic.*** From the needs assessment, it was confirmed that the subject matter for the case study was *"Product Defect"*.
- ***Relationship to TSM.*** I was able to gain some input in relation to TSM concerning Supportive Information and Procedural Information. In this case study, I could identify that Supportive Information covered a list of product defects that would be used by the learners frequently while carrying out the learning task. Procedural information covered background information about the machinery parts.

- ***Medium of delivery.*** As I was aware of the context of teaching and learning for the module, I felt it was relevant to use mobile devices for delivering the instruction. This was because mobile learning allowed learners to access the content anytime and anywhere they needed to. I envisaged that the sections on supportive information and procedural information would be particularly useful and accessible as a reference in this format while the learners were working in the injection moulding workshop.
- ***Language barrier.*** Building on my experience in Case Study 1, I approached the English language elements with the mindset that the instructional material should not be too complicated for the learners to comprehend. However, I needed to use English in this material as it was difficult to translate the technical terms into Bahasa Malaysia.
- ***Knowledge about the course content.*** I felt a bit insecure in approaching this content as I was not the content expert and injection moulding was a foreign topic for me. I made significant efforts to learn about product defects and consulted professionals with engineering experience. I also had Mr. S to check on the content beforehand.

5.3 Design and development

I began my design and development task by developing the blueprint for the case study. Based on the notes I had made during needs assessment on the types of defects and following the curriculum documents, I started researching product defects online and had an engineering expert colleague confirm my findings. I

thereby shortlisted six of the most commonly encountered product defects: *short shot, jetting, flash, flow line, sink mark,* and *warping*. These served as the supportive information for the instructional material. Later, also using notes gathered during needs assessment, I searched for more information on the injection moulding machine; this was to be presented as procedural information, and was also reviewed with the help of my engineering colleague. Upon identifying the supportive information and procedural information, I then began to think about the learning tasks for the topic. This can be seen in Table 5.3-1.

Table 5.3-1 Adaptation of TSM in Case Study 2

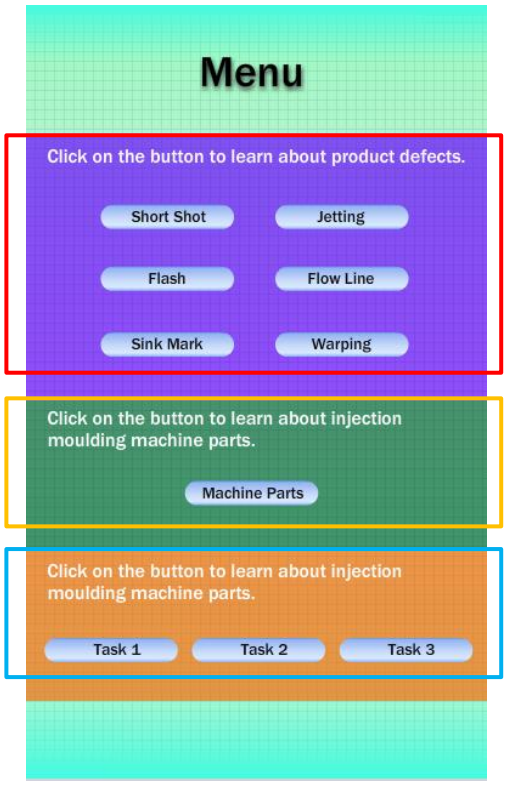
Four components	Steps in TSM	What is the strategy?	Descriptions
Learning task	Design Learning Task Develop assessment instruments Sequence learning task	• Worked-out examples • Completion task • Conventional task	I chose several strategies to design learning tasks ranging from simple to complex, using a worked-out example task, a completion task, and a conventional task. In this case study, a worked-out example task refers to examples of product defect that learners needed to evaluate; a completion task refers to identifying the type of defect and matching it with the image of a product defect; and a conventional task refers to predicting the output of a product, based on given parameters. There was no development of an assessment instrument, as the assessment portion was based on the existing assessment used by Mr. S. The tasks went in sequence from simple to complex. In other words, the level of support and guidance decreased from one task to another. Learners were required to apply a greater level of autonomy as they carried out each consecutive task.
Supportive Information	Design Supportive Information Analyse Cognitive	• Causal model	Supportive information referred to information or the theory that helped the learners to perform the learning task. The supportive information possibilities were identified during the needs assessment and were referred to as a list of product defects. The strategy chosen in presenting the supportive information was the Causal model within the material. Learners covered six types of product defects to allow them to perform the learning

	Strategies Analyse Mental Models		task. Thus, the six product defects were presented directly to learners as information for learners to study and apply. Learners were provided with animation of how the defect occurred. Thus, learners would be able to establish a strong knowledge of the relationship between type of defect and its causes. The presentation about types of defect and its causes needed to be developed from scratch. I consulted Mr. S on the product defect issues and was given a reference table of the types of defect. By using the table, I could identify rules about defects and causes. I also spoke to a subject matter expert I happened to know to understand more about the injection moulding process, product defect and its causes.
Procedural Information	Design Procedural Information Analyse Cognitive Rules Analyse Prerequisites Knowledge	Prerequisite knowledge	Procedural information refers to information presented to learners when they needed it in order to perform routine aspects of the learning task. Procedural information possibilities were identified during the needs assessment. The procedural information covered background knowledge background about injection moulding machines. The information was presented in a controlled animation.
Part-task practice	Design Part Task Practice	Practice item	Part-task practice refers to additional practice given to the learners to comprehend the topic and help them retain knowledge. Since the courses already had their own job sheets for practical lab wherein there was no part-task practice provided in the instructional material, this practice was carried out away from the instructional material.

Upon identifying the content, I began to design the flowchart of the material to see the logical flow of structure and content, followed by designing the storyboard (see Appendix D). The flowchart and the storyboard were emailed to Mr. S for him to review and the feedback was positive. From the storyboard, I then proceeded to design the material using Flash.

As seen in figure 5.3-1 below, the supportive information consisted of six types of defects which were short shot, jetting, flash, flow line, sink mark and warping (these are highlighted in red box. See figure 5.3-1). The procedural information included in the material was information on the injection moulding machine parts (highlighted in yellow box. See figure 5.3-1). This was then followed by three learning tasks (highlighted in blue box. See figure 5.3-1). As seen, the chronology of the content presented in the instructional material began with supportive information and was followed by procedural information and the learning tasks. I was hoping that by this latter stage learners would be better prepared for the tasks as compared to Case Study 1. This did alter the chronology that TSM suggests for presenting the material.

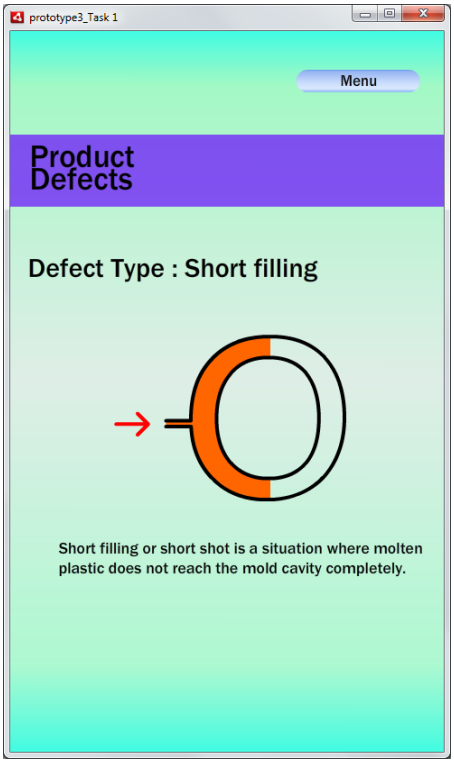
Figure 5.3-1 Screen shot of menu interface



I also learnt from the previous case study that it was important to keep sentences simple so that learners would find it easy to follow the content. The font size was made bigger to increase readability. Furthermore, considering the choice of mobile device, positioning the media elements was crucial as I was dealing with limited screen space. Too many screen elements would clutter the presentation of the instructional material which might hinder the delivery of information. In order to deliver supportive information, I used animation to explain how the defect occurred, supported with text to explain the phenomenon (see Figure 5.3-2 below). The use of animation was particularly suitable for the strategy I had chosen (Causal Model), since the information was about product defect and thereby involved explanations of concepts or phenomena that were useful for

learners in predicting the possible types of product defect. I wanted to use 3D animation to add some realism, but there were time and resource constraints. Besides, it was difficult to visualise the actual process of injection moulding, for example what happened once the melted plastic entered the mould cavity. I would have required a technical expert and longer to develop the material in order to build the animation in 3D.

Figure 5.3-2 Screenshot of an animation sequence showing a product defect



I designed the procedural information by separating the information about the machine into four main parts: *injection unit*, *clamping unit*, *hopper* and *control panel* (see Figure 5.3-3). I positioned it as procedural information because these four areas played an important role in the running of an injection-moulding machine;

learners will recurrently deal most frequently with these parts when operating the machine.

Figure 5.3-3 Screenshot of machine parts within product moulding

5.4 Evaluation

The implementation and evaluation exercises in this study followed along similar lines to those in Case Study 1, although some aspects were different. Unlike in Case Study 1, this time I was able to conduct these sessions myself on site at the institution. The methods used to gather data for the evaluation phase in this case study were an online survey, an open-ended question, observation and an interview with Mr. S. For this purpose, I was given a room where I could conduct the evaluation and was able to test and evaluate the material using my

own laptop. The testing started at 9.30 am and finished at 4.40 pm with an hour break for lunch. Each learner session was roughly between 15 minutes to 30 minutes. After the evaluation, the learners were asked to complete a learning task provided in the material and their answers were recorded in a notepad. These were saved in a coded naming convention to maintain anonymity. They were later asked to fill in a survey before ending the evaluation session.

Online survey. For the survey, learners were asked to fill in an online questionnaire. The questionnaire consisted of 17 questions in a Likert-scale format and one open-ended question. As described in the Methodology chapter, the questions covered four domains; knowledge, attitude, skill, and accessibility. The accessibility aspect included questions about graphics, text and colour in the learning material. I adopted the same survey that was used during the second evaluation round in Case Study 1, but the questions were tailored to suit the context of this case study. The language used was English but I assisted learners who needed help to translate the questions during the evaluation.

Table 5.4-1 Dimensions and questionnaire items

Dimension	Question No.																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Knowledge	/	/															/
Skills				/		/											
Attitude			/		/		/										
Accessibility								/	/	/	/	/	/	/	/	/	

The survey showed that learners were mostly positive about the instructional material, with some learners were undecided about how they felt. Similar to Case Study 1, it could be assumed that they found the material helpful but not to the extent they felt confident enough to explain and apply what they had learnt. I could strongly say this because looking at the accessibility questions, the material was very well received by the learners. The feedback showed learner confidence was slightly lower around transferability, but the response was still positive. The structural use of TSM was supposed to address the problem of transferability, but there were learners who felt they understood the topic but didn't feel confident in explaining the defects. This could be an indication that higher order skills were required for them to be able to explain the concept of product defect. In terms of the design of the material, the learners were very pleased with the cosmetics. In evaluating cosmetic features, it was difficult to know whether learners are considering other factors as well. On the one hand, to say the learners liked the design if they did not really understand the concept of injection moulding was problematic, but on the other hand learners might think the design was good because it allowed them to understand the content. On this basis, it could be suggested that overall, most learners engaged with the instructional material and found it useful for learning. I would say this case study was much better than Case Study 1. This might be because the complexity level of the content was lower than that in Case Study 1. It may also be because I was present during the evaluation unlike in the previous case, meaning I was there to help and guide the learners in use of the material.

Table 5.4-2 Summary of participants' perceptions of instructional material (n=21)

Item	Statement	Agree (%)				Neither		Disagree (%)				
		Strongly Agree		Agree				Disagree		Strongly Disagree		% of +ve
		3	14.30	13	61.90	5	23.80	0	0.00	0	0.00	
1	I know most of the problems that caused the defect.	**16**				**5**		**0**				**76.20**
		10	47.60	9	42.90	2	9.50	0	0.00	0	0.00	
2	I understand most injection moulding defect types.	**19**				**2**		**0**				**90.50**
		2	9.50	11	52.40	8	38.10	0	0.00	0	0.00	
3	I feel confident to explain the problem that caused the defect.	**13**				**8**		**0**				**61.90**
		7	33.3	11	52.40	3	14.30	0	0.00	0	0.00	
4	I can identify injection moulding defects on a product.	**18**				**3**		**0**				**85.70**
		3	14.30	14	66.70	4	19.00	0	0.00	0	0.00	
5	I feel confident about justifying my solution to overcome the defect.	**17**				**4**		**0**				**81.00**
		6	28.60	8	38.10	7	33.30	0	0.00	0	0.00	
6	I find injection moulding defects an easy concept.	**14**				**7**		**0**				**66.70**
		7	33.30	10	47.60	4	19.00	0	0.00	0	0.00	
7	The learning package developed my confidence about injection moulding defects.	**17**				**4**		**0**				**80.90**
		14	66.70	4	19.00	3	14.30	0	0.00	0	0.00	
8	I enjoyed using the learning package.	**18**				**3**		**0**				**85.70**
		12	60.00	5	25.00	3	15.00	0	0.00	0	0.00	
9	I liked the presentation of the content.	**17**				**3**		**0**				**85.00**
		10	47.60	8	38.10	3	14.30	0	0.00	0	0.00	

10	I liked the colour scheme used in the learning package.	**18**				**3**		**0**				**85.70**
		13	61.90	7	33.30	1	4.80%	0	0.00	0	0.00	
11	The menu structure in the learning package was easy to understand.	**20**				**1**		**0**				**95.20**
		13	65.00	6	30.00	1	5.00%	0	0.00	0	0.00	
12	I was clear about how and where the buttons worked.	**19**				**1**		**0**				**95.00**
		14	66.70	4	19.00	3	14.30	0	0.00	0	0.00	
13	The graphics were helpful in understanding the topic.	**18**				**3**		**0**				**85.70**
		11	52.40	9	42.90	1	4.80%	0	0.00	0	0.00	
14	The content was well organised.	**20**				**1**		**0**				**95.30**
		18	90.00	1	5.00	1	5.00%	0	0.00	0	0.00	
15	The learning package was easy to use.	**19**				**1**		**0**				**95.00**
		15	75.00	3	15.00	2	10.00	0	0.00	0	0.00	
16	The text was easy to read.	**18**				**2**		**0**				**90.00**
		14	70.00	4	20.00	2	10.00	0	0.00	0	0.00	
17	The activity in the learning package was helpful.	**18**				**2**		**0**				**90.00**

Open-ended question. The open-ended question used in the survey was, *"My suggestions about how the package could be improved"*, and all the learners submitted a response. Although the learners found the material helpful, they suggested that more tasks should be added to give variety in terms of problems to be solved. They suggested the use of different question formats, such as objective questions and subjective questions. They also suggested that content could be enriched

with more information such as details about machine components, and types of machines such as extrusion, blow moulding and blown film.

It was also suggested that the presentation of the content could be improved by showing the causes of defect and using the animation to show the details of the injection processes in every part of the machine. There was also a suggestion to use video footage to explain how the defect occurred. The presentation timing of the injection information on screen also was described as too fast, and a playback button was suggested to provide control over the information. One of the learners said that the explanation was not clear to them, and suggested that simple sentences would be helpful. He suggested increasing the size of the font and using different colours. The feedback is summarised in Table 5.4-3 and some excerpts from the open-ended feedback are also shown in Figure 5.4-1.

Table 5.4-3 Summary of suggestions from open-ended feedback

	Feedback	**No. of mentions**
1	Suggestion to improve presentation of content	7
2	Suggestion to add more tasks	3
3	Suggestion to add more information about machine components	3
4	Suggestion to add multimedia elements	3
5	Suggestion to add different formats of tasks	3
6	Suggestion to add more information about defects	2
7	Suggestion to add more information about injection moulding	2

Figure 5.4-1 Excerpts from open-ended feedback: suggestions to improve the material

"It is a good application, but I think it needs more tasks so that the user can individually solve a multiple problem or defect about plastic" – CS2.EV.OE.06

"Provide different sections of questions such as section A: objective, section B: subjective and section C: provide a problem that requires learners to provide the solution. For the animation, if possible, begin the explanation of the defect from the nozzle and how the material is being injected into the mould" – CS2.EV.OE.14

"Make the font size bigger for every title and use attractive colours" – CS2.EV.OE.20

Besides these suggestions, the other feedback given in relation to the material fits into three themes: ***perceptions of using the material*****; *perceptions of the content material*****; and *the helpfulness of multimedia*****.**

Perception of using the material. Feedback was various on this theme. Learners found the material was easy to use and it helped them in learning the topic. Other perceptions which were mentioned a few times included that it had good application (3), was interesting (3), the material is easy to use (3) and fun (2), the cosmetics of the material are nice (2), and it is comfortable to use (1). Some of the excerpts from feedback on this theme are shown in the Figure below.

Figure 5.4-2 Excerpts from open-ended feedback: perception of using the instructional material

"My comment for this application is this learning kit is nice, okay and easy to understand…" - CS2.EV.OE.09

"Very interesting" – CS2.EV.OE.07

Perceptions of content material. The learners also commented on the content of the material, with some advising that they found the learning task helpful to refresh their knowledge about the topic. They also said that the task was easy to understand. Other feedback indicated the content was easy to understand (9), it was easy to revise from (6), the task was helpful (2), and the content was easy to remember (1). Some of the excerpts from this feedback are seen in Figure 5.4-3 below.

Figure 5.4-3 Excerpts from open-ended feedback: content of the instructional material

"Helpful to identify product defects. Makes learning becomes easy…" – CS2.EV.OE.07

"Easy to understand and to do my revision" – CS2.EV.OE.03

Helpfulness of Multimedia. There was also some feedback on the use of multimedia (4) whereby learners found the multimedia was helpful in that the animation was fun and easy to understand, as were the graphics. Excerpts of comments for this theme are shown in Figure 5.4-4.

Figure 5.4-4 Excerpts from open-ended feedback: media used in the instructional material

"The animation is fun and easy to understand too…" – CS2.EV.OE.09

"The images are easy to understand…" – CS2.EV.OE.11

Observation. Observation took place when the learners were trying out the material during the evaluation. The same open-ended observation checklist was used (see Appendix F) an altered according to the needs of this case study as the observation took place. There were 11 sessions in total, with two learners being observed in each session and two laptops being used for the purpose of the session. This allowed me to closely observe the learners while they were using the material. The exercises took about 30 minutes for each student, but there were some that took longer.

During the testing, I was able to observe how the instructional material was used by the learners and was able to troubleshoot any issues. The focus of my observation was to see how the learners accessed the content in the material (supportive information and procedural information), how or if they carried out the learning task, how many times they needed my guidance and was the query about content or a technical issue that they were dealing with. Through the observation, I was able to assess learners' perceptions of the instructional material in more depth, adding data that could not be picked up in the survey and open-ended question. The data from the observation notes were coded based on the focus area of my observation. Later, the coded data were grouped according

to theme. Themes emerging from observation data were ***the usability of the instructional material, attitude while using the material,*** and ***content of the material.***

The usability of the instructional material. As seen in table 5.4-4, my observation notes showed learners needed my guidance while using the instructional material during most of the session. The reason they needed my guidance covered elements on navigation structure, instruction of the task and menu.

Table 5.4-4 Some of observation notes

CS2.EV.OB.06	*They did ask question about the instruction. They could understand what the question wants (understand English) but were not sure what they need to do.*
CS2.EV.OB.08	*I still have to guide them on what they need to do.*
CS2.EV.OB.09	*They do not understand the sequence of what they need to do with the given prototype.*
CS2.EV.OB.10	*They did not understand where to navigate from the defect page.*
CS2.EV.OB.11	*He did not understand what he needs to do.*

The issues were mostly related to unclear instruction and navigational structure in the material. Some learners were unsure about the navigational structure as some of them were seen to be clicking on other menus. For example, they did not know to which interface they needed to navigate next from the defect interface. Other than unclear instruction and navigational structure, there was one

observation session in which the learners were curious about the size of the interface which they described as small, though it was explained earlier that the medium was for mobile learning.

Content of the material. All learners did complete all the learning tasks in the instructional material, although some of them expressed that the topic was quite new for them and they were not very confident about it; some of the groups were seen discussing the learning tasks during the evaluation as a result. Nevertheless, there were also some learners who seemed to know more about the topic and looked calm and confident while carrying out the learning task in the instructional material. From the learning task, all of them manage to give a correct answer and some were also able to explain about product defects as requested in the learning task.

Interview. The session was followed by an interview with the lecturer in order to get feedback about the learning material. The same interview schedule was used and the questions was generated around the components of TSM adapted in the learning material, its usefulness, the presentation, and the pros and cons of the material (see Appendix B). Some of the questions used in the interview are shown in figure 5.4-5.

Figure 5.4-5 Some of the questions used in the interview

How does the content address or help learners to understand the concept of product defects?

How does the content about product defects relate to the defects being presented?

How does the explanation of the process relate to the machine part being presented?

Do you think there is a need to add in more information in the instructional material?

The feedback gathered from the interview was about the content in the learning task and supportive information, content sequence and multimedia elements. Mr. S suggested that the animation needed a control button so that learners could view it at their own pace. Mr. S also suggested adding in a defect table, and a task giving learners options to choose possible parameters. However, we were both aware that this functionality would require a high level of programming which would take time to develop. During the interview, I also asked Mr. S for his view about the structure of the content that was delivered in the same sequence as in Case Study 1. According to Mr. S, he understood the approach but he thought it might be a bit problematic for the learners to understand such a learning process. It could be said therefore that Mr. S gave the same feedback as given by Miss H in Case Study 1 as regards the content structuring based on TSM.

Figure 5.4-6 Some excerpt from the interview with Mr . S

"The content about the product defect was fine, but the timing of the animation that explains how the defect happens should be a little bit slower giving some time for the learners to understand the defect phenomena"

"The structure of the content would preferably be rearranged in this sequence: machine parts -> injection moulding process -> defect -> tasks"

"Add on a defect chart as a reference for them"

"Add options to choose possible parameters that need to be adjusted in order to find the solution to the product defect. Learners need to get familiar with the parameters. It is a skill that they need to master"

"I think real images will be better. It provides clearer image of the defects"

"Provide a function that allows the learners to choose or key in parameter value and show the result of defect based on the parameter they enter. However, I understand the process of doing this requires a high level of programming and it will take time"

I was not able to do a follow up evaluation due to time and cost constraint. However, I managed to talk to Mr. S for some feedback. According to Mr. S, not so many learners opted to use the material as it felt inconvenient to access the mobile while they were working in the injection moulding workshop. It could be assumed the learners did try using the app outside learning hours but he felt the learners preferred or benefited more via learning through direct experience. It might be worth considering the integration of the app into the curriculum in future, for example it could contribute to a flipped classroom in which learners could try the apps prior to the lecture or technical activity at the workshop.

5.5 What I learnt

How did TSM help in designing the instructional material?

Breaking down the learning task. As seen in the design and development section, the learning task was the first design activity done after the topic had been identified during the needs assessment. The learning task designed in this case study was centred on the topic "Product Defects". As seen in this case study, the learning tasks were presented using three different kinds of strategy; a worked-out example; a completion task; and a conventional task. The skills that needed to be performed by learners at the end of the lesson were embedded in the learning task at different levels of complexity ranging from simple to complex. Through designing the learning tasks, I was able to break down the task based on the skills required, and this guided me to identify the relevant content to support the learners while carrying out the learning task.

Structuring the content. As mentioned, the process of designing the learning task enabled me to centre my thoughts on relevant content to support the learning task. As seen in the design and development section of this chapter, the topic in this case study was "Product Defects" and the supporting topics were "Types of Defects" (supportive information) and "Machine Parts" (procedural information). This design activity was crucial because each learning task should be supported by these two types of information to which the learners could refer while carrying out the task. Similarly, to Case Study 1, TSM allowed me to manage the content in providing a structure which divided the content into sections.

What are the obstacles to adapting the model in designing instructional material?

The role of subject matter expert vs the designer. Unlike in Case Study 1, I started this case study with zero experience of the learners' subject matter and felt a bit insecure because of my lack of knowledge on the topic. The design task in this case study became difficult since I was not an expert in the subject area and did not know what to expect. The tricky part was to develop rapport with Mr S and to invite him to engage with the design process, while at the same time trying to understand the topic in order to meet expectations for the module. The process of identifying the topic, the learning tasks and the supporting content for the topic would not have been possible without the help of the lecturer. The role of Mr S in the process of designing the instructional material was important in terms of validating the content and contributing his experience as the lecturer.

Since I was lacking knowledge of the topic, I found that the process of analysing the type of content and choosing the strategy to present them needed an extra attention. Thus, it made the task of designing supportive and procedural information was a bit challenging. Although I could rely on Mr. S, I felt insecure and this was beyond my control unlike my experience in Case Study 1. However, in the end the result in this case study was more positive as compared to Case Study 1. I learnt that it was impossible for all designers to know all areas of what they were designing. Therefore, a strong relationship with the subject matter expert was an important aspect in order to understand the area.

Choosing strategy was a complex task. There were many types of strategies suggested by van Merriënboer in designing the learning tasks, supportive

information and procedural information. With a lack of knowledge and experience in the topic area, I found it difficult to choose strategy for these three components. The complicated part was to choose a proper strategy to present the learning tasks through from simple to complex while at the same time ensuring that the tasks enabled learners to integrate their knowledge, skills and attitude. It could be said that it is through integrating these elements that learning transfer truly occurs.

Apart from designing the learning task, the two other components of procedural and supportive information also required strategies in order to be presented in the learning material. I found the process of choosing the strategy quite complex as I needed to analyse the type of information I had and match it to the available strategies. For example, the supportive information in this case could be categorised as causal model since it concerned the relationship between the defects and factors that contributed to those defects. Learners needed to grasp these facts and concepts, and my task was to identify how this information could be presented to learners in a way that enabled them to find the relationship between the concepts they learned and the defects they encountered. I would say that different kinds of content require different strategies.

Unlike procedural information, the designing of supportive information required one to identify non-routine aspect or problems that were not confronted daily by the learners while carrying out the learning task. It was explained by Mr. S that there could be more than one cause that influenced a product defect, depending on other variables such as temperature of the lab during the production, the types of plastic resins used, the setting of the temperature, and mould factors. This was

difficult for me to take into account due to my lack of knowledge about injection moulding. As for a novice user of the TSM, it would take some effort to choose the strategies regardless of whether they were designing for a learning task, supportive information or procedural information.

Designing the procedural information in this case study was less complex as compared to for the supportive information. This was probably because the information, such as types of machine parts as shown in the earlier design and development section, was straightforward and less complex. My task was to ensure that this information enabled learners to recall information about machine whenever they needed to.

Other design reflections that do not relate to TSM

Media. At the beginning of designing and developing the learning task, I assumed that the media to be used in designing the learning material was also important as it supported presentation especially of the supportive information and procedural information offered to learners. For that reason, I decided to use 3D models and animation to represent the supportive information in this case study. However, after the evaluation session, it turned out that some of the feedback indicated that learners would prefer real images and video footage of how the product defects occur. This would have required greater media and resources than I had available. To design learning material for a short duration and limited range of content, such as in this case study, one needed to consider the available resources along with the preferences of the learners. Although my study did not include the cost of producing or obtaining such media, it would

give a greater impact to the overall design and development in any common project if photographic or images and detailed video of how the whole process worked were used.

Learner readiness. I found that learners in this case study seemed to have fewer problems in carrying out the learning task and understanding the content presented in this learning material than in Case Study 1. This was probably because the given task and content were in areas in which they had knowledge and experience (ZPD). Throughout my observation, I found that the learners were using the instructional material as I expected them to, with the exception of those times when they needed guidance to explain the instructions used in the instructional material. I suspected the instructional material was less complex as compared to the Case Study 1. Therefore, it took less for them to explore and it was less difficult for them to figure out what to do.

Language issues. Although it was mentioned by Mr. S during his needs assessment interview that language issues were part of the challenges in delivering the topic, there was no mention about language issues in any of the open-ended feedback given by the learners. I could relate this to my presence during the evaluation, as the learners who needed it received my guidance to explain the instruction used in the instructional material.

Menu and navigation structure. The navigation structure and menu was one of the elements observed during the evaluation as causing some learners a slight degree of uncertainty, as they needed my guidance to justify what they were doing or to confirm whether they were about to click on the correct button. Although

the content in this case study was less complex as compared to the Case Study 1, it does seem that there was a real issue with the way the navigation structure was designed, which I had not been aware of beforehand. Either way, this showed the significance of menu and navigation structure in learning material, especially material that uses a self-directed learner approach.

5.6 Summary

This chapter has given an overall description of the design and development process of the case study of subject matter Product Defect taken from a module, Injection Moulding. It was organized based on several phases that included needs assessment, design and development, and evaluation. Each process in the phases and its relation to other phases were described in detail. At the end of this chapter, what was learnt from the cases in relation to how did the TSM helped in designing the learning material, obstacles of adapting the model and other design reflection that did not directly relate to TSM were described.

CHAPTER 6: THE CASE OF WEB DEVELOPMENT

6.1 What is this chapter about?

This chapter explains the third case study. It describes the process of needs assessment; the design and development of the learning material; the implementation and evaluation; and what I learnt from the design process and the evaluation. The process can be illustrated as follows:

Figure 6.1-1 Design and development of the third case study

This case study was conducted at a community college in south Malaysia and involved two cycles of design and development into evaluation, as above. The topic covered was PHP programming, chosen from a module on Web Programming. The topic focused on teaching learners about PHP coding, and

they were expected to apply the newly acquired knowledge around using web programming languages, including PHP, in developing a tourism website for their final project using the Dreamweaver platform. LectureMaker was used as the authoring tool to develop the learning material. The learning material was to be accessed at college in the computer lab, which fit the normal mode and location of study for the learners. The key events in this case study are summarised in the table below.

Table 6.1-1 Summary of the types of data collected based on the design and development phase in Case Study 3

Phase	**Method / Action**	**Type of data**	**My actions/objectives**
Analysis	Needs assessment: interview with Miss L	Interview	Scoping of needs assessment
Design	Blueprint design Flowchart and storyboard	Design log	Using the blueprint to design the instructional material Designing and developing a flowchart and storyboard for Miss L to check on the content and provide feedback
Development 1	Prototype development	Design log	Using the flowchart and storyboard to design the material
Evaluation 1	Feedback from Miss L	Interview	To understand what needed to be changed to improve the material

	Feedback from learners	Interview	To gain learners' perceptions of the material
	Observation	Observation notes	To assess learners' perceptions of the material.
Development 2	Prototype development	Design log	Using feedback gained in Evaluation 1 to improve the material
Evaluation 2	Feedback from learners	Online survey	To gain leaners' perceptions of the material
	Feedback from Miss L.	Interview	To gain the lecturer's perception of the material

6.2 Needs assessment

The needs assessment exercise was conducted on 10 January 2016 via Skype interview with the lecturer, Miss L, who taught Web Programming. I used Skype because I was not able to travel to conduct the session in person due to cost and the time constraint of travelling from England to Malaysia. The duration of the interview was about 45 minutes. The questions were prepared based on the interview schedule as seen in Appendix A. It basically covered Miss L's experience of teaching Web Programming, methods and materials used in teaching and learning, assessment methods, and challenges in delivering the topic. Some of the interview questions asked during needs assessment are shown in figure 6.2-1.

Figure 6.2-1 Some of the interview questions in the needs assessment

Can you share your experience of teaching web programming? what type of assessment methods and material that you used?

You mentioned there were four topics covered in the subject. How do you felt teaching these topics? Were there any challenges that you faced?

Why do you think learners find it hard to do PHP programming?

From the needs assessment interview, I was able to gain an understanding of the **background of the subject matter expert**, **context of the case study** and **valuable input for the case study.**

Subject matter expert. Miss L has a Master's degree in Information Technology from a technical background university. She has some years of experience teaching web programming, having started teaching in a polytechnic before being transferred to her current college. I sensed that Miss L was confident to teach the subject and knowledgeable in terms of the curriculum and subject matter content. Although Miss L was familiar with instructional design, she was not at all familiar with TSM but she understood the purpose of my field of study.

Context. The college where Miss L taught was a community college located in a small village in south Malaysia. It offered certificate and diploma programmes for locals. The learners were typically those who had been unable to meet the higher entry requirements for a prestigious college or university, and due to their lower academic performance level, the course might appear new to them. With this case study, the participant learners were those who had enrolled for the certificate

programme. Some themes related to this context emerged from the needs assessment interview, including ***syllabus; methods of delivery and assessment; teaching material;*** and ***problems and challenges.***

Syllabus. Web programming was one of the modules taught in the certificate programme in the institution. The syllabus was divided into four chapters as described below. Chapter 3 was the longest section to be completed, covering 70 percent of the allotted time.

- Chapter 1: The idea of a website: what is a website? What is a web domain?
- Chapter 2: Planning, designing and developing a website. This included the storyboarding process, and database planning for the final project of the programme.
- Chapter 3: Web programming languages which includes PHP programming. This covered basic coding to complex coding with PHP programming.
- Chapter 4: the migration process of a website to a server.

Methods of delivery and assessment. The approach to teaching and learning in the institution was hands-on, and learners were given computer lab access throughout the course. The assessment was based on 70 percent project work and 30 percent comprehension of theories tested in a timed examination. One of the project work elements that involved a practical task was the final project, in which the learners needed to design and develop a website. During my visit, the

learners had already decided on their project and were currently working on the design of the website.

Teaching material. The main teaching material for the web programming course came in the format of lab sheets. The lab sheets were given to the learners at the start of each topic of the module. They contained examples of coding that the learners needed to enter, run, and evaluate the output. A significant part of the teaching was experiential in which learners were expected to understand the structure and function of the code, and to be able to apply that structure in their own work and to programming problems given to them. However, there was some input from the lecturer to explain about the coding and its structure to the learners as the learning process progressed.

Problems and challenges. Miss L identified Chapter 3 to be the most challenging part in teaching the module. This was because the chapter contained coding all the way through from basic to complex syntax. The topic was challenging because, according to the lecturer, the learners were only able to follow the coding in the lab; they were not able to apply it later to their own task or to an assessment task.

Miss L was also aware that her learners had had limited access and exposure to computing in the past and she felt the learners struggled with the content because of that. In addition, the terminology in programming was mostly in English, meaning language was again an issue. She herself taught in Bahasa Malaysia and translated some of the terms for the learners. Although terms could be translated to Bahasa Malaysia, the reference and external sources, such as websites, were

mostly in English. Another level of challenge Miss L identified was that it required logical and mathematical thinking in order to understand the concept of programming. This was the part that she thought the learners seemed to struggle with the most, and they found the concept difficult as the course progressed.

Valuable input for the case study. The needs assessment exercise enabled me to get some useful input for case study preparation, including a ***subject matter topic, the medium of delivery, difficulty of the content,*** and ***the material.***

- ***Subject matter topic.*** From the needs assessment, it was confirmed that the subject matter for this case study was "PHP Programming". However, I did not cover all the sub-topics within PHP Programming due to time constraints. In this case study, the specific topics covered were functions on *comment, display date, display time, variable* and *PHP tag.*
- ***Medium of delivery.*** Since most of the teaching occurred in a computer lab and the web authoring tool used by the learners was Dreamweaver, I felt it was relevant to use a computer based means of delivery for the instruction. It had the advantages of easy access and being cost effective, since the learners were used to working in a computer-based environment and all the equipment was already in place. This format provided a seamless transition from the material into working with Dreamweaver, and it would be much easier for the learners to access the material. Besides that, I did also consider the potential issue of split attention from the learners if the material was not delivered in a computer-based environment.

- ***Difficulty of the content.*** I realised that the main difficulty with the content lay at the level of remembering and understanding it. In relation to Bloom taxonomy, without being able to remember and understand the function of PHP programming, learners were not able to apply the knowledge to their own tasks. One of the other factors, as in the other case studies, was the language barrier, which in this case was because some of the learners found it difficult to remember and understand the concept of programming, i.e. its function and structure, because most of the terms were in English.
- ***Material.*** I was given materials by the lecturer in order to help me develop the instruction material. However, I understood that I needed to make some effort in understanding the content besides working alongside Miss L.

6.3 Design and development 1

From the needs assessment, the programme chapter that had been identified as challenging was Chapter 3, the coding chapter itself. The chapter content as described by the lecturer included Basic Syntax, Operator Concept, Looping, Form, and PHP Coding. For the purpose of this case study, PHP Coding was chosen as the subject matter or the overarching topic. The reason was that the learners should be able to write PHP coding as part of the skills required to develop a website. There were several versions of blueprint in this case study; the final version is summarised in the table 6.3-1.

Table 6.3-1 Adaptation of TSM in Case Study 3

Four components	**Steps in TSM**	**What is the strategy?**	**Descriptions**
Learning task	Design Learning Task Develop assessment instruments Sequence learning task	• Worked examples • Completion task • Imitation task	I began designing the learning task with an inquiry: what are the skills needed by the learners to enable them to write PHP coding? Several strategies were chosen to design learning tasks ranging from simple to complex using a worked-example task, a completion task, and an imitation task. In this case study, a worked-example task refers to learners needing to reflect by explaining the function of the coding in relation to the output that they get by running the script; a completion task refers to learners needing to complete a PHP script and get a similar output to that given; and an imitation task refers to learners needing to produce an output based on a given output. There was no development of assessment instrument involved in this case study as it was based on the existing assessment methods and material used by Miss L. The tasks went in sequence from simple to complex tasks that could help learners to understand, memorise and apply PHP coding.
Supportive Information	Design Supportive Information Analyse Cognitive	• Conceptual Model • Structural Model	Supportive information refers to information or the theory that helped the learners to perform the learning task. The supportive information possibilities were identified during the needs assessment and were referred to as activities (coding) involving solving different kind of PHP coding. The strategy chosen in presenting the supportive information was the Structural Model, which involved learners rearranging certain coding and

	Strategies Analyse Mental Models		comparing or predicting the output, and the Conceptual Model, which involved learners comparing the function of the coding in similar scenarios. From solving different kinds of coding, the learners would be able to establish a strong knowledge of the relationship between the coding, in terms of function used and its output. Doing this helped to develop a "template" in learners' mind which they could mapped on when writing PHP code.
Procedural Information	Design Procedural Information Analyse Cognitive Rules Analyse Prerequisites Knowledge	• Prerequisite knowledge	Procedural information refers to information presented to learners when they needed it in order to perform routine aspects of the learning task. Procedural information possibilities were identified during the needs assessment. The procedural information referred to different kinds of PHP syntax that the learners needed to use in writing PHP code. In this case study, the learners used procedural information to help them to recall their prior knowledge of PHP syntax.
Part-task practice	Design Part Task Practice	• Practice item	Part-task practice refers to additional practice given to the learners to help them retain knowledge and comprehend the topic. Since the course already had a designated computer lab sheet, there was no part-task practice provided in the instructional material. Learners' practice was carried out away from the material.

After designing the blueprint, I developed the flowchart and storyboard. These documents were then emailed to Miss L for feedback. The feedback on the flowchart and storyboard was positive. This was followed by the development of the learning material based on the flowchart and storyboard (see Appendix E).

Following the TSM, I needed to determine the learning task, supportive information and procedural information. As per the previous table, the learning task was the programming task that the learners needed to solve, and which was presented using a worked-example task, a completion task and an imitation task. This different approach was important in trying to address the issues identified during the needs assessment. For example, the idea behind using the worked-example task in this case study was that learners should able to compare the coding and the output it produced through the example given in the task. This type of task stimulated learners to think of the logical and mathematical structure behind the coding. To support learners with the tasks, they could also refer to supportive information and procedural information in the material.

The supportive information constituted different kinds of PHP coding examples covering the topics mentioned earlier; *comment, display date, display time, variable* and *PHP tag*, this section provided learners with coding example of how the function, for example *comment* and *variable* were used in PHP programming context. As seen in the table, the conceptual model and structural model made up the approach governing the design of this information. This was aimed at enabling learners to make sense of the function of PHP coding in order to get certain output. I felt it would allow learners to connect their understanding with the concept and structure of the coding. Meanwhile, the procedural information provided was a

basic syntax of PHP which was presented as prerequisite information that supports learners in performing the learning task. The basic syntax was important and relevant to learners as it helped them to recall the information when writing the coding.

Although it was suggested by van Merriënboer that support and guidance (supportive information and procedural information) should be reduced as learners progressed to the next task, at this stage I felt that this would not be the correct approach given the learners' backgrounds and how the additional support would help them to develop their understanding on the topic. Supportive information and procedural information were therefore made available throughout the learning material at all stages.

The learning material was developed using authoring software LectureMaker. Initially the medium chosen for delivery of the instruction was Massive Open Online Courses (MOOC) platform called openlearning.com. However, since training on the platform would have been required for both Miss L and the learners, a computer-based instruction medium was seen to be more practical to suit the purposes of the study. It was also more convenient to use the material via a computer because the learning tasks were carried out using the computer. LectureMaker seemed to provide an easy interface which I felt learners might find it easy to use. The screenshot below shows the three main components of the study: learning task; supportive information; and procedural information in the instructional material.

Figure 6.3-1 Learning tasks used in the learning material

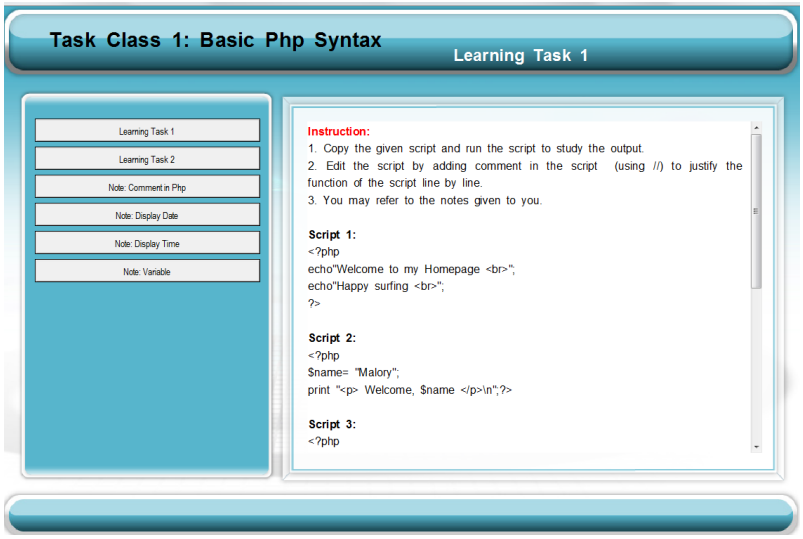


Figure 6.3-1 shows the learning task (Learning Task 1) that needed to be carried out by the learners. There is also a menu on the left side of the interface which provided access to the notes or supportive information to which learners could refer while carrying out the learning task.

Figure 6.3-2 Learning tasks used in the learning material

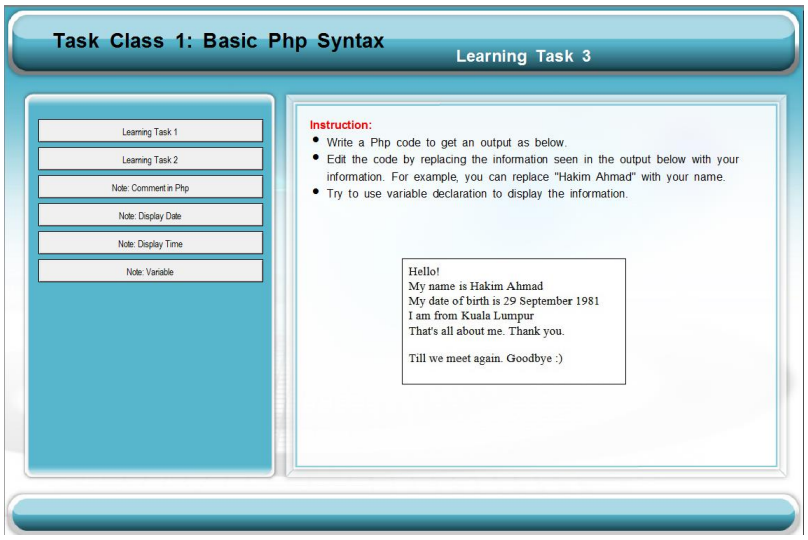


Figure 6.3-2 shows Learning Task 3 which used Conventional Task strategy whereby learners were given less support and guidance. However, as seen in the screenshot, (procedural) information on *comment, display date, display time* and *variable* was made available for learners to refer to while carrying out the task. Although this was the type of information that fits the description of supportive information, I felt that the learners would keep coming back to this information whenever they found it difficult to recall, especially the syntax. Thus, they were presented as procedural information rather than supportive information.

6.4 Evaluation 1

There were two sessions involved; evaluation with the learners, and evaluation with the lecturer who taught the subject. The evaluation took place at the institution itself in a computer lab. However, the process did not go as planned because there were only five learners available for the evaluation; the rest were involved in an activity and were not at the college during my visit. There have consequently been some changes to the method used in the evaluation as compared to other cases, but I decided to go ahead and conduct the evaluation, and closely observed the five learners.

The aim was to understand how they used the instructional material. The session was then followed by a short interview with them to understand what they thought after using the instructional material. Each session was about 30 minutes, which included 20 minutes of trying out the material and 10 minutes of short interview. There were three female and two male learners involved in the session. The observation exercise enabled me to observe how the material was used, and I

was also able to guide the learners around any problems they encounter while using the material. During trying out the material, the learners needed to carry out the learning tasks and save their answers (script) in Notepad.

Observation. Two major concerns were discovered during my observation: usability issues and how the instructional material helped in learning. There were several instances of feedback indicating usability problems around the use of menu, instruction, content flow, inappropriate titles, and navigation. The issue with the menu may have been the consequences of inappropriate title use to represent the menu compounded by unclear instructions in the instructional material, which combined had led to a navigation problem for the learners. For example, the observation exposed that some of the learners needed more guidance than others and were not very sure which buttons to click. This indicates that they might have been confused by the instruction used and ended up clicking the menu buttons without thinking, although instruction had already been given in the learning material. It might also indicate the presence of language issues, as the instructions were all in English. In spite of issues on menu and navigation, they figured out where to find the information after using the instructional material for a while. My later observations did identify that the learners successfully used the information provided to them (supportive information and procedural information) in solving the learning task. This demonstrated that making support and guidance available all the time to the learners helped in their learning process.

It was clear during the observation that the instructional material appeared to have helped the learners in learning the topic, in that some of them demonstrated

the ability to apply skills that they had learnt by solving Learning Task 1, and were able to transfer the skill into solving another learning task. They were also able to manipulate the script and syntax, demonstrating their understanding that there might be more than one way of achieving the same output. Some of the observation notes are showed in figure 6.4-1.

Figure 6.4-1 Observation of Case Study 3

7	*He understands how to run the script and view the script in browser; he copies and pastes the script to notepad and uses the filename of the notepad to run in the server. CS3.OB.B7*
8	*In display time script, he seems to know what he is doing. CS3.OB.B8*
9	*In script 4, he took some time to think CS3.OB.B9*
10	*In doing task about display time, she didn't refer to the note provided but ended up editing the script/coding. CS3.OB.A9*
11	*She refers to learning task 1 while carrying out learning task 3. CS3.0B.E8*

Interview with the learners. I was able to conduct a short interview with the five learners after the observation. The interview raised some input about the learning material in the area of: ease of use, multimedia elements, interface theme and language. All learners find the learning material was easy to use in the sense that they were able to understand what they were expected to do, able to understand the instruction provided to them, and were able to use the notes to carry out the learning task. There were also some of them who mentioned that they also applied what they learn from Learning Task 1 in Learning Task 2 and 3. Hence, this was consistent with my observation notes described earlier. In

addition, learners also preferred the learning material be delivered in Bahasa Malaysia medium rather than English. They would have felt more comfortable if the instruction had been in Bahasa Malaysia and but were happy for the content (notes) to be in English medium.

Figure 6.4-2 Some of the excerpt during the interview with learners

The notes are simple. Not too long. It would be nice if graphic was used to support the notes. It helped in memorizing. It is difficult to read and understand if it is too long. (CS3.EV1.INT.A8)

It was a bit difficult at the beginning. But I finally did it [learning task] (CS3.EV1.INT.B3

As seen in other two cases, multimedia elements were one of the areas of feedback given by learners. In this case study, some of the learners suggested to use graphics to support the presentation of the notes. Some however felt adding graphics did not add any value to the presentation since the focus was more into learning how to code. Besides multimedia, interface theme was also one of the feedback given by the learners. It was suggested to use graphic to support the presentation of the notes and some did mention about the difficulty of reading the text in the learning material.

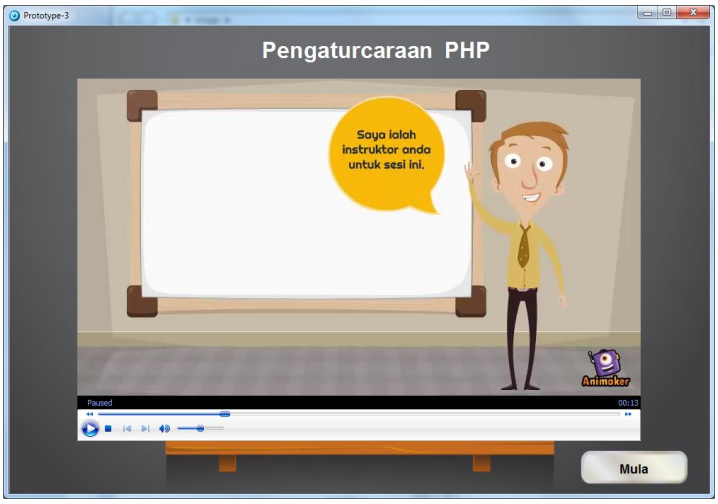
Interview with the lecturer. After the trial session with the learners, Miss L was given the chance to try out the instructional material. The main concern that she raised was the usability of the instructional material, for which she suggested I reduce the amount of text used to explain the concept and consider the use of animation and graphic. Using animation and graphics might have helped the

learners to develop their understanding of the concepts covered in PHP programming topic. It was also suggested that the interface theme should be more attractive to gain learners' interest. Miss L also commented on the layout and structure of the content presented in the instructional material in that she agreed with the idea of presenting the learning task first in the material. However, she felt the learners might not be ready to learn with that kind of approach. In normal practice, the content was usually presented to the learners first, followed by the learning task. In terms of content, Miss L suggested we should add another important sub-topic, *looping*. According to Miss L, looping is also one of the hardest concepts for the learners to grasp. She felt that the use of media might help the learners to understand the looping concept.

6.5 Design and development 2

Design and development 2 involved the amendment of the instructional material based on the feedback gathered in Evaluation 1. The amendment included changes to the look and feel of the prototype, the structure of content, language, the instruction used in the learning task, and the addition of media to support content delivery.

Figure 6.5-1 Screenshot of the introduction screen

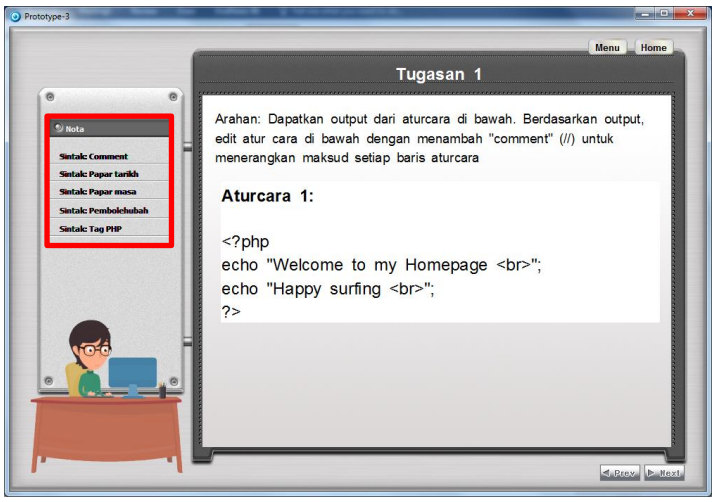


The above screenshot shows the start-up screen for the instructional material once it had been amended according to the learners' feedback. As seen in the above screenshot, the language in the material has been changed from English to Bahasa Malaysia.

Figure 6.5-2 Screenshot of menu screen

The above screenshot shows the main menu page, which briefly explains each of the learning tasks in the instructional material. Learners could navigate to each of the learning tasks by clicking the relevant button.

Figure 6.5-3 Screenshot of the learning task



The above screenshot shows the learning task that the learners needed to carry out. Unlike the previous version, the instruction has also been changed into the Bahasa Malaysia language so that the learners understood what was expected from them. However, the example of PHP script and some of the concept explanation was still in English. There were also Previous and Next button which could be clicked by the learners to navigate between the learning tasks. As seen in the above screenshot, there is a menu list on the left side of the interface that provides access to notes, i.e. procedural information (highlighted in red), to which learners can refer while carrying out the learning task.

Figure 6.5-4 Screenshot of the use of multimedia

The above screenshot shows the multimedia used to explain the concept in the procedural information notes. The animation was added along with a control button that allowed learners to control the presentation at their own pace. Besides that, supportive information (highlighted in green) was also presented whereby learners could try out the activities of solving PHP programming and examine the programming concept behind it.

6.6 Evaluation 2

Evaluation 2 was conducted remotely because of the distance between England and Malaysia. Before the evaluation, the execute file of the prototype was uploaded into a secure Dropbox folder which could be accessed only by my colleague and by Miss L. The evaluation of the prototype took place at the computer lab at the institution, and was administered by my colleague with the

help of Miss L. For the purposes of the evaluation, the prototype was downloaded and shared to the computers in the lab. There were 18 learners involved in the evaluation; they were given 30 minutes to try out the prototype before filling in an online survey questionnaire which included one open-ended question.

Open-ended question. Feedback from the open-ended question in the online survey focused on two main suggestions: media and content. Animation was the main suggestion from the feedback; it was suggested that using animation could make the presentation more interesting, could enhance learners' interest in learning, and could be used to explain how PHP coding works. The feedback also suggested that I add more buttons (it was not specified which buttons in particular), video, sound (background music or sound effects), audio narration and pictures.

Online survey. For the survey, learners were asked to fill in an online questionnaire. The questionnaire consisted of 18 questions in a Likert-scale format and one open-ended question. The survey was adapted from the same survey that was used in other case studies. However, the questions were tailored to suit the context of this case study. The language used was English, but during the evaluation Miss L assisted the learners who needed help to translate the questions. As in the other two case studies, the questions covered four dimensions; knowledge, attitude, skill, and accessibility. The dimensions and their corresponding question numbers are as follows:

Table 6.6-1 Dimension and questionnaire items

Dimension	**Question No.**																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Knowledge	/	/	/															
Skills				/	/	/												
Attitude							/	/										
Accessibility									/	/	/	/	/	/	/	/	/	/

Table 6.6-2 Summary of participants' perceptions of instructional material (n=15)

Item	**Statement**	**Agree (%)**				**Neither**		**Disagree (%)**				
		Strongly Agree		**Agree**				**Disagree**		**Strongly Disagree**		**% of +ve**
		11	73.33	4	26.67	0	0.00	0	0.00	0	0.00	
1	I understand that PHP programming requires different syntax than html.	**15**				**0**		**0**				**100.00**
		11	73.33	2	13.33	2	13.33	0	0.00	0	0.00	
2	I understand that PHP coding could be used within html coding.	**13**				**2**		**0**				**86.67**
		4	26.67	7	46.67	3	20.00	0	0.00	1	6.67	
3	I can differentiate the kind of PHP syntax and its function presented in the	**11**				**3**		**1**				**73.33**

	learning package.											
		1	6.67	12	80.00	2	13.33	0	0.00	0	0.00	
4	I can write a PHP coding based on a given output.	**13**				**2**		**0**				**86.67**
		0	0.00	10	66.67	3	20.00	2	13.33	0	0.00	
5	I can write a simple PHP coding without looking at the notes.	**10**				**3**		**2**				**66.67**
		2	13.33	8	53.33	4	26.67	1	6.67	0	0.00	
6	I can predict the output when looking at the PHP coding.	**10**				**4**		**1**				**66.67**
		3	21.43	9	64.29	2	14.29	0	0.00	0	0.00	
7	The learning package developed my confidence to write a code using PHP programming.	**12**				**2**		**0**				**85.71**
		5	33.33	6	40.00	3	20.00	1	6.67	0	0.00	
8	I enjoyed using the learning package.	**11**				**3**		**1**				**73.33**
		8	57.14	5	35.71	1	7.14	0	0.00	0	0.00	
9	I liked the presentation of the content.	**13**				**1**		**0**				**92.86**
		8	53.33	6	40.00	1	6.67	0	0.00	0	0.00	
10	I liked the colour scheme used in the learning package.	**14**				**1**		**0**				**93.33**
		9	60.00	6	40.00	0	0.00	0	0.00	0	0.00	
11	The menu buttons in the learning package were easy to use.	**15**				**0**		**0**				**100.00**
		7	46.67	4	26.67	3	20.00	1	6.67	0	0.00	

12	I was clear about how and where the buttons worked.	**11**				**3**		**1**				**73.33**
		8	53.33	5	33.3	2	13.33 %	0	0.00	0	0.00	
13	The graphics were helpful in understanding the topic.	**13**				**2**		**0**				**86.67**
		6	46.15	5	38.46	2	15.38	0	0.00	0	0.00	
14	The content was well organised.	**11**				**2**		**0**				**84.62**
		10	66.67	4	26.67	1	6.67	0	0.00	0	0.00	
15	The learning package was easy to use.	**14**				**1**		**0**				**93.33**
		7	50.00	5	35.71	2	14.29	0	0.00	0	0.00	
16	The text was easy to read.	**12**				**2**		**0**				**85.71**
		9	60.00	6	40.00	0	0.00	0	0.00	0	0.00	
17	The drag and drop activity was helpful.	**15**				**0**		**0**				**100.00**
		7	46.67	6	40.00	1	6.67	1	6.67	0	0.00	
18	The feedback was helpful.	**13**				**1**		**1**				**86.67**

The table above shows that the feedback was mostly positive, with minor negative feedback about the transferability of skills and knowledge. The data for question 5 and 6 seems to indicate that there was a small number of learners who may still have needed support and guidance when writing programming codes; they felt they were not able to transfer their knowledge to a higher level by predicting the output based on given codes. In keeping with the challenges mentioned by Miss L during needs assessment, this showed that the problem of not being able to remember and apply PHP programming was still encountered even after learners had been given the material.

In terms of the accessibility of the material, most feedback was positive with minor feedback from a neutral position. The positive feedback mostly covered the accessibility dimension, in which most learners found the learning material was easy to use. However, question 12 in the survey data, though still positive, showed the lowest score among other questions around accessibility. There were some learners who were unsure how the buttons in the learning material worked.

6.7 What I learnt

How, if at all, did the model enhance the process of designing and developing the instructional material? What did I learn with regards to the adapted model?

Task breakdown. The strength of this model lies in the task breakdown, which indirectly helps to scaffold learning from simple task to complex task. In adapting TSM, I began to realise that it channelled my focus on the tasks that are important to learners in order to help them with transfer of learning. As seen in this case study, a worked example, a completion task and a conventional task were used to present the learning task overall. These tasks required the learners to integrate their knowledge on different kinds of syntax in writing a PHP codes.

Structuring the content. By adapting the model, the process of structuring the content became easier. Identifying the task enabled me to discover other skills and information needed by the learners in carrying out the identified learning task. This indirectly helped to breakdown the content of the subject matter into sections. As described earlier, these sections could be designated procedural information and supportive information, as evidenced in the learning material:

the two main sections were "The Activity" and "Notes". Ideally, the focus of my design was more toward procedural information or "Notes", as it contained syntax and explanation of syntax which needed to be referred to and applied by the learners while carrying out the learning task. "Activity" presents several examples of programming cases that use PHP coding for learners to refer to.

What are the obstacles of adapting the model in designing instructional material?

The roles of subject matter expert and designer. Although I had some experience in the topic for this case study because of my computer science background, I found it difficult to design the content. Verification from the subject matter expert (Miss L) was still needed in terms of identifying the crucial topics to be added into the instructional material. Apparently, experience of learning the subject was different from experience of teaching the subject. The experience of teaching the subject gave Miss L an advantage in terms of understanding the problems faced by the learners as the learning took place. I found that the role of the subject matter is still important in all the case studies, especially in determining which content should be used and what sections the content belonged to. However, the subject matter expert experience and perspective alone might hinder other possibilities of enhancing the teaching and learning approach, as one might still be attached to the current approach to which one was accustomed.

The next challenge then was to choose the strategy of the learning tasks, supportive information, and procedural information. Due to my not knowing the content very well, the process of choosing the strategies to present the learning

task, supportive information, and procedural information in this case study became difficult. This was obvious from the early version of the blueprint developed in this case study. The challenges were to balance the range of simple and complex tasks making sure that they were within the expected outcome and in line with the learning objectives. Too simple a task might not meet the expected learning outcome, whereas too complex a task might have demotivated learners from using the learning material.

Complexity of choosing an appropriate strategy. Although breaking down the content according to the design components helps to manage the process of designing instructional material, the tricky part is to choose a proper strategy to present the learning tasks, supportive information, and procedural information. There are various types of strategies suggested by Van Merriënboer. For example, in this case study I chose a worked example, completion task and conventional task in designing the learning tasks. The process of choosing these should match with the type of learning task intended to be presented to the learners, which needs to be in line with the learning objectives or outcomes of the topic. When choosing the strategy for the learning task, one should also consider sequencing the tasks from simple to complex, and this of course reflect the type of the strategy chosen. As you design a more complex task, less guidance should be given to learners. However, it was learnt in this case study that support and guidance should be given in certain circumstances.

Apart from designing the learning task, the two other components of supportive information and procedural information also require design strategies. I found the task of choosing the strategy quite complex as there are many to choose

from. I would say the more complex the content, the more thought and effort is needed in order to choose the strategy, but I would observe that designing procedural information is less complex in comparison with supportive information. This is probably because it was more straightforward information and covered routine skills or information that needed to be used most of the time by learners while carrying out the learning task. Designing supportive information, on the other hand, requires one to identify non-routine aspect or problems that are not daily confronted by learners while carrying out learning task. This was the part that I found difficult as I needed to think of a variety of programming problems to be presented to learners, and I did not have a strong background in the subject matter. For a novice user of TSM, it will take some effort to understand the strategies and to match them with each of the components.

Cultural assumptions. In using this model, the content structuring is the other way around to how instructional material is normally designed. Traditionally, learning material usually begins with the presentation of content, normally referred to as the concept, which is then followed by a learning task to support the content. In this case, it begins with the learning task, because TSM suggests that learners learn by carrying out learning tasks and integrating routine and non-routine skills (supportive information and procedural information.

Other design reflection that do not relate to the Tens Steps model.

Learners find their own ways of learning. Although the model has advantages in dividing the content into sections as describe earlier, it was discovered that

learners will always find their own way of learning. My earlier assumption had been that the learners would tend to refer more to the "Notes" and "Activity" sections. However, my observation from Evaluation 1 showed that learners found their own way to learn and benefited from the instructional material. For example, during the first observation, some of the learners carried out the 3rd learning task by referring to the 1st learning task rather than referring to the "Notes" or "Activity" sections. This theory, that learners will find ways to use and benefit from the learning material, could be supported by the mostly positive feedback gathered following Evaluation 2, which indicates that some of the learners were able to transfer what they have learnt in one learning task to another learning task.

Media. The concepts in programming were mostly at the level of tacit knowledge and difficult to be explained verbally. In this case study, animation and graphics were an important element to explain programming concepts to learners, for example the concept of the variable and how it holds value in a programming code. However, one issue related to the use of media is the cost of developing it. Although cost was not the focus area in this study, it is one of the important design aspects to be considered.

6.8 Summary

This chapter has given an overall description of the design and development process of the case study of subject matter PHP programming taken from a module, Web Development. It was organized based on several phases that includes needs assessment, two phases of design and development, and two

phases of evaluation. Each process in the phases and its relation to other phases were described in detail. At the end of this chapter, what was learnt from the cases in relation to how did TSM enhanced the process of designing and developing the learning material, the obstacles of adapting the model and other design reflection that do not relate to TSM were described.

CHAPTER 7: DISCUSSION

7.1 What is this chapter about?

As the reader will be aware, this thesis centres on design and development research. As explained in Chapter 3, it has a particular focus on products (the learning materials produced in the three case studies) and on model (the concept of TSM). The conclusion will explore the finding that this dual focus brings opportunities but also difficulties. By carrying out the research, I have been able to gather evidence to address the four keys research questions. This chapter aims to address the overarching question, **what is the value of the Ten Steps model?** as well as those four key research questions:

1. What is the model?
2. How does the model work?
3. Is the model useful?
4. What are the contexts that need to be considered in adapting the model?

As seen in the case study chapters (Case Studies 1, 2 and 3) the main themes discovered have two main aspects;

Themes that directly relate to the model and instructional design process:

- Dealing with difficult content

- Task breakdown and choosing strategy
- Content/subject matter breakdown and choosing strategy
- Knowledge of the content area (experience of teaching)
- Dealing with required level of difficulty (to match course expectation)
- Adaptability with ISD model – ADDIE model

Themes not related to the model but essential to the design and development process:

- Multimedia and interface elements used in the learning material
- Learners' sense of control as an aspect while using the learning material
- Learners' readiness for the learning material
- Cultural assumption about learning and learners finding their own way of learning

These themes will be discussed later in this chapter based on the research questions described.

7.2 RQ1: What is the model?

The Ten Steps to Complex Learning Model (TSM) is an instructional design model claimed to enable designers of instructional material to support complex learning. It could be defined as a procedural model since it captures the series of steps needed to design learning tasks for complex learning. In relation to model taxonomy and the context of this study, this model could be categorised as a product-oriented one as can be seen in the three cases.

TSM is a procedural model. An instructional design model offers an integrated set of strategy components, such as the particular way the content ideas are sequenced, the use of overviews and summaries, the use of examples, the use of practice, and the use of different strategies for motivating the learners' (Reigeluth, 2013). There are various instructional design models which can be found in the literature and many ways of categorising models (see Andrews and Goodson, 1980; Edmonds, Branch and Mukherjee, 1994). However, we usually think of a model as abstracting the key steps or components in a process or activity and showing how they fit together. Drawing on Harre (1960), Richey et.al gave three categories of instructional design models; *conceptual models* (a general description that may relate to a specific concept drawing on experience or limited data only); *procedural models* (a series of steps showing how to perform a task to produce an instructional product); and *mathematical models* (an equation showing the relationship between various components and introducing ideas of causality (Richey, Klien and Tracey, 2011).

The procedural model according to Richey, Klien and Tracey (2011) is more straightforward, as it describes the task and how it should be carried out. It is usually based on knowledge or on a theory of creating an instructional product. To relate this to the first research question, TSM is a prescriptive model derived from 4C/ID model as described by van Merriënboer. TSM fits the description of a procedural model as it sets out the steps to be implemented in designing instructions. However, being prescriptive, it loses some flexibility when it comes to modifying the processes to suit context. As with other instructional design models, TSM is presented in a series of steps. It is a linear model and also a

prescriptive one in which the steps are expected to be followed no matter what the context. Flexibility is introduced through needs analysis and the involvement of subject matter experts but the steps themselves are expected to be useful in any complex learning context. In contrast descriptive models are much more focused on the components of design in general. For example, the 4C/ID model consists of four components i.e *i) learning task, ii) supportive information, iii) procedural information* and *iv) part-task practice*. These main components give the general idea about the design process but not the detail needed to address each component. This raises questions as to the relative value of working with prescriptive or descriptive models. Being a novice designer, one would probably prefer a prescriptive model because it sets out the steps needed to be taken. The descriptive approach, in contrast, captures the main phases of design process in which we could assume each designer will have different interpretations of what they need to do in each phase depending on their experiences. An experienced designer might have different interpretation compared to a novice designer and different expectations as to what they want from a design model.

TSM is also a product-oriented model. As seen in Chapter 2, instructional design models can be viewed through a taxonomy which, according to Gustafson and Branch (2002), covers classroom oriented models, product oriented models, and system oriented models. This is a taxonomy which focuses attention on the context in which the model will be used. A classroom oriented model usually refers to one that will be used in a classroom context; a product oriented model refers to a model that is used to develop a specific instructional product; and a system oriented model usually refers to a model that is used to manage systems

such as a learning management system. Following Gustafson's example, Morrison, Ross and Kemp's model is a classroom oriented one because some of the steps can only be carried out in a face to face classroom; Bergman and Moore's model is a product oriented one because it comprises steps to develop instructional materials; and Dick and Carey's model is a system oriented one because of its comprehensive scope, e.g. it would readily fit with an online learning management system.

The categories of the taxonomy described above not only demonstrate the context in which the instructional design could be implemented, but other criteria such as the people involved, resources, and expectations regarding the output. Although instructional designers are normally the personnel associated with the instructional design project, teachers or educators could also be the designers of their own instruction. For example, besides delivering the instruction, teachers are indirectly the subject matter expert and also the designer of the instruction in a classroom oriented model. Teachers are both pedagogical and content experts and have the additional advantage of being able to adapt learning materials to suit their particular learners. However, there is clearly some ambiguity in the distinction between product and classroom models, as in some cases, and in particular in this study, the same model can be used in both contexts. Thus, my products, i.e. the learning materials, were used in the computer lab with lecturer facilitation, but the same learning materials were intended to be used independently by learners and perhaps by learners and lecturers in other classes in the future who had no input into the design of the original material. However,

it could be said that the use of TSM in my study more easily fits the product-oriented category as I did not follow a heavily user centred approach model.

In comparing other instructional design models with TSM, I found that the design process in the Nieveen model (see Chapter 2) in many ways mirrors the process that I went through while working on the case studies, especially as it involved developing learning materials. Indeed Nieveen's objective was to produce a computer-based electronic support system for developing educational materials (see Gustafson and Branch, 2002, p.39).The involvement of the subject matter expert (lecturer) and the learners in each of my case studies seems to me to fit the design activities mentioned by Nieveen. I also find that the way she viewed the effectiveness of the materials based on the learners' experience aligns with my own observations while working on the case studies. However, I doubted whether the design of the learning materials alone influenced the learners' perspective on the effectiveness of those materials. As I worked on the three cases, I became increasingly aware of other contributing factors such as learners' prior knowledge of certain topics and their learning styles.

Finally, a clarification on the relation between TSM and the widely used instructional design model, ADDIE, is needed. If we compare the phases of TSM with the generic instructional design model, ADDIE, TSM emphasises the design phase and in particular draws attention to the breakdown of learning tasks and the structuring the content. As described earlier, the ten steps in TSM were slotted into a more conventional ADDIE approach, with TSM providing a focus on the design phase. The design phase is where a designer should consider the pedagogical elements which are the backbone of any instruction. As seen in the

cases, the learning material were self-paced learning material. Designing self-paced learning needs more consideration in terms of pedagogy because teachers are absent during the learning process. This represents a gap in terms of support and the learning material should be carefully designed in such a way that it is able to fill in the gap.

The same ten steps could have been slotted into other models apart from ADDIE. However, ADDIE was chosen in this study because it clearly abstracts the essence of instructional design process holistically. The focus of TSM lies in ADDIE's design phase, as design is obviously a key concern to all instructional design processes. On one hand, this limited focus on design in TSM reduces its scope and, perhaps, its appeal; on the other hand, it deserves our attention because design is so fundamental to instruction.

7.3 RQ2: How does the model work?

TSM works by breaking down competencies or complex skills and providing blueprints for complex learning in four basic components; learning task, supportive information, procedural information, and part task practice. As seen in Chapter 2, TSM is a prescriptive version of the 4CID model (1997) developed by van Merriënboer. Steps 1, 4, 7 and 10 in the model correspond to the four main components in the 4CID model respectively.

Before discussing the ten steps further, as applied in the cases, I remind the reader that a needs assessment was conducted at the beginning of each case. Although I realize that this was not an explicit part of the model I felt that a

needs assessment was important to understanding the context and gave me a better understanding of the context of the case study and of specific issues such as current teaching and learning practice and complexity. I now go on to discuss the application of the ten steps in this study.

Step 1: Designing learning task is the first and most important step in TSM. It focuses on breaking down competencies and complex skills into learning tasks ranging from simple to complex. These tasks can be viewed across a spectrum with the *conventional task* at one end and *worked-out example* at the other (van Merriënboer and Kirschner, 2013). This spectrum serves to sensitise the designer to the complexity of the task given to learners, and for deciding how to present the learning task. Each strategy in TSM represents a different degree of task complexity. In this study, the difference between a conventional task and a worked-out example could be seen in the level of support and guidance provided alongside the learning material. For example, a conventional task is considered to be a complex or difficult task because the support or help on offer is reduced and learners are expected to be able to solve the problem given to them. A worked-out example, by contrast, provides support and guidance, e.g. a case study where learners are led to evaluate the solution given.

As suggested by van Merriënboer, learning tasks can also be designed with different kinds of strategies in mind. Such strategies used in this study included *completion tasks* and *imitation tasks*. A completion task is a type of learning task that provides learners with a problem and a partial solution to that problem. Learners are then expected to give a complete solution by examining the partial solution. An imitation task enables learners to examine the solution given within the task

and use that to address a new task. In Case Study 1, the learners were given a worked-out example task which entailed studying and evaluating elements of good interface design based on an example that was provided. This was a simple task that helped to build knowledge and skills that could be used in solving complex tasks later. The table below summarises the strategy employed in each of the case studies to present the learning task. As can be seen, the strategies were varying and designed to suit the subject matter in each case.

Table 7.3-1 Strategy used in presenting the learning task

Case Study 1	**Case Study 2**	**Case Study 3**
Strategy: Worked-out Example Learning task: Learners are given a design case based on a good example of web or device interface design; learners can study or evaluate the design.	**Strategy: Worked-out Example** Learning task: learners are given a 3D picture of a plastic product with its defect name; learners need to evaluate the product and familiarise themselves with the type of defect.	**Strategy: Worked-out Example** Learning task: learners received three good examples of scripts covering different kind of syntax. Learners need to explain the function of the coding (using comment command on the coding) in relation to the output that they get by running the script.
Strategy: Completion Task Learning task: learners are given a design case (bad design website or multimedia application) that requires the learner to provide a design solution that will	**Strategy: Completion Task** Learning task: Given a 3D picture of a plastic product defect, learners need to identify the type of defect and estimate the causes that contribute	**Strategy: Completion Task** Learning task: learners received incomplete scripts and an output. Learners need to complete the script and get the desired output, based on a screenshot of the output. They then need

overcome the bad design.	to the defect.	to figure out the script that generates the output.
Strategy: Conventional Task Learning task: learners are provided with a design specification (for example client requirements) and learner are required to provide a design solution independent of help.	**Strategy: Completion Task** Learning task: given a certain value or parameter setting, learners need to predict the output of the product for possibilities of defects.	**Strategy: Imitation Task** Learning task: learners received a question that requires them to produce an output based on a given example of PHP script.

It can be seen throughout this study that designing the learning task is the core of designing instruction in TSM. All the various types of learning task described above focus on breaking down the competencies and complex skills into tasks ranging from simple to complex in nature. Learning tasks could be viewed across a spectrum with the conventional task (complex) at one end and worked-out example (simple) at the other end (van Merriënboer and Kirschner, 2013). It could be said that a conventional task is a complex task which stimulates the learner's cognitive domain to provide a solution to a given problem which is naturally varies from one context to another. A simple task, by contrast, focuses on providing the foundation of a specific skill that can be usefully applied to a complex task. From my reflection on working within the case studies, I felt that complex tasks, such as a conventional task, focused on higher order skills whereas a simple task such as a completion task focused on lower order skills. The idea of TSM is that the learning task is designed in such way as to provide support for complex learning and to offer alignment with a real-life task.

However, authenticity was found to be difficult in my experience of practising TSM. It was difficult to understand the real-life task when it was not in my area of expertise. This meant particularly in Case Study 2, I needed to refer to the lecturer in order to design the learning task as well as a colleague from engineering department.

Step 2 is Develop the Assessment Instrument. At the beginning of this study, it was assumed that it was not possible to develop new learning objectives and learning outcomes for the subject matter chosen in each of the case studies. I needed to work with existing curriculum rather than developing a new one**.** This was because it was difficult to even suggest changes given the time constraints and I would not get the commitment of learners or teachers to alternative approaches.

Reflecting upon the three case studies, the learning tasks were designed to align with the subject matter content and in each case, the subject matter content was not simply defined by the syllabus but by the interpretation of the syllabus from the people involved. This suggests the norm is that designers work from the definition of learner needs given to them, and they are constrained by the syllabus and the interpretation of the syllabus by the subject matter expert (lecturer). This is a very important point because it was not possible for me to deviate from the learners' understanding or to understand the complex context of the subject matter without the participation of the lecturer. In fact, in the studies the lecturers were not involved directly during the development of the learning material, but their feedback about the learning task was necessary to inform the design process. For example, feedback from the lecturer on the conventional task

was that this task was too difficult for the learners' level (this is detailed in the evaluation section of the Case Study 1). It was an independent task and learners needed a higher level of knowledge and skills in order to complete it. This makes a general point that lecturers know about their learners because of their direct involvement with them and their years of teaching experience. A designer removed from the classroom may have less teaching experience and gaps in subject knowledge. This does not rule out that at times lecturers may have a distorted understanding of their learners and may miss opportunities for new ways of teaching and learning. This points to the challenging nature of negotiation between practitioner and designer.

Step 3: is Sequence the Learning Task. As described earlier, the many strategies that can be used in order to scaffold the learning task lie in a continuum from simple to complex. In Case Study 1, for example, the task began with a worked-out example task (an example of good interface design). Again, to remind the reader, this was a simple task that helped to build knowledge and skills that could be used in solving complex tasks later. In the same case study, a conventional task was also used as a learning strategy after learners had been presented with a worked-out example task and a completion task. In the conventional task, learners were given a design specification from a client which required them to work independently by providing a design solution based on the given specification. Conventional tasks are important as they show evidence of learning and the transfer of learning to a real or simulated context. Conventional tasks might be appropriate for learners that are already familiar with or expert in a certain area and have already gained certain knowledge and skills. Those who

are less familiar might need additional support and guidance (Merill, 2007). Less support will make learners feel the task is too difficult; more support may make solving the task too easy.

It is undeniable that carrying out learning tasks and progressing from simple to difficult tasks will help to develop learners' mental models crucial to the development of problem solving skills. However, designing learning tasks from simple to complex requires thought and effort in order to balance the level of difficulty of the task in respect of the subject matter, the intended learning outcome, learners' readiness, and maintaining a good level of motivation among the learners.

Once I had an understanding of the learning tasks, I then needed to consider transferability. A key problem throughout the study was the limits put on transferability in the curriculum itself in each case. van Merriënboer and Kirschner described complex learning as integrating knowledge, skills, and attitudes by coordinating qualitatively different constituent skills, and often transferral of what is learned in the education or training setting into daily life and work settings. In school or college situations transferability is rarely tested in real life settings, and much of the curriculum stops at the level of knowledge and comprehension or transferability to simulated settings such as scenarios and case studies. In this study, the transfer of learning was possible in the classroom for example in learners' ability to apply the principles of interface design and PHP programming in their final project as seen in Case Studies 1 and 3. In Case Study 2 it was not seen as possible to produce and correct defects during activity in the injection moulding workshop due to cost, safety and access. So, this limited

learners' ability to transfer learning into real life scenarios. Upon identifying the possible learning task for the subject matter in each case, the next step was to identify different kinds of information to support learners in carrying out the task.

Step 4 is to Design Supportive Information. Supportive information refers to *'general information on how to solve problems within the task domain, including information on the organization of the domain, examples illustrating this domain-specific information, and cognitive feedback on the quality of the task performance'* (Kirschner and van Merriënboer, 2008, p.140). It focuses on helping the learners to perform non-routine aspects of the learning task that usually involve problem solving and reasoning. Supportive information connects what the learners already know with what they need to know in order to carry out the learning task. It deals with cognitive strategies and mental models. Typically, this information is likely to be theory that is presented in text books and lectures (van Merriënboer and Kirschner, 2013). van Merriënboer suggested strategies that can be used in designing supportive information; for example, information that is concerned with mental models could be analysed in terms of three kinds of domain model: conceptual models, structural models, and causal models (van Merriënboer and Kirschner, 2013, p.142).

I now discuss how I designed the supportive information in the case studies. In Case Study 1, the 18 principles of interface design were presented as supportive information. Each principle was presented with an accompanying design case that highlighted how the principle was applied. In Case Study 2, product defect types were provided as supportive information; learners were presented with an

animation to explain the phenomenon of product defect. In Case Study 3, PHP programming was presented as supportive information; learners were given a set of PHP coding and needed to rearrange the programming code and predict the output. Within these examples, supportive information could be categorised into Conceptual, Causal and Structural. As seen in the Case Study chapters, the information or content in the three cases concern mental models because the chosen subject matter of the three cases focused on concepts, facts and principles.

Step 5 is to Analyse Cognitive Strategies and Step 6 is to Analyse Mental Model: These two steps are discussed together because cognitive strategy and mental models are related to one another. In other words, the better a learner's knowledge about a particular domain is organized in mental modes, the more likely it is that the use of cognitive strategy will lead learners to carry out the learning task appropriately (van Merriënboer and Kirschner, 2013, p.196). As discussed above, supportive information helped learners to perform learning tasks that involved problem solving. Analysing cognitive strategies and mental models enabled me to understand how learners understood and processed information and how to present content meaningfully. For example, in Case Study 1, learners found it difficult to remember and relate the 18 principles with designing interfaces. Thus the 18 principles were categorised around three main categories. Organizing the list in this way helped learners to recall, use the principles efficiently, and retain the information at some level. Another example is in Case Study 2, in which learners were given an activity that required them to rearrange and replace certain parts of the programming code. They were then

asked to compare and predict the output. As learners were building up their knowledge and understanding through activities (ranging from simple to complex), learners could see the relation between the programming code and the effect of changing the code. By analysing cognitive strategy and mental models, I could design content that enabled learners to formulate the problem in the learning task given to them. The Table below summarised the strategies used in presenting the supportive information.

Table 7.3-2 Supportive information and strategy

Supportive Information		
Case Study 1	**Case Study 2**	**Case Study 3**
Strategy: Conceptual Model List of principles of interface design supported by a design case to explain each principle	Strategy: Causal Model List of cause of defects of product; animation to support the explanation	Strategy: Structural Model Rearrange certain coding and compare or predict the output
		Strategy: Conceptual Model Learners needed to compare the function of the coding in similar scenarios.

After designing the supportive information, the next step is designing procedural information **is step 7 is to Design Procedural Information)**. Procedural information is described by van Merriënboer and Kirschner as *'just-in-time*

information displays that provides learners with the rules or procedures that describe the performance of recurrent aspect of a complex skill as well as knowledge prerequisite for correctly carrying out those rules or procedures as well as instances of the perquisite knowledge, and corrective feedback on errors' (van Merriënboer and Kirschner, 2013, p.198). I adopted how-to-instruction (cognitive rules) and just-in-time information (prerequisite knowledge) to design procedural information for the case studies.

Step 8 is to analyse cognitive rules and Step 9 is to analyse prerequisite knowledge): Analysing cognitive rules involved analysing and understanding the procedures of performing a recurrent aspect of learning task. The procedures normally take the form of if-then procedure. The analysis of cognitive rules also enabled the identification of prerequisite knowledge. For example, in Case Study 1, by understanding the process of designing the interfaces (sketching, brainstorming and storyboarding), I was able to identify the prerequisite knowledge need to be included in the learning material. As can be seen in Case Study 1, the prerequisite knowledge or just-in-time information included were colour theory and multimedia principles. This information was essential to design an interface but could be accessed as and when needed.

Even though TSM suggested that analysing cognitive rules allows for identification of prerequisite knowledge, I felt in certain context, such knowledge might not be needed. For example, in Case Study 2, learners were presented with steps explaining how to operate the injection moulding machine. However, the just-in-time information or the prerequisite knowledge was not provided as I felt it was sufficient for the learners to know how to operate the machine and there was no relevant information, at least about the machines itself, that needed to be

provided. Further information might end up being redundant as they could understand the steps of operating the machine via a controlled animation. Likewise, in Case Study 3, the basic syntax of PHP and other syntax, such as operator, was presented as just-in-time information through animations which helped learners to recall the concept while carrying out the learning task. There was no relevant step-by-step procedure need to be provided to learners about how to write PHP code since PHP was built on another topic i.e. HTML. The strategies used for procedural information are summarised in the table below:

Table 7.3-3 Procedural information and strategy

Procedural Information		
Case Study 1	**Case Study 2**	**Case Study 3**
Strategy: how-to-instruction Designing an interface (step by step) design solution to overcome design faults	Strategy: how-to-instruction How to operate the machine procedures, broken down in a controlled animation	Strategy: just-in-time Notes about basic syntax, operator, looping and form are given to learners in a pdf format
Strategy: just-in-time Design theory and principles; colour theory and multimedia principles		

Drawing from the feedback about the importance of guidance and support (as explained earlier), it was understood that guidance and support are both crucial in

instruction (Kirschner, Sweller and Clark, 2006). Therefore, supportive and procedural information was made available for the learners at all times in all instructional material for the three case studies in case learners needed them.

As seen earlier, the definitions of supportive information and procedural information were both directly quoted because they are terms which are difficult to define, a difficulty which is increased by an element of inconsistency. I came across this problem throughout my reflection; for example, I had difficulty deciding whether to classify information about basic syntax as supportive information or procedural information. I felt that basic syntax could be categorised as supportive information because it literally supports learners in PHP programming tasks. On the other hand, I also understood that procedural information refers to routine aspects of learning task, and in this respect basic syntax does fit the description of procedural information. I therefore felt that it could be considered both supportive and procedural, but there is an open question as to where one ends and the other begins.

Reflecting on the three case studies, it was difficult to determine whether the learning task and the content of the material (supportive and procedural information) was broken down at a level that permitted learners to find the relationship between the learning task and the content. In relation to complex learning, learners need to be able to integrate the knowledge, skills and attitude covered in the learning task and content, in order to solve problems during the learning task. However, integrating the three elements in solving problems was a difficult task itself, especially when learners could not find the interconnection between the elements. This was demonstrated in the feedback collected from

learners in their post-task survey. In Case Study 2 for example, although learners mostly understood the information provided on the types of product defect, some learners were not sure that they could explain the problem that caused the defect. In Case Study 3, while learners felt they could write a PHP coding based on a given output, some learners were not convinced that they could do so without looking at the notes.

Step 10 is Designing Part Task Practice: To remind the reader, part task practice is practice exercises that given to learners after the instruction in order to promote a high level of automaticity. In the three cases learners attended a lab tutorial which was part of the syllabus in the course. In Case Study 1, the lecturer provided a structured tutorial in which learners needed to complete their final project. In Case Study 2, learners were given a lab sheet that contained instruction on producing plastic product. Based on the lab sheet, they needed to run the machine as in industrial production and produced a report at the end. In Case Study 3, learners were given lab work that explained different examples of PHP coding. As such, the material for Part-Task practice was not developed in the cases. Instead, the learners used the existing material as outlined in the syllabus as part-task practice but I was given feedback by the lecturers.

Reflecting on the ten steps.

By illustrating the ten steps in TSM above, I could sense that even though TSM looked promising in terms of producing a good output or product, I became more aware of the context in which that product is used in ways that TSM did not always allow for. For example, I became aware of learners' uniqueness i.e.

learners have their own way of acquiring knowledge and transfer that knowledge into meaningful learning. Models are important as they guide the designer throughout the design process. However, we should not be bounded by the model because we work in unique context. This will be discussed further in Q3.

7.4 Q3: Is it useful?

Drawing on the discussion of Q1 and Q2, TSM is useful in the sense that it sensitised me as a designer to the nature of the subject matter and its breakdown through learning task and content. Without TSM, I would be easily drawn into the presentation of content and neglect what the content was about and the conceptual difficulties learners might have in understanding that content. Furthermore, TSM shows that different kinds of subject matter content require different strategies. In fact most instructional design models present the information or subject matter to be covered to learners first, and this is followed by learning activities which allow the learners to practise what they have learned (see for example (Martin, 2011). In contrast, following TSM the content in the three cases was presented *through* learning tasks rather than *preceding* the learning tasks. Learners were expected to refer to the supportive information and procedural information while carrying out the learning task. This was to enable the lecturer to grasp the integrated nature of the task and to promote better engagement. The supportive information was needed to reduce the complexity of the task. In practice, however, observation of learners and feedback from lecturers showed that this more task based approach was unusual for learners and challenged expectations. The feedback showed that the subject matter expert or

lecturer in all three cases preferred the conventional method rather than the TSM approach. This was disappointing in that it was more difficult than I predicted to adjust the model to the particular teaching and learning context. However, I still consider that in principle the TSM approach has much to recommend it and it lends itself to a more problem based learning approach which better integrates learning with purpose. This could have become more fairly evaluated in institutions which were more open to problem based learning approaches. Whatever the case the TSM is useful in showing a different way to conceptualise instructional design and to broaden the repertoire of approaches open to designers. The case studies show, however, that design principles always need to be pragmatically adjusted to the context in which the designer is working.

For a novice to TSM, it might be difficult to translate the model into practice. As I was new to TSM and I needed to constantly keep returning to the book for reference. Is there something about it being 10 steps that make it unwieldy? The design concept (terms) used to describe each stage seemed overly technical. As seen in this study, I had particular difficulties with translating analysing cognitive strategies and analysing mental models within the Supportive Information phase. These steps were needed to understand learners' prior knowledge and to think of a cognitive strategy which would be appropriate for the learner. There are three problems here. First, how can I access learners' mental models without carrying out the kind of long and detailed study that academics in the field have carried out (Westbrook, 2006). Secondly, how can I best account for learners' different preferences in terms of strategies and their past learning? One answer is obviously by providing more and different routes through the material but this is

unlikely to be comprehensive and very likely to be time consuming and expensive. Thirdly, there is the problem of scale. It might be possible to carry out focus groups or small experimental studies with small groups of learners but how would it possible to access the preferred learning strategies of large sets of learners remembering that computer based material might be used in contexts far removed from where the programs were first developed?

Ironically, given that TSM is interested in context, when following the model, I had missed important features of my context. This might be a reflection that TSM's strength was it helped to sensitise and invite me to think critically about the learning task and content, but this dominated my attention so much that it drew me away from considering where and how the materials were going to be used. The context in this study was challenging particularly the appropriateness of the courses learners were following given their past education. In fact, the three cases involved learners at varying in educational levels. Case Study 1 was a degree programme; Case Study 2 was a vocational diploma programme; and Case Study 3 was a certificate programme. Case Study 1 represented the highest academic level and Case Study 3 the lowest. Although the three case studies differed in terms of level, they all involved hands-on and vocational courses. In Malaysia, vocational courses are often considered poor relations to academic programmes and are taken by learners who find it easy to identify themselves as being academically unsuccessful, even failures. It is the same picture in many countries. Clearly the usefulness of TSM is compromised if it does not explicitly sensitise the designer to context and suggest strategies for dealing with difficult situations like the one I describe in Case Study 1.

Another challenge faced by learners in comprehending content was the medium of the English language which was chosen by the institutions, and I was obliged to follow. The reasoning was that it would give learners greater exposure to English as an international language. This would also make it easier for learners to learn and use specialist terminology, for example "comprehensibility" in Case Study 1, and some concepts in Case Study 3 that were difficult to translate to Bahasa Malaysia, such as looping concept "If…Else". The material for teaching and learning was presented in English, but communication during teaching and learning was in Bahasa Malaysia. However, learners had more language difficulties than I had anticipated and in addition there were international learners in the class who did not speak Bahasa Malaysia (Case Study 1). The language issue emerged particularly in Case Study 1 as the learners had noticeably weak levels of English. This was one reason why they were not able to grasp the rationale behind interface design. Learners' confidence and understanding was limited due to this language issue. English is not a medium of instruction in most public schools in Malaysia, thus, making English as medium of instruction at higher education institution raises issues about the accessibility to the curriculum. Although this was not my focus, this study raised wider concerns with implications for teaching languages in schools and universities.

With issues of readiness for the programme and English proficiency as a contributing factor, a recurring theme in the three case studies was the difficulty learners had with comprehension of content. I was aware of this from the needs analysis stage in three cases and understood that comprehensions were going to be a challenge in the final materials. However, I was constrained to a large extent

by the curriculum and could not change the learning objectives to make them more accessible in the language used. The problems this raised are picked up later in discussion of adapting the model, but what it suggests is that there is an issue around translating content into design which is difficult to address in any instructional model. Nonetheless, the needs assessment exercise proved to be valuable for sensitising me to the issue of subject matter comprehension especially for the cases in which I was not an expert. For example, in Case Study 2 I was able to witness the learning in the classroom which was valuable to further develop my understanding of the subject matter. The table below summarises each of the case study in regard to the difficulty of the content.

Table 7.4-1 Difficulty of the content theme

	Topic	**What was difficult for learners to understand**
Case Study 1	18 principles of interface design	Some learners were confused with different terms used and could not see ways of organising the list of principles and, later, the application of the principles.
Case Study 2	Types of common injection moulding defect	Some learners were confused about the different nature of defects; such understanding was needed to analyse the cause of the defect.
Case Study 3	PHP basic syntax	Syntax was not always understood and learners found it difficult to write a programming code using particular syntax.

As can be seen from the table In Case Study 1, although the content needed to be applied, it was difficult for the learners to understand the principles in the first place. There were 18 principles of interface design that needed to be understood.

Although it might not have been necessary to apply all 18 principles in one design task, it was important for the learners to comprehend them, identify differences between them, and identify which was appropriate for the tasks given to them. Similarly, in Case Study 2 learners needed to apply their understanding of the nature of product defects. These learners were more successful in applying what they had learnt than those in Case Study 1, as the level of challenge was lower. In Case Study 3 there was a similar problem of application in applying an understanding of different syntax to solve a web programming task. If learners are unable to comprehend a topic, it is difficult for them to infer meaning and link the knowledge with other sets of knowledge or prior experiences. As such, in relation to Bloom's Taxonomy, learners might find it difficult to move from the Comprehension and Knowledge levels to higher order levels.

It is clear that some learners in all the case studies found it difficult to comprehend and apply subject matter. In Case Study 1, this applied to most of the learners, while the problem affected only a minority of the learners in Case Study 2 and in Case Study 3 it involved more learners than in Case Study 2 but fewer than Case Study 1. This finding was striking, as one of the most attractive features of TSM is that it asks designers to really engage with the subject matter content by thinking about ways of breaking down the content and representing it. The key question to be asked here, then, is why did I still encounter this problem of learners being unable to understand the topic? It seemed like the content was received as an isolated concept, lodged into short term memory, and not well integrated into learners' schema. Is this the fault of the model, or does the fault lie elsewhere? Whatever the case at least it made me conscious of the subject

matter as a problem of design and modelling, and led to a better product. A subsidiary question here concerns transference. The model was designed to address transference of knowledge and skills but transference was a difficulty. Again, is this the fault of the model or the fault of something else?

In principle, I want to defend TSM because it is useful in terms of its value in sensitising the designer to the nature and presentation of the subject matter. Without the model, the focus of design might be solely on learner needs, an approach which can be implemented non-problematically, for instance by asking learners what they want to learn or more likely treating learning outcomes as learning needs. Using the model, the designer needs to ask what does the content consists of, how can it best be presented, and what can the learners do with their knowledge. The process of designing supportive information and procedural information was useful as it gave an idea of how to organise the subject matter content and to think about how that content could be presented effectively to the learners. In retrospect, this particular part of the process was not overcomplicated even though other parts were. The process of designing supportive and procedural information gave me opportunity to analyse and categorize the content in two groups.

In practice, however, I found there were some aspects of TSM which were complicated and difficult to apply. For example, TSM talks about understanding the mental models of the learner but this in itself raises deep questions as to how learners learn and how different learners learn in different contexts. There is no simple resolution to such a query. Furthermore, there is very limited literature that exemplifies the use of the 10 steps model and I was put in the exact

problematic position that van Merriënboer explains: how can I use the knowledge and skills gained in a formal context to apply to complex situations, i.e. using the model to design instructional material? I found it very difficult to move from comprehension or knowledge of the model to applying the model in practice.

In discussing its usefulness, TSM might be compared to Shulman's idea of pedagogical and content knowledge (Shulman, 1986). Both are trying to say the same thing: what is the content that the learner is expected to grasp, and how can I best put over this content so that the learners might learn and apply it. Shulman sees pedagogical content knowledge as a combination of understanding what to teach and how to teach it, i.e. in what way the learning material could be designed to deliver the content effectively. Shulman draws on the wisdom of practice as well as his understanding of formal pedagogy. Perhaps the designer is not a lecturer or classroom teacher, but it might have been more straightforward to think about the problem of presenting content in terms of pedagogical content knowledge rather than in terms of supportive and procedural information. Schulman perhaps offers a more accessible approach and might promote more open-ended thinking about design, but this is just conjecture without experimentation.

Without models, it is difficult to abstract what we need to do when designing and hence, we might find the process laboured and outcomes problematic. However, we should always be aware that learning is not the outcome of one factor, for example the quality of learning material, but a web of interaction and

understanding. The process of teaching and learning are also influenced by a social cultural context. This will be discussed later in RQ4.

7.5 Q4: What are the contexts that need to be considered in adapting the model?

From the case studies, there were several themes emerged that were not directly related to the TSM but essential to be considered in adapting the model. As discussed in RQ3, TSM draws attention to the need to think critically about breaking down the learning task and structuring content. In so doing it offers less focus on context, something that is essential in designing instruction. The implications of this are discussed below.

TSM should be used flexibly. In relation to the instructional design process, TSM emphasises the design phase and provides steps to break down learning tasks before the development phase. As suggested by van Merriënboer, TSM can be used along with other models such as the ADDIE model, particularly in the design phase. TSM is not a standalone model. For example, by integrating TSM into the ADDIE design phase, attention is drawn to content, task, and strategies. The model is flexible enough to be adapted to classroom oriented or system oriented contexts in a design phase.

A designer should care about the subject matter content. TSM focuses on breaking down the learning task and subject matter content. The designer needs to engage with the subject and be curious about it. The designer should not see themselves as a technical expert, but rather as someone who has an interest in

how knowledge is integrated to build a concept that could help the learner to learn better. This attitude will put a designer in a better position even though the subject matter is not within his or her area of expertise. Of course, it might be an advantage for a designer to have a greater experience and understanding of the subject matter. Lack of experience of teaching the subject matter requires a designer to build a good rapport with the subject matter expert in order to receive their support throughout the process of developing an understanding of the topic and, later, help to visualise which strategy is appropriate in presenting the learning task, supportive information and procedural information.

In my case studies, Case Study 1 felt the most straightforward because of my personal experience of teaching Interface Design. Case studies 2 and 3 were comparatively difficult as the content was based outside of my areas of expertise. Case Study 2 was particularly difficult as Injection Moulding was a foreign subject for me. However, I was able to grasp the content relatively easily with the help of the lecturer, by reading the material used by the lecturer, and by researching other references related to the content. In terms of learning tasks, I felt from the feedback that the tasks were relevant and strategies were well chosen. Nonetheless, I felt a sense of insecurity throughout the process even though the evaluation was positive. Reflecting on the three cases, I wish I could have asked more questions about the choice of English as the medium and on what bases the learners were accepted into the programme; was there any consideration of learners' prior educational background? However, since my focus was on adapting the TSM in designing the instructional material, my questions were

limited to the context of the complexity of the subject matter and how the course was being carried out.

Looking back, I can see now that despite the uncertainty, there are some advantages if the designer does not know the subject matter very well. He or she can approach the subject matter with a more open mind and is better able to stand in the shoes of the learners rather than making assumptions as to the best ways of learning the subject matter. The relationship with the lecturer may be more straightforward, as the designer must find it easier to acknowledge the lecturer's subject matter expertise. Of course, these are drawbacks because design becomes more time consuming and there is a danger of missing something important in the content. However, this need not be a problem if the designer approaches the work with a curious mindset and is dedicated to getting it right.

A designer should consider the place of multimedia. In order to help learners to deal with complex content, an appropriate scaffolding technique is needed. One of the techniques to deliver complex content is through the use of software tools (Reiser, 2004). Using ICT as a medium of scaffolding benefits learners if it can represent the complex content in such a way that helps them to understand the content in a more manageable fashion. For example, Abrami (2001) discusses some research around using technology for knowledge construction as a result of interacting with the content developed through technology. It is this attempt to use ICT to scaffold learning that will be investigated in this study.

In TSM, the use of multimedia was mentioned in presenting supportive and procedural information, but it should be understood that it is not necessary to have all multimedia elements in a content presentation (Mayer, 2009). As a designer, there is a need for me to consider the affordances of the elements and how they afford the learners assistance that helps with learning, rather than focusing on how interesting the elements are or how sophisticated learning will become through the use of multimedia elements. Below is the summary of the multimedia used in each of the case studies.

Table 7.5-1 Summary of multimedia elements used in the cases

	Text	**Graphic**	**Animation / interactivity**	**Video**	**Audio / Sound effect**
Case Study 1	x	x	x		x
Case Study 2	x	x	x		x
Case Study 3	x	x		x	x

In the case studies, multimedia supported the delivery of the content and particularly the delivery of supportive and procedural information. It helped learners in processing the content presented to them. The multimedia elements were determined by the type of content; for example, in Case Study 1 some animation was used to present the concept of each principle of interface design, but it was not used extensively because graphics were also appropriate in the

explanation of those principles. In Case Study 2, animation was core to explaining the process of how defects in injection moulding occurred, as I needed to show the process as a series of causal links. The same applied to Case Study 3 whereby animation was needed to explain the logic of programming.

Here I will discuss the use of multimedia in my cases and draw conclusions as to how it can be used in this context. Feedback showed that learners would have preferred more multimedia elements and found the material too text-based. The use of multimedia seemed to influence how learners perceived the quality of instructional material presented to them, rather than judging the value of the multimedia elements in supporting the presentation of the content. The desire for more multimedia also appears to be a default response from learners. This could be because most learners perceived multimedia as easy compared to text-based material (Salomon, 1984). Designers need to be aware of this and to treat this feedback critically.

Although multimedia was perceived as easy compared to text-based material, multimedia should not just be used as a favour or substitution of the text per se. Rather its potential should be used to help learners in learning engagement includes showing the practical application of a concept, help with understanding the concept and address negative attitude towards a concept (Neumann, Neumann and Hood, 2011). As seen in the cases, the use of multimedia (animation and graphic) in supportive and procedural information assisted learners to understand the concept in the subject matter. Besides, with the right use, multimedia encourages learners to engage in cognitive process of the given content. For example, the learning task in Case Study 3 required learners to self-

explain how PHP coding works by writing the explanation in coding *comment*. Being able to self-explain is a good indicator for learning engagement and transfer of learning to occur (Wylie and Chi, 2014). However, multimedia still did not address negative attitude among a small number of learners towards the topic in the case studies. As seen in the case studies, some still find the concept difficult to understand. Of course, earlier it was understood that some of the learners were having issue with English and low entry level. This showed that these issues needed more attention before considering the use of multimedia.

Besides multimedia elements, designers need to consider menu and navigation structure. The criteria of a good navigation structure lie in how well the user can find and retrieve the information they want. The navigation will help the learner to feel a sense of control and will influence the learner's motivation. In practice, some learners in my cases navigated through the instructional material in unexpected ways. For example, some learners were found to randomly navigate through the instructional material without reading the instructions properly.

On reflection, this may have had more to do with learner readiness (or lack thereof) than how the instructional material was structured. Another possible explanation to the randomly clicking behaviour seen in the case study could be relate to butterfly defect (Salomon and Almog, 1998). Salomon and Almog described butterfly defect as learners unconsciously fluttering across information on screen whether clicking or not clicking information. Although they described the butterfly defect in the context of learners using hyperlinks and internet, this somehow relevance to the learners' behaviour randomly clicking the menu experienced in my case studies. Since all the instructional material in the case

study were designed and developed with a theoretical underpinning of self-directed learning or self-paced learning, there were many elements (menu) that invited learners to click. For example, in Case Study 1, there were many menus to cater the presentation of each principles of interface design, thus perhaps encouraging butterfly defect. Although giving a sense of control is important when considering for self-directed or self-paced learning material, it should not disrupt learners' attention to focus on the important information presented to them.

The theme of the interface was also raised by the participants during evaluation sessions. In Case Study 3 it was raised more often by the participants, who suggested that the interface could be more attractive by changing its theme. This was perhaps to be expected as in the LectureMaker platform used had limited design features. For example, the button design was basic as compared to the use of Flash in Case Study 1 and Case Study 2. However, in terms of delivering the content, the LectureMaker platform was fit for purpose and this raises the question as to whether the cosmetic features of the product take precedence over the content in the minds of some learners.

Finally, choices over using multimedia or computer-based instruction were influenced by factors such as technical facilities in the institution in question. For example, it was not an issue to use computer-based instruction with Flash support in Case Studies 1 and 3 because there were sufficient facilities at the institution. However, this was not the case for Case Study 2. As described in Chapter 5, although at the design stage I felt mobile device would be a better medium, the feedback showed that learners felt it was inconvenience for them.

It was learnt that, although mobile gadgets offered learning on-the-go features that benefited learners, it might not be the best option in every learning situation for example as seen in Case Study 2. Using mobile gadget as reference and at the same time dealing with technical activity at the injection moulding workshop was not taken up. Perhaps this might be because it would create split attention which is something that I had overlooked. Although technology is well known to assist and support learning, the designer should not consider technology as the default solution. Rather, technology should be adapted according to learners' comfort and readiness (Mayer, 2009).

A designer should consider learner readiness. Learner readiness in the context of this study refers to learners' prior knowledge and understanding of the subject matter. The concept of a zone of proximal development expounded by Vygotsky (1978) is a useful one to capture the gap between learner understanding in the present moment and what understanding is achievable. For example, in Case Study 1, the goal of understanding the 18 principles of interface design, I would not argue, lay outside of some learner's zone of proximal development because they did not have practical experience that allowed them to grasp what was being instructed. In Case Study 3, some learners were not ready because they did not have the prior knowledge of programming that they needed to engage with the material. Some of the consequences of lack of learner readiness were observed during my own visit in that learners tended to randomly click on the menu and navigate from one interface to another rather than following the provided instructions. A possible explanation for this is that when the tasks lay outside a learner's zone of proximal development, learners rush

through the material, wanting to get to the end even if they do not understand it. In addition, it was noted that the use of the English language as the medium was outside of the learners' zone of proximal development. This suggests that there should be a more critical relationship between the designer, the lecturer and the institution so that potentially difficult questions can be asked about the suitability of the curriculum. In particular considering English as delivery medium in the policy and the process of how learners are selected for the courses.

Learner readiness also poses the questions of differentiated routes within the material. TSM looks more at the tasks than at the learners, but we need to look at the learners and understand that they have different levels of readiness. What is needed is a way of providing personalised routes within the material or even different types of material for different learners. This indicates that the model needs to be adapted to consider differentiation and curriculum suitability. In order to achieve this, the designer should develop a rapport with the subject matter expert.

Design takes place in a wider ecological context. To discuss this, I would like to make a reference to the idea of Bronfenbrenner's ecological system that was seen as influencing the development of an individual. This had its origins in discussing children's development but has been widely adapted into other fields. According to Bronfenbrenner's theory of human development (Bronfenbrenner, 1979), a development of an individual (child) is affected by his or her relationship with the surrounding environment. Bronfenbrenner described the environment as consisting of different levels i.e. microsystem, mesosystem, exosystem, macrosystem and chronosystem. *Micro* is the level directly experienced by an

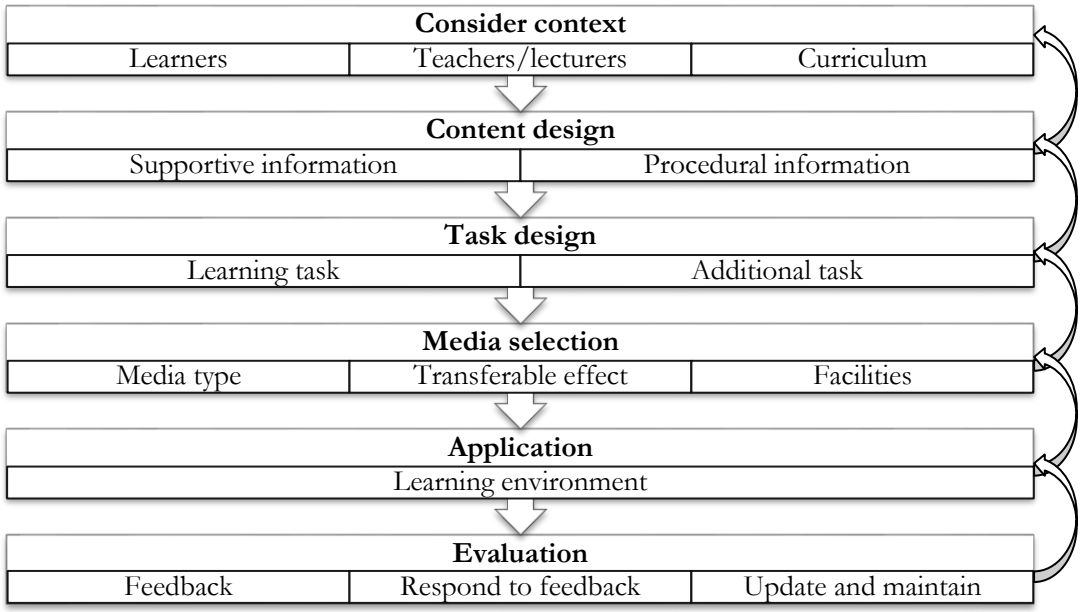
individual for example the relationship between a child and parent within an environment such as home or school. *Meso* is the level where there is linkage between micro and wider systems, for example there might be an impact of the home environment on the school micro system. The *Exosystem* is the level that involves systems in which the child does not engage directly but has an indirect influence on the child, for example the working environment of the child's parent might have an indirect influence on family life. The *Macrosystem* is at a level which the child does not directly experience, for example, the cultural context in which the child lives or the socioeconomic status of a country.

All of the issues raised in terms of designing for teaching and learning in the case studies had micro, meso and macro dimensions. For example, the language issue could be viewed from Bronfenbrenner's ecological system theory. At a micro level English proficiency made some of the learning material directly difficult to access. But it was important to understand that this was influenced at a meso level by decisions taken by institutions to make English as the medium of teaching and learning. Meanwhile at macro level discourses around the use of English made the use of English widespread in higher education institution in Malaysia (see Md. Noor and Hii, 2011; Mohd Amin and Rahim, 2010; Surif, Ibrahim and Kamaruddin, 2006; Haron et al., 2008). The task based learning or problem based learning issue could further be discussed in micro, meso and macro dimensions. New approaches to learning approach, were difficult for some learners to access at micro level especially for learners who were used to a different way of teaching. As such, some of the learners struggled with the content (see Mohamad Termizi and Md Yassin, 2013; Berhannudin, 2007).

However, their difficulties needed to be seen at meso and macro levels as institutions were making decisions about the curriculum which were in turn responding to government policy.

Finally, I come to offer as a concluding statement a more holistic approach to design based on my study. Design I now see in terms of six core steps (Figure 7.5-1)

Figure 7.5-1 Six core steps



The initial step for a designer is to consider the context for learning, this includes knowing the background of the learners and their academic experiences, preferences and language experience, challenges faced by both the lectures, their willingness to work with designers and their preferences for teaching and learning. At this stage, the designer needs to consider the curriculum and the support offered to the teacher in terms of texts books, schemes of work and

examination practice as well as its fitness for purpose. This brings in micro, meso and macro levels.

Of course, not all products are designed for known audiences and this would require sampling strategies in order to generalise about learners. This would give the designer an overview of possibilities and challenges and in extreme cases the designer might conclude there is no viable basis for continuing the project.

The second step is to consider the content or the subject matter for the learning material. In this step, designer needs to reflect on their own understanding of the topic, and how they are going to address gaps in their knowledge. They need to understand how to break down the topic into accessible parts and how learning can be supported by drawing on ideas within TSM, in particular structuring the content into supportive information and procedural information.

The third step, again drawing on TSM, is to consider the tasks that the learner needs to show competence in. These tasks could be divided into the main learning task that learners need to carry out and additional tasks if needed.

The fourth step is media selection. The designer needs to consider the type of media, and organisation of media, to deliver the content and tasks in attractive, and consistent ways for the learner. Pragmatic choices need to be made and some opportunities might have to be avoided as, for example, the software is too expensive, the likely machines to be used do not have the required capacity, the designer may lack the skills, the implementation is too costly or too time consuming. There need not be an assumption that ICT will be used.

The fifth step, application, requires the designer to consider the learning environment in which the learning material will be used. The environment covers access to facilities that support the delivery of the learning material, and face-to-face support to trouble shoot learners' difficulties as well as offering more instructional guidance.

The final step is an iterative one in which evaluation is sought on the material enabling the designer and the lecturer to identify what works well and what needs to be changed. These changes may involve the learning material itself but they may also involve the context, for example changing the conditions in which the material is used. This kind of design model of course needs to be tested and extended but it captures the key learning from the thesis. It draws on aspects of TSM which were found to be valuable, but offers a much more holistic and in many ways accessible guide, the process of design for learning.

7.6 Summary

This chapter has addressed the overarching research question: "What is the value of the Ten Steps to Complex Learning model?", and sub questions. It discussed TSM in regard to instructional design model types and taxonomy, and reflected on the ten steps involved in developing instructional materials and the strength and weaknesses of TSM within the scope of the three cases. The chapter also offered a discussion of the important context that need to be considered in adopting TSM. At the end, a design framework that combines important elements in TSM and context was introduced

CHAPTER 8: CONCLUSION

8.1 What is this chapter about?

This chapter concludes this thesis by presenting a summary of findings for each research questions, contributions of the thesis, the implications on research and practice, limitations and recommendation for future studies.

8.2 Summary of findings

This study is a design and development research that has interest on the TSM and its adaptability in designing learning material. This study was developed based on the approach of pragmatic inquiry and action-oriented elements. It seeks to explore the value of the TSM by planning, acting, observing, and reflecting on the process of design and development of learning material and make used of available tools and adapt them to the context of the case study. The case of Interface Design, Injection Moulding and Web Programming in this study served to provide an in-depth experience of how the TSM works across different context in designing and developing learning material. Each case study was examined with direct reference to the TSM and this process of reflecting on action build up knowledge about TSM and how it works in practice. Through this, the four sub research questions were addressed and some adaptive elements were introduced. It was proposed TSM should be used flexibly and a designer should care about the subject matter content, consider the place of multimedia,

should consider learner readiness in implementing instruction and being aware that design takes place in a wider ecological context. At the end of this thesis, the final statement of the overarching research question was addressed.

8.2.1 Summary of Research Question 1

The first research question was "What is the model?". This model is a procedural model, could be categorized as product oriented model and could be applied in the Design phase in respect to ADDE model. TSM is a procedural model as it was presented in a form of prescriptive steps of designing instruction. In considering the placement of the TSM in relation to the three cases, TSM could be considered as product-oriented model. The context of how the TSM was adapted in the case studies and the instructional material produced in each case fits the product-oriented category. However, it was also felt that TSM could also be categorized into two other taxonomies depending on the context of how and where the model is adapted. In relation to ADDIE model, the TSM is applicable in the Design phase as the approach of the ten steps engage us in the process of designing learning task and the content of instruction.

8.2.2 Summary of Research Question 2

The second research question was "How does the model work?". There were two main keys of how the TSM works. TSM works by:

Breaking down the competencies or complex skills into learning task. By directly reflect on the TSM, it was found that the model helped to breakdown competencies or complex skills and translated to learning task. As a result of

breaking down the competencies and complex skills, learning tasks designed in all the three cases were varied ranging from simple to complex that is useful to promote learning transfer. I learnt that even though TSM provides the steps and strategies of designing the learning task, it was limited within the scope of learner needs and syllabus, and interpretation of the syllabus by the subject matter expert (lecturer). It is crucial to consider the level of difficulty of the task in respect of the subject matter, the intended learning outcome, learners' readiness, and maintaining a good level of motivation in the learners. However, in consequence to these considerations, it put limitation to the possibility of transferability in each case into real life scenario.

Structuring the content of the subject matter via supportive and procedural information. In reflecting on the process of adapting the steps of designing supportive information and procedural information, it was found that TSM helped to structure the content of the subject matter. Looking back at the design process of all the cases, TSM provides a guide to separate the content into two sections; (i) the one that is useful for problem solving i.e. covered the non-routine aspect of the learning task, and (ii) the one that is useful for just-in-time information i.e. covered the routine aspect of the learning task. The strategies suggested for supportive and procedural information engaged me in thinking process by viewing the content differently and made me to critically analyse the nature of the content and fitting the content into a box. However, it was a bit problematic in determining the box of where the content fit in as it was found in the cases that there was content that could be both supportive and procedural. Although it was suggested in the literature that supports and guides needed to be

gradually reduced as learners move from one task to another, this was found problematic in this study. Considering learners background and the type of content (most of the content involved in the three cases involved concept and knowledge development or low order skills), it was important to maintain the supportive and procedural information throughout the learning material.

8.2.3 Summary of Research Question 3

The third research question was "Is it useful?". Looking at the two previous research questions "What is the model?" and "How does the model work?", it could be said that the model was useful as it invited me to critically engage with the subject matter by raising awareness about what does the content consists of, how it can be presented and what can learners do with their knowledge. In the sense that it raised the same query asked of all teaching (see Shulman earlier): *what is the content that the learner is expected to grasp, and how can the content be best put over to enable learners to learn and apply it*. Although some of the parts in the design process using TSM were found to be useful, there were also some parts that were complicated in the sense that they did not properly addressed issues on learners' difficulty of comprehending the content and learning transfer. This raised awareness that there are other important points to consider in adapting TSM. As found in this study, the complexity of the content and the context of each setting, in particular learners' low entry level and English proficiency, were seen as important aspect. It was also important to take into account the context of where the learning material was used as it was found that the setting of learners working alone with the learning material did not work nearly as well as when there were people there to assist them.

8.2.4 Summary of Research Question 4

The fourth research question was "What are the contexts that need to be considered in adapting the model?". By adapting the TSM in the three cases, some adaptive elements that found to be useful for practice were introduced. Since TSM is not a standalone model, the first thing to know about adapting the TSM is it should be used flexibly in order to complement other instructional design phases especially in design phase. A designer should care about the subject matter content and approach the subject matter with an open mind. It was also found that a designer should consider the place of multimedia especially in presenting the content of the subject matter. Learner readiness was also found to be important in adapting TSM in designing learning material.

8.2.5 Overarching Research Question

Knowing the main key themes in each of the research questions, this enables me to address the overarching research question: what is the value of the model? TSM is an instructional design model that emphasis Design phase in instructional design process. As seen in chapter 2, this model does belong to the Design phase in instructional design process and it needed to be supported with other instructional design model. In relation to the model taxonomy, TSM could fit in any Design phase of instructional design model belonging to the three taxonomies; classroom oriented, system oriented and product oriented. It offers a systematic approach to sensitise the designer in respect to important aspects of design. It draws our attention to think critically about the learning task and content of a subject matter. Adapting TSM provides a new way of viewing design

process by intelligently breaking down the learning task and the content rather than focusing on the integration of multimedia or technology solely. Emanating from some of the mixed responses to material generated in the three cases, it could be said that context play an important role. The usability of any product, irrespective of design approach followed, depends on context. Context might be referred to learners' background, learners' readiness and instructional environment.

8.3 Contribution to knowledge

This study contributes to several areas of research in particular design and developed research (DDR). The areas are *action oriented as research design in DDR; combining two approaches of DDR to inform practice; contribution to the design and development knowledge base; methods;* and *using negative data to informed practice.*

Action oriented as research design in DDR. As seen in Chapter 2, this was an account of model use (Type 2) which focused on designers' experience. As such this is an underreported approach and led me to focus on design and evaluation at the same time. Holding a dual-role position in this study provided an opportunity to integrate elements of action oriented research by planning, acting, observing, and reflecting on the process of design and development.

Combining two approaches of DDR to inform practice. As described in Chapter 2, this study is a combination of model use study (Type 2) and product development (Type 1) in which the use of TSM was reflected based on the product developed in each case. As seen in the literature., most studies were

normally focuses on either product research or model research. By combining these two types as seen in this study, I showed the relationship between how the instructional material was developed and the approach used in producing the material. Although the studies were bounded within the context of the cases, the adaptive elements on TSM proposed in this study could be generalized to those who is confronting with similar context. This contributes knowledge that is useful to practitioner.

Contribution to the design and development knowledge base. As seen in the literature, Richey and Klien described six domains that related to the knowledge base (See Chapter 2). This study has contributed to some areas in the design and development knowledge base. The areas are *learners and learning processes* whereby this study has showed some evidence how learners used the learning material and how they learn through it; *content structure and sequence* whereby this study showed some evidence of how the content was sequence according to TSM and how learners and the lecturers feedback on the sequence that is unfamiliar to them*; media and delivery systems* whereby this study showed some evidence of how the presentation of the content could be supported by media, what works and did not work; and *designers and design processes* whereby this study showed some evidence of design reflection towards the use of TSM in developing the learning material.

Methods. Since this study was action oriented, the process of reflecting on the design process suggests that a design log be used as a method. Design log in this study could also be referred to as researcher's diary which contains reflections

and personal note of a researcher as the study goes. The reflection was used to triangulate the interview and survey data.

Using negative data to inform practice. As seen in this thesis, interview, design log, survey and observation were used as methods to understand the used of TSM in each case. It is the norm in DDR or perhaps in other research for the researcher show positive data, for example the success of a product or how a specific instructional design model helped to developed efficient instruction. However, in this study, I showed the difficulties and challenges and this kind of real life feedback can really help to inform practice. As seen in the case studies, the mixed feedback experience in Case Study 1 forced me to look at other elements (e.g. language use and learner readiness) which I had not considered before and raised the importance of understanding context.

8.4 Limitation of this study

There were some limitations while conducting this study. the limitations include: *dual role position; context influence; novice experience; cost;* and *survey as method.*

Dual role position. In this study, I am the key instrument for data collection and this requires me to be reflexive throughout the three cases. The reader is thus able to see how the data were collected and interpreted based on my prior experience of design and my developing understanding of TSM. Although combining two approaches in DDR (product development and model use) brings opportunity as described in section 9.3, it also raises issues. Being in a dual role position, my reflection on the use of TSM would necessarily be subjective which

might lead to bias. How I addressed this issue was explained in Chapter 3, but I needed to be aware of my positionality in this study all the time. As can be seen in the three cases, I used a design log (researcher's diary) to record the work I was doing as I developed the learning material. The record of the design process was crucial to inform how TSM was used and also helpful to interpret data collection from the survey, observation and interview. It is difficult to eliminate bias especially in social research, in fact it is impossible as all data are collected with the researcher's particular purposes in mind and are interpreted according to those purposes. However, I needed to use strategies which would give me greater objectivity. One such approach was to triangulate the data from the survey and interview with the design process recorded in the design log. This gave my findings greater credibility.

Context influence. It is the norm in product research (Type 1) for the project to be bounded within a specific context. This study involved three different contexts (i.e. three kinds of subject matter and three different colleges) and the description of the strengths and weaknesses of the TSM were grounded within these cases. As seen in this study, each case was unique and had its own boundaries that influenced my decision as to how the TSM was used. Thus, other designers should be wary of drawing generalised conclusions on the basis of this study. Far better is that they see the cases as relatable and make comparisons between their context and the ones I have described here. In fact, my study shows that each case has unique features and that a flexible approach to design is needed.

Novice experience. My experience about TSM was relatively new. The TSM was adapted and reflection about the use of TSM was made within the scope of my own knowledge about the TSM. There may have been a different output if I had developed prior knowledge about TSM.

Cost and time limitation. This study was also conducted within the duration of my PhD study and was not a funded study. Most of the product development was carried out by myself with some help from the subject matter expert and colleagues to help me understand the content. There was time limitation in terms of developing the learning material for each case.

8.5 Recommendation and future study

Working closely with TSM makes me realize that there is more opportunity for future research in some areas; *using TSM in different context, adding more iteration in design and development process,* and *combining TSM with other instructional design model.* These areas provide opportunity to produce rich description about the use of TSM.

Using TSM in different context. Using TSM in different context provides opportunity to explore the model. This is because different designers might make different design decisions. Context in this sense refers to using *different content or subject matter*, using *different* instructional *medium* and apply the learning material on *different group of learners*.

Different content or subject matter. As seen in this study, the subject matter used for each case focuses on concept, for example principles of interface design in Case Study 1 and concrete operations, case study 3. It would be very useful to explore how TSM could be used in different contexts, for example ones that involved physical skills, or soft skills.

Using *different* instructional *medium.* TSM could also be explored in different instructional medium such as MOOCs with different opportunities for providing supportive and procedural information Having said this, TSM does not necessarily have to be ICT based. Depending on the needs and suitability of instructional context, the instruction could also be delivered in a non-ICT medium. For example, a face-to-face session could also be a medium of instruction in which learning task could be delivered to learners in a form of demonstration by the lecturer (worked-example task); the supportive information could be in the form of reference book; and procedural information could be adapted in a form of paper based user manual.

Using on different group of learners. As seen in this study, the learners involved in all the three cases had similar profile in terms on low entry level. Given this background, learners were challenged by the content design in the curriculum. It is also worth questioning whether the designed curriculum was suitable for them. It would be useful to explore how TSM could help learners with different background profiles. TSM might be useful in training context where learners had already developed certain set of skills rather than learners who were still in the process of developing foundation or knowledge of certain area. It

is also worth considering more personalised learning approaches which would be better adapted to learner readiness.

Adding more iteration in design and development process. It is also recommended that more iteration cycles needed in order to reflect on the design and development process of instructional material. As described earlier, there were limitations in terms of time for each case study which hindered the iteration cycle. More iteration would enable reflection in terms of design consideration for example enabling the use of real photos and video of injection machines. From the reflection of using TSM in this study, I would suggest that the analysis phase should be integrated in every step in the model. This is because as we learn more from the iteration cycle of doing design and development, we began to know the context better.

Combining TSM with other models from different taxonomy. As seen in the literature, there were three types of instructional design models i.e. classroom-oriented, product-oriented and systems-oriented. This study itself combined TSM with ADDIE model and was considered as product oriented. However, since TSM emphasised the Design phase, it would be useful to find out how it can be implemented in other Design phase from different model such as Morrison, Ross and Kemp model (classroom-oriented) and Smith and Ragan model (systems-oriented).

8.6 Concluding note

This study was motivated by my own personal interest in the area of instructional design, in particular content development. Being a multimedia developer and a content developer in a subject I taught at university, my work has always been closely related to content and how material can be put together for teaching and learning purposes. I began exploring the TSM at the beginning of my PhD journey and as described earlier, I was a novice user of TSM. This triggered my journey to understand the model. My research changed my view about design.

What I found attractive about TSM was that it looked like providing an answer to designing material in an organised and effective way. But I was wrong. TSM provided a useful framework but teaching and learning was much more complicated than I thought. Being a novice user of the model, I was challenged by the complexity of the design, the necessity to comply with the ten steps and at the same time trying to reflect on how the model worked. I must say I was struck in all three cases by the complexity of learning. In fact, in writing this concluding note, I begin to see that thinking about design is much more than just adapting and adopting of one model over another. Despite the difficulty I had, this does not stop me from exploring and perhaps using TSM in the future. It has something to offer but there is a need to improvise based on as clear an understanding of context that is possible. I began to understand that designing instruction remains a process of asking yourself: what to teach, who are you teaching and how should you teach.

Finally, integrating elements of action research in my study introduced me to the idea of reflection. I was encouraged to reflect on what I was doing and maybe this process of reflection would have been as valuable no matter what model I was evaluating. Working with three different contexts, I achieved a much broader sense of teaching and learning. I was able to reflect on my design practice as well and appreciate the need to be flexible. Design is not a linear process. If there is a need to change the order of steps to be taken, or drop one or two altogether, then change. I felt the field of instructional design could benefit a lot from more accounts of design reflection, like the cases studies presented here which tell the story behind design and development and does not pretend there are easy answers or 'one size fits all' models.

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LIST OF APPENDICES

APPENDIX A

INTERVIEW SCHEDULE: NEEDS ASSESSMENT

These are the main interview question that guided the interview session during needs assessment. However, the main questions were follow-up with additional questions based on the needs as the interview took place.

Session	Topic	Description
Introduction	Greet and introduce myself.	Provide letter from university to prove student status and currently doing PhD
	Purpose of coming to the institution and about research (objective and what is needed for the research).	Explain about the study. Explain roughly about the model if the participant has query about the model. Explain about the need to choose a subject that could be used as a content (subject matter) for the to-be-developed learning material. Explain what is expected from the participant.
	Develop rapport	Your expertise and experience you had teaching the subject is valuable to my research. I am looking forward to learn more and work together with you.
	Timeline of the	The interview will take about XX to XX. But it depends on you. If

	interview	you are not comfortable at any time during this interview, do let me know.
Main body of the interview	Introduction	I made my own reading about the course XXX and subject offered in your programme. In the letter I sent, I am interested on (name of the subject XXX).
	About the lecturer	Demographic question; experience, education background.
	About the subject	Ask about the background of the subject; material used for teaching and learning; assessment methods; teaching experience; issues and challenges.
	About the learners	Ask about learners' background in general; learners experience, issues and challenges)
Ending the interview	Summary	Sum up what was covered during the interview.
	Research planning	My plan for this research will be… (Research planning that involved lecturer and learners' participation).
	Maintain rapport	Thank you for your participation in this interview. This has been a great session. Contact details (email or phone)

APPENDIX B

INTERVIEW SCHEDULE: EVALUATION

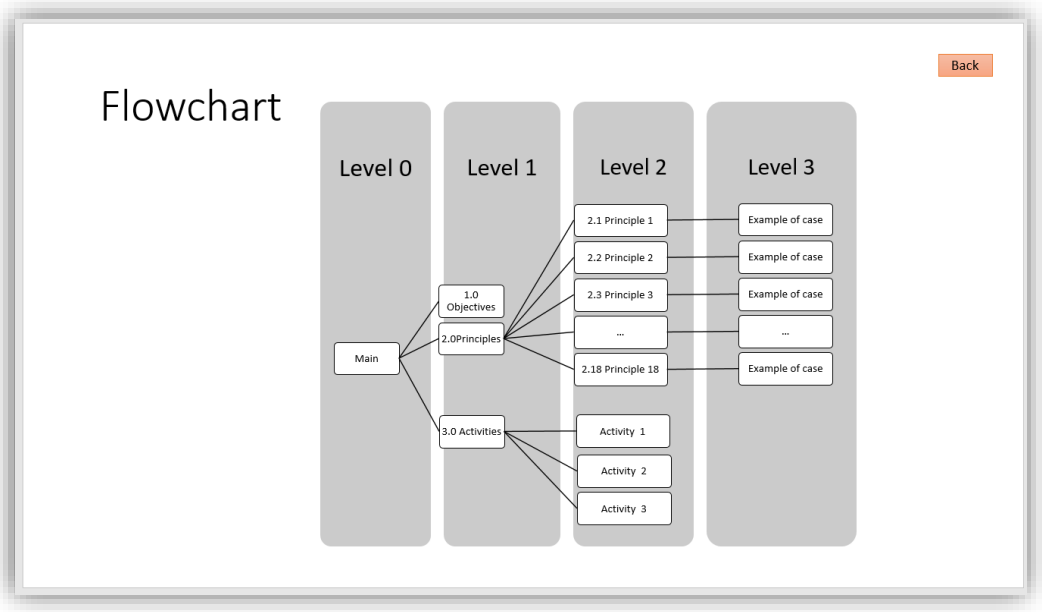
These are the main interview question that guided the interview with the lecturer during evaluation session. However, the main questions were follow-up with additional questions based on the needs as the interview took place.

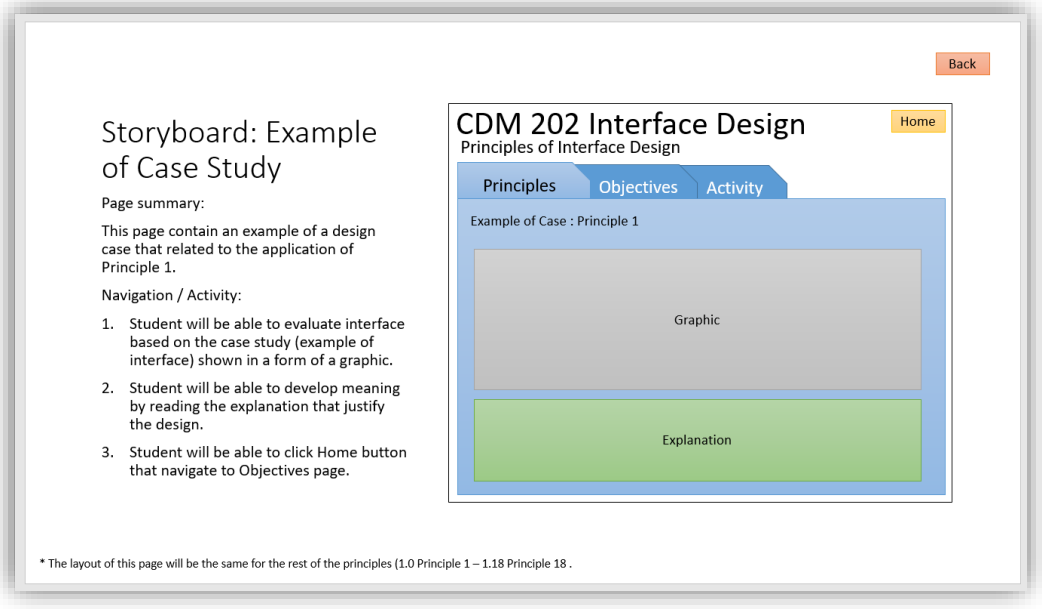
Session	Topic	Description
Introduction	Greet and appreciation	Assalamualaikum. Thank you for your participation in evaluation session.
	Refresh	Recall about previous meeting.
	Purpose	Explain the purpose of the interview and the significant of the interview to the study.
	Timeline of the interview	The interview will take about XX minutes to XX. But it depends on you. If you are not comfortable at any time during this interview, do let me know.
Main body of the interview	Components of the TSM	Ask about the components of TSM in the learning material. Example: • what do you think about the content (component: supportive information) • do you think the XXX (component of TSM) helped learners carrying out the learning task?
	Usefulness	Ask about the usefulness of the learning material. Example: Do you think learners find the material helpful? Do learners need your help or guide to use the learning material?

	Presentation	Ask about the presentation of the learning material that include accessibility and design of the learning material. Example: Can you follow the learning material? was it easy?
	Pros and Cons	Ask about the overall feeling of using the learning material. Example: What do you like about the learning material? what was the challenges of using the learning material.
Ending the interview	Summary	Sum up what was covered during the interview.
	Research planning	My plan for this research will be… (Research planning that involved lecturer and learners' participation).
	Maintain rapport	Thank you for your participation in this interview. This has been a great session. Will it be ok if I email you if I have more questions?

APPENDIX C

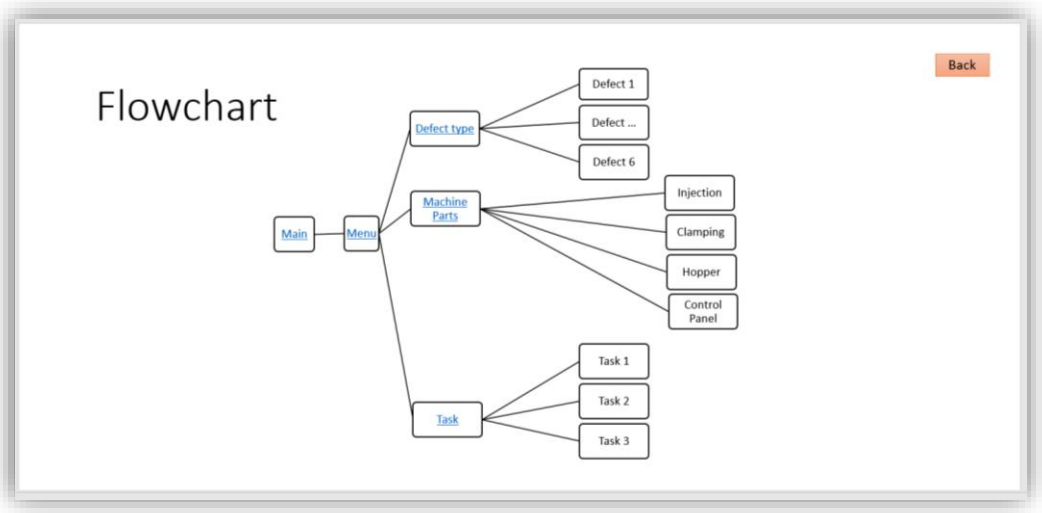
Sample of flow chart and storyboard used in Case Study 1.

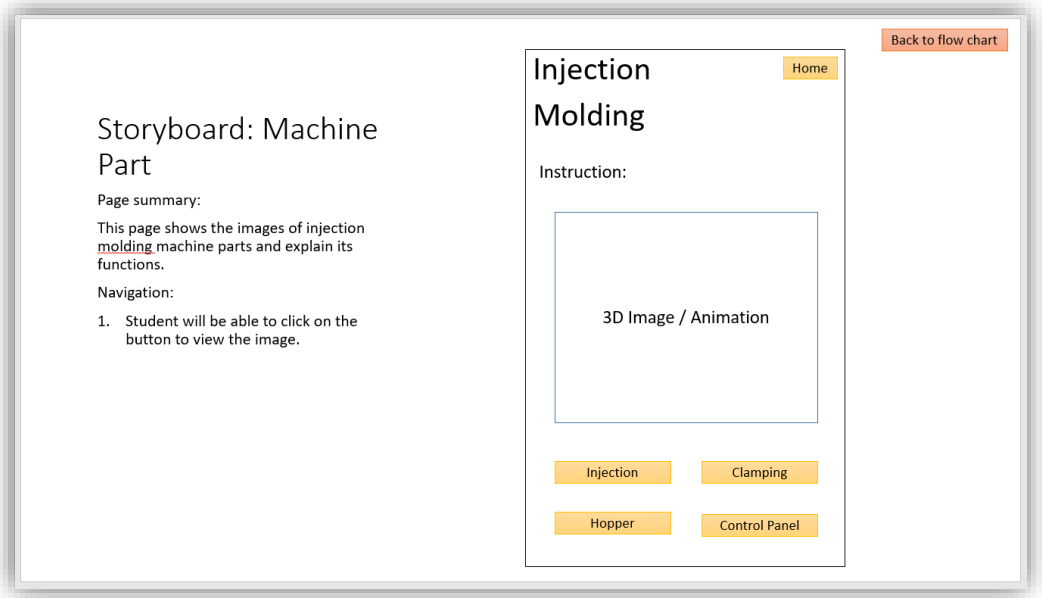




APPENDIX D

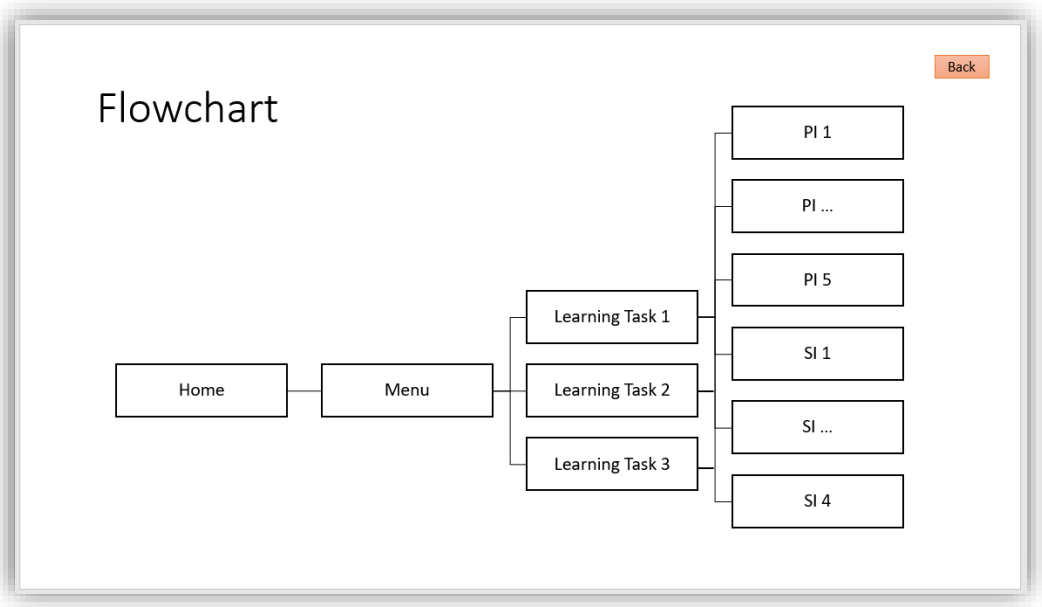
Sample of flow chart and storyboard used in Case Study 2.

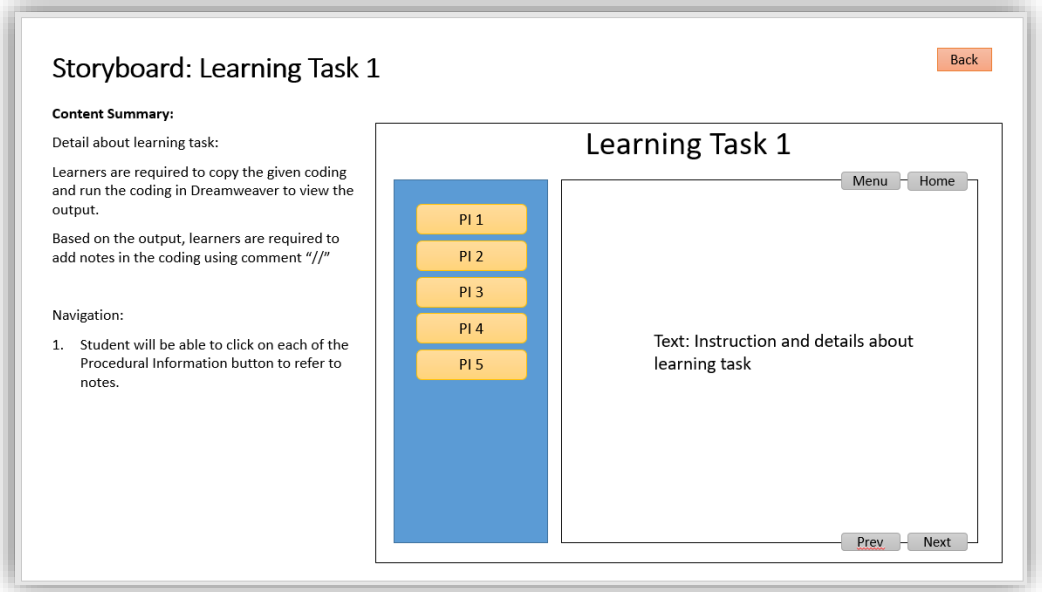




APPENDIX E

Sample of flow chart and storyboard used in Case Study 3.





APPENDIX F

Sample of open-ended observation list used in this study.

Date:

Time:

Location or setting:

Checklist:

1. Do learners find the learning material easy?
2. Do learners click the menu (for example learning task menu button)?
3. Do they need help and guidance while trying out the prototype?
4. What type of help do they need?
5. Is the help related to usability issue such as how they navigate?
6. Are there any difficulties they encounter?
7. Do they have any questions or comments about the learning material that you observed?
8. Do the learners discuss among themselves?
9. What is their attitude or emotion while using the learning material that you can observed?

APPENDIX G

Sample of survey used in this study.

1. I understand that interface design is a step by step process.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

2. I understand the principles of interface design in real life settings.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

3. I feel confident about designing an interface by following the step by step approach.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

4. I can identify the strengths and weaknesses of my own designs.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

5. I feel confident about justifying my design decisions.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

6. I find interface design an easy concept.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

7. The learning package developed my confidence in interface design.

1 (Strongly Agree)
2 (Agree)
3 (Neither)
4 (Disagree)
5 (Strongly Disagree)

8. I enjoyed using the learning package.
1 (Strongly Agree)
2 (Agree)
3 (Neither)
4 (Disagree)
5 (Strongly Disagree)

9. I liked the presentation of the content.
1 (Strongly Agree)
2 (Agree)
3 (Neither)
4 (Disagree)
5 (Strongly Disagree)

10. I liked the colour scheme used in the learning package.
1 (Strongly Agree)
2 (Agree)
3 (Neither)
4 (Disagree)
5 (Strongly Disagree)

11. The three tab menu ("Objectives", "Principles" and "Activity") were easy to use.
1 (Strongly Agree)
2 (Agree)
3 (Neither)
4 (Disagree)
5 (Strongly Disagree)

12. I was clear about how where the buttons worked.
1 (Strongly Agree)
2 (Agree)
3 (Neither)
4 (Disagree)
5 (Strongly Disagree)

13. The graphics were helpful in understanding the topic.
1 (Strongly Agree)
2 (Agree)
3 (Neither)
4 (Disagree)
5 (Strongly Disagree)

14. The content was well organized.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

15. The learning package was easy to use.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

16. The text was easy to read.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

17. The drag and drop activity was helpful.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

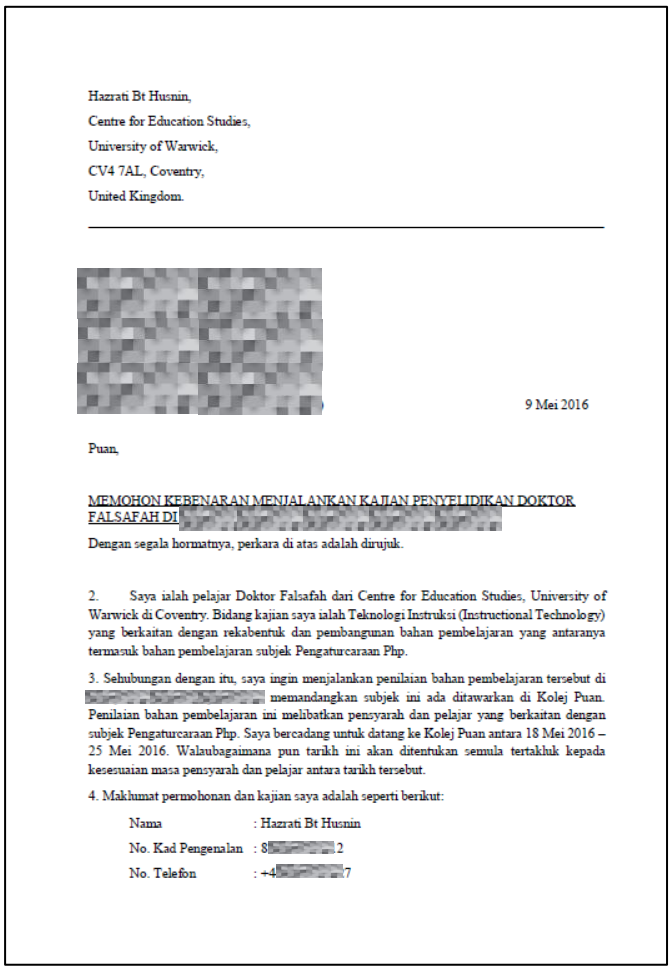
18. The feedback was helpful.
    1 (Strongly Agree)
    2 (Agree)
    3 (Neither)
    4 (Disagree)
    5 (Strongly Disagree)

19. My suggestions about how the package could be improved.

_____

APPENDIX H

Sample of letter of permission given to the lecturer or head of department in this study.



Hazrati Bt Husnin,
Centre for Education Studies,
University of Warwick,
CV4 7AL, Coventry,
United Kingdom.

[redacted]

9 Mei 2016

Puan,

MEMOHON KEBENARAN MENJALANKAN KAJIAN PENYELIDIKAN DOKTOR FALSAFAH DI [redacted]

Dengan segala hormatnya, perkara di atas adalah dirujuk.

2. Saya ialah pelajar Doktor Falsafah dari Centre for Education Studies, University of Warwick di Coventry. Bidang kajian saya ialah Teknologi Instruksi (Instructional Technology) yang berkaitan dengan rekabentuk dan pembangunan bahan pembelajaran yang antaranya termasuk bahan pembelajaran subjek Pengaturcaraan Php.

3. Sehubungan dengan itu, saya ingin menjalankan penilaian bahan pembelajaran tersebut di [redacted] memandangkan subjek ini ada ditawarkan di Kolej Puan. Penilaian bahan pembelajaran ini melibatkan pensyarah dan pelajar yang berkaitan dengan subjek Pengaturcaraan Php. Saya bercadang untuk datang ke Kolej Puan antara 18 Mei 2016 – 25 Mei 2016. Walaubagaimana pun tarikh ini akan ditentukan semula tertakluk kepada kesesuaian masa pensyarah dan pelajar antara tarikh tersebut.

4. Maklumat permohonan dan kajian saya adalah seperti berikut:

Nama : Hazrati Bt Husnin
No. Kad Pengenalan : 8[redacted]2
No. Telefon : +4[redacted]7

Emel : [redacted]

Tajuk Kajian : Design and development of learning materials with the Ten Steps to Complex Learning Model: A Multiple Case Study

Sampel Kajian : Pensyarah dan pelajar subjek Pengaturcaraan web (PHP)

Bersama-sama surat ini saya sertakan surat pengesahan dari penyelia berkenaan kajian saya untuk rujukan pihak Puan.

Segala kerjasama yang diberikan amat saya hargai. Semoga segalanya berada dalam penerimaan Puan. Sekian, terima kasih.

Hazrati Bt Husnin,

Warwick ID: [redacted]