

Using HCI Principles to Design Interactive Learning Material

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Abstract

The aim of this paper is to reflect on the design process followed to create interactive learning material for 1st year students at the North-West University, Vaal Triangle Campus (NWU VTC). The interactive learning material was created for a theory based module named Human-Computer Interaction (HCI). Traditional paper-based study material was translated into interactive learning material during the design process of the artefact. The study followed the design science research framework for the creation of the artefact. The artefact was then evaluated by its users. The goal of the paper is to highlight important HCI principles which were found appropriate to adhere to when designing interactive learning material.

Keywords: human-computer interaction, HCI principles, interactive learning material, design science research

1. Introduction

Traditionally, learning involves studying from paper-based textbooks. It is important to note that even though we still make use of this method that “there is now a growing body of evidence detailing the very real impact of technology on both formal and informal learning” (Underwood, 2009:8). Constantly using cellphones, tablets and personal computers to search for information, students sometimes find the need for traditional learning material, such as books, obsolete. For this reason, an artefact for interactive learning is suggested, provided that its design adheres to the necessary human-computer interaction (HCI) principles. This article starts with a brief literature review of the key concepts of the study which are HCI principles and interactive learning material (Section 2). This is followed by a review on the design science research (DSR) framework used as methodology for the creation of the artefact (Section 3). Section 4 illustrates the HCI principles used to design and create the artefact. Section 5 provides the results from the evaluation of said artefact. This is followed by a discussion on the findings of the results in Section 6. The research is concluded and suggestions for future research are made in Section 7.

2. HCI Principles and Interactive Learning Material

The aim of the brief literature review is to create a shared understanding on the concepts of human-computer interaction principles as well as interactive learning material.

2.1 Human-computer interaction principles

Human-Computer Interaction (HCI) is concerned with the design, the evaluation and the implementation of an interactive artefact within the context of its use (Dix, Finlay, Abowd & Beale, 2003:4). The aim of HCI is to promote the best user experiences. In order to achieve good user experiences, one needs to understand the interaction that takes place between the user and the system (Terblanche & Goede, 2014; Rogers, Sharp & Preece, 2011:18; Terblanche, 2013:31). Within the field of HCI, principles have been identified as design guidelines to adhere to when trying to ensure that a design is user-centered and that it will promote the best user experiences. These HCI principles are design rules to ensure that a usable artefact has an efficient, satisfactory and effective design (Dix et al., 2004:259; Rogers et al., 2011:25; Te'eni, Carey & Zhang, 2007:195; Terblanche & Goede, 2014). The HCI principles focused on in this study are the 14 principles that support usability according to Dix et al. (2004:260). These 14 principles are divided into three categories as depicted in Table 1.

Table 1. Principles that support usability (summarised from Dix et al., 2004:260)

Principles that support usability		
LEARNABILITY	FLEXIBILITY	ROBUSTNESS
Predictability	Dialog initiative	Observability
Synthesizability	Task migratibility	Recoverability
Familiarity	Multi-threading	Responsiveness
Generalizability	Substitutivity	Task Conformance
Consistency	Customizability	

This study will focus on the implementation of HCI principles that can be found appropriate for the design of interactive learning material. The next section briefly explains the concept of interactive learning material.

2.2 Interactive learning material

Traditionally, learning involves studying from paper-based textbooks. It is important to note that even though we still make use of this method that “there is now a growing body of evidence detailing the very real impact of technology on both formal and informal learning” (Underwood, 2009:8). Students now entering university form part of the Generation Y group – a generation who are used to receiving both verbal and visual information through mediums such as television and the internet (Wolf, 1996:124). It can be argued that learning material should be adapted according to the level of knowledge and skills that Generation Y possesses pertaining to technology. Parsons and Ross (2002) further support this argument by stating that the power of information technology has created learning communities in which students can share their understanding and expertise. Furthermore, many universities have started implementing e-learning methods because of its ability to transform formal classroom situations into alternate virtual spaces which suit the needs of students who prefer learning at their own pace. Students at the NWU VTC tend to prefer new interactive methods of learning to traditional paper-based learning material. As part of the results found in this study, Figure 1 depicts student preference between traditional paper-based learning material (31%) and interactive learning material (69%). Figure 2 depicts student preference between a traditional bulleted list of information (33%) and information explained using an interaction that expands as the user selects a specific option (67%).

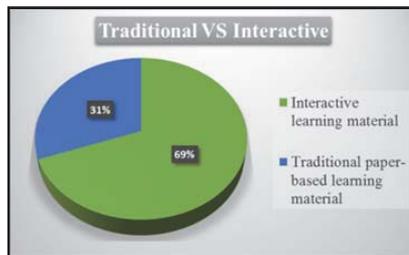


Figure 1. A comparison of student selections between traditional paper-based learning material and interactive learning material.

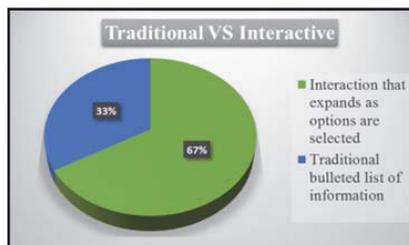


Figure 2. A comparison of student selections between a traditional bulleted list of information and an interaction that expands as options are selected.

The following section will discuss the sample and methods used to obtain data in this study.

3. Methodology

This section reflects on the sample, the research methodology, the measuring instrument as well as the data analysis approach used for this study.

3.1 Sample and procedures

The participants for this study comprised of 36 students who were enrolled for the module Human-Computer Interaction. These students formed part of the first group that was exposed to the specific interactive learning material artefact. The artefact was used as a learning tool instead of a traditional textbook. All information contained within the artefact was translated from a textbook.

3.2 Research methodology

This section reports on the research methodology followed for this study. As the focus of the study is on the creation of an artefact, the most appropriate framework to follow is that of design science research. "Design science research (DSR) is a research paradigm in which a designer answers questions relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of scientific evidence" (Hevner & Chatterjee, 2010:5). This means that the researcher gains knowledge through the creation of artefacts, a statement supported by Vashnaivi and Keuchler (2004) who defines the concept of DSR as "knowing through making". Vashnaivi and Keuchler further describe DSR as a technique that complements interpretivistic and positivistic research methods in IS. DSR involves usability analysis of artefacts and for this reason interpretivistic or positivistic methods may be used to aid in the analysis. The DSR framework by Vashnaivi and Keuchler (2004) is used as a guiding tool for the research process followed in this study. The model iterates through five process steps namely awareness of problem, suggestion, development, evaluation and conclusion (as illustrated in Figure 3).

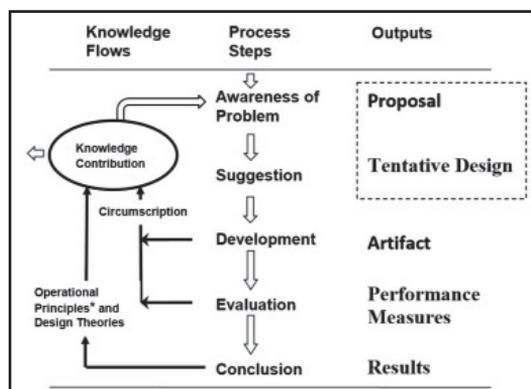


Figure 3. The design science research process model (Vaishnavi & Keuchler, 2004).

In this study, there was an awareness of a problem – i.e. traditional paper-based learning material which students tend to find tedious to use. The next step in the process was to make a suggestion that addresses the problem – i.e. to replace the traditional paper-based study material with interactive learning material which students may find engaging. The researcher then continued to develop interactive learning material using HCI principles as design guidelines for the usability of the artefact. The artefact was evaluated by the students after the first six months of its use through the use of an interpretive questionnaire. The study does not conclude after this evaluation of the artefact as the researcher became aware of new problems that need to be addressed. The design process will re-enter the design science research process steps in future research until all problems are addressed and the artefact can successfully be concluded. In Section 4, these phases will be used to illustrate the design process of the artefact.

3.3 Measuring instrument

As the goal of the evaluation of the artefact is understanding, quantitative as well as qualitative research was done from an interpretive perspective. Students were asked to complete a questionnaire created in Google forms upon completion of the module, containing both quantitative and qualitative questions regarding their experience with the design and functionality of the artefact. At the NWU VTC, we commonly refer to the interactive learning material as a 'SmartGuide' and questions asked used this terminology for equal understanding. Questions were asked regarding HCI principles used in the design of the interactive learning material. Their knowledge about HCI principles were accepted to be sufficient, seeing as they had completed two tests, two assignments and an examination project regarding the general use of HCI principles during the course of this module, Human-computer interaction. The students also had to report on any functional problems they experienced with the interactive learning material.

3.4 Data analysis

Feedback received from the quantitative data is presented by means of descriptive analysis. A comparison of two questions is used to support the choices made regarding HCI principles appropriate for the design of interactive learning material. Open coding (Straus & Corbin, 1990) was used to analyse the qualitative feedback received regarding the functional problems that were encountered. The results of the methods used are described in Section 5.

4. Using HCI Principles to Design Interactive Learning Material

In this section the process followed to create the interactive learning material artefact is described using the DSR framework as discussed in Section 3.2. This process includes the initial problem the researcher became aware of, a suggestion made towards solving the problem, the development of an artefact according to the solution suggested and the evaluation of the artefact.

4.1 Awareness of the problem

The researcher first attempted to bridge an e-learning gap in 2012. There was a definite change needed regarding the manner in which students received their education at tertiary level. After the successful use of social media as communication tool in the lecture room, the next step was to find a way to make the learning material more relevant to the students that form part of the Generation Y group. Constantly using cellphones, tablets and personal computers to search for information, students sometimes find the need for traditional learning material, such as books, obsolete. This was also found to be true for the printed study guides at the NWU VTC. Also in 2012, a project was initiated to start translating the traditional paper-based study guides into interactive electronic study guides.

4.2 Suggestion

Many software tools were tried and tested for the creation of the electronic study guides. Many of these software tools also failed because of specific requirements they did not meet, such as, mobile and tablet accessibility, network capabilities and integration with the NWU VTC's learner management system. During 2013, a suitable e-learning creation software tool called Articulate Storyline was discovered. The researcher then decided to use this tool to translate the book contents for the module Human-Computer Interaction into interactive learning material. As the module itself pertains to the efficient interaction between the user and the system and also highlights important design rules to follow in the creation of any artefact, it was important that the design of the interactive learning material artefact also adhere to efficient design rules or HCI principles. The researcher firmly believes that the design of any artefact greatly impacts the decision of the user to utilise the artefact. For this reason it is crucial that the interactive learning material artefact not only be usable but that it should also promote good user experiences via good design, to encourage the students to continue using the artefact.

4.3 Develop

For the initial design of the artefact, three HCI principles were chosen as immediate design guidelines. These HCI principles include *consistency*, *familiarity* and *responsiveness*. This section will illustrate and explain the usage of the

three aforementioned HCI principles.

4.3.1 Consistency

According to Dix et al. (2004:264) *consistency* refers to the resemblance of behavior that may arise from situations or tasks that are similar, and is the most used principle in literature. In the interactive learning material artefact, the principle of *consistency* is depicted through the consistent use of colour, text fonts, page layouts, interactions and avatars. Figure 4, 5, 6, 7, 8, 9 and 10 illustrates the use of *consistency*.

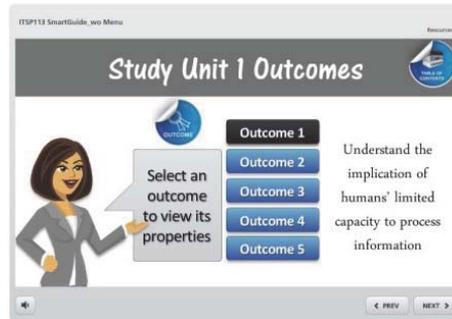


Figure 4. Figure 4 and 5 illustrate the consistency principle in terms of colour and layout.

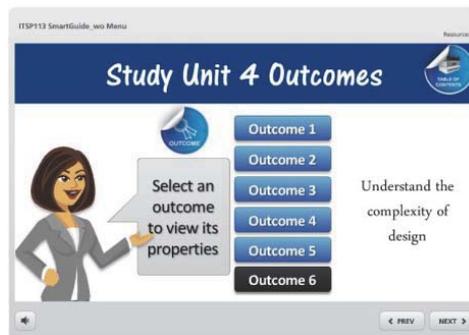


Figure 5. Figure 4 and 5 illustrate the consistency principle in terms of colour and layout.

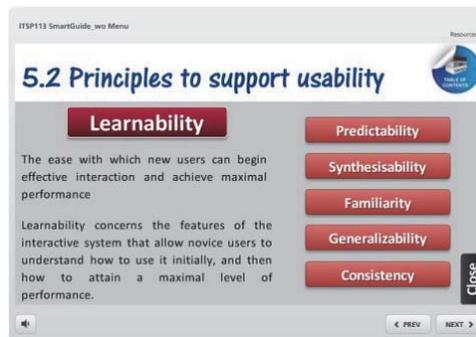


Figure 6. Figure 6, 7 and 8 illustrate consistent layouts.



Figure 7. Figure 6, 7 and 8 illustrate consistent layouts.

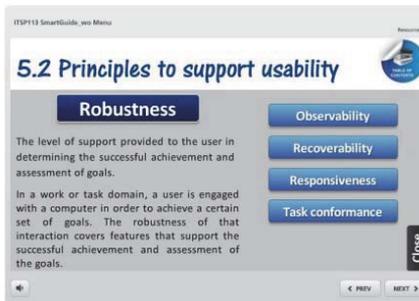


Figure 8. Figure 6, 7 and 8 illustrate consistent layouts.

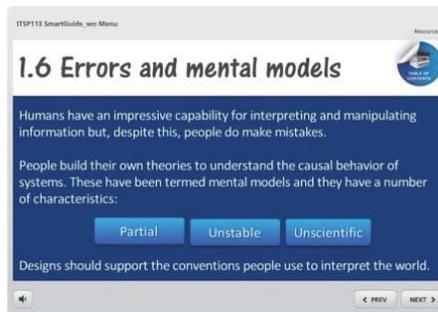


Figure 9. Figure 9 and 10 illustrate consistent usage of fonts, text sizes and interactions.



Figure 10. Figure 9 and 10 illustrate consistent usage of fonts, text sizes and interactions.

4.3.2 Familiarity

According to Dix et al. (2004:264) *familiarity* refers to “the correlation between the user’s existing knowledge and the knowledge required for effective interaction”. In the interactive learning material artefact, the principle of *familiarity* is depicted through the familiar affordances of interactions, tests and quizzes. Figure 11, 12, 13 and 14 illustrates the use of *familiarity*.

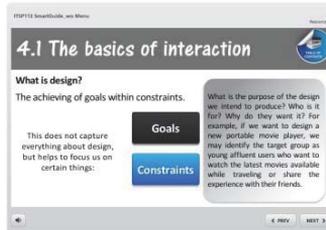


Figure 11. A button interaction provides the affordance that it needs to be pressed or selected – a familiar interaction for anyone who has used a computer.



Figure 12. Figure 12 and 13 depict an interaction that expands in the same manner as an accordion.

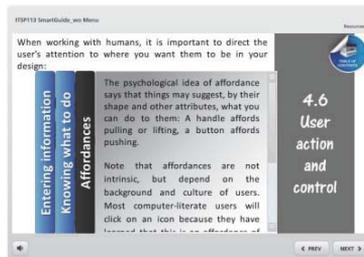


Figure 13. Figure 12 and 13 depict an interaction that expands in the same manner as an accordion.



Figure 14. An assessment question posed in the same manner as a traditional paper-based multiple choice question.

4.3.3 Responsiveness

According to Dix et al. (2004:264) *responsiveness* “measures the rate of communication between the system and the user”. In the interactive learning material artefact, the principle of *responsiveness* is illustrated using feedback as an example. Figure 15, 16, 17 and 18 illustrates the use of *responsiveness*.



Figure 15. Figure 15 and 16 depict the responsiveness of the artefact by providing feedback to the user in the form of colour and object changes when an option is selected.

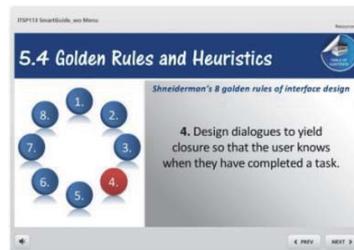


Figure 16. Figure 15 and 16 depict the responsiveness of the artefact by providing feedback to the user in the form of colour and object changes when an option is selected.



Figure 17. Figure 17 and 18 depict the responsiveness of the artefact by providing feedback to the user when options are selected during the assessments.

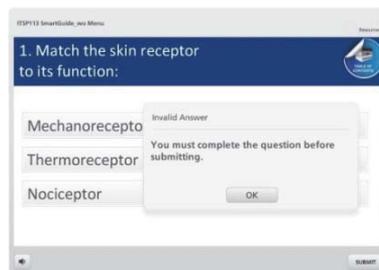


Figure 18. Figure 17 and 18 depict the responsiveness of the artefact by providing feedback to the user when options are selected during the assessments.

4.4 Evaluation

As mentioned in Section 3.1 the 36 participants were the first group of students that were exposed to the initial design of the interactive learning material artefact. These students interacted with the artefact for 6 months and were asked to report problems experienced if any. Students completed a questionnaire on Google forms pertaining to the usability of the artefact. Valuable feedback was given (results discussed in Section 5) which will be taken into consideration for the next design iteration before the second release of the artefact in 2015.

4.5 Conclusion

The feedback from the evaluation indicated that some changes still need to be amended in the next design iteration. This means that the artefact will iterate back into the development step of the DSR framework. The artefact will be re-evaluated after the changes have been made. The re-evaluation may indicate that more changes need to be addressed and the artefact may enter the development step again, or the users may be satisfied with the artefact as is in which case the DSR framework process will conclude.

5. Student Perceptions on Using Interactive Learning Material

This section reports on the perceptions of the students who used the interactive learning material. As part of the evaluation step of the DSR Framework, students were asked to complete an interpretive questionnaire on Google forms. The questionnaire contained questions pertaining to the design and functionality of the interactive learning material.

5.1 Section 1: HCI Principles

In question 1 of the questionnaire the students were asked the following: "According to you, select the HCI principles that you believe the design and layout of the ITSP113 SmartGuide adheres to. Carefully consider each principle." Students could select multiple responses from any of the 14 HCI principles in Table 1. Table 2 illustrates the number of times that each HCI principle was chosen. The order of the HCI principles in Table 2 indicates the top choices that the students believe the specific interactive learning material for this study adheres to. In question 2, the students were asked the following: "According to you, what are the 5 most important HCI principles that the design of interactive learning material (e.g. the SmartGuide) should adhere to? (Choose exactly 5)". Students had to select exactly 5 options from the 14 HCI principles which they believed were the most important principles that any interactive learning material should adhere to. Table 3 illustrates the number of times that each HCI principle was chosen. The order of the HCI principles in Table 3 indicates the top choices that the students believe that any interactive learning material should adhere to.

Table 2. Student perceptions on HCI principles that the current design of the HCI interactive learning material adheres to.

	HCI Principle	N	n	%
1	Consistency	36	28	78
2	Recoverability	36	22	61
3	Responsiveness	36	21	58
4	Predictability	36	19	53
5	Familiarity	36	19	53
6	Dialog initiative	36	17	47
7	Task Conformance	36	14	39
8	Generalizability	36	14	39
9	Observability	36	13	36
10	Synthesisability	36	12	33
11	Task migratibility	36	9	25
12	Substitutivity	36	8	22
13	Multi-threading	36	6	17
14	Customizability	36	3	8

From Table 2 and Table 3 it is interesting to notice that the first 6 positions in both tables, even though in different orders, list the same 6 principles namely consistency, recoverability, responsiveness, predictability, familiarity and dialog initiative

(highlighted in yellow and green respectively in both tables). This indicates that the design of the interactive learning material evaluated in this study adheres to the top expected HCI principles that students believe any interactive learning material should adhere to. One could possibly suggest the aforementioned HCI principles as appropriate design rules for any interactive learning material to adhere to.

Table 3. Student perceptions on HCI principles that all interactive learning material should adhere to.

	HCI Principle	N	n	%
1	Recoverability	36	21	58
2	Responsiveness	36	21	58
3	Predictability	36	19	53
4	Consistency	36	18	50
5	Dialog initiative	36	17	47
6	Familiarity	36	16	44
7	Multi-threading	36	15	42
8	Generalizability	36	12	33
9	Task migratability	36	11	31
10	Task Conformance	36	8	22
11	Customizability	36	7	19
12	Observability	36	7	19
13	Synthesiability	36	5	14
14	Substitutivity	36	3	8

5.2 Section 2: Functional errors

In question 3 students were asked to indicate how many functional errors they encountered during the 6 months they made use of the interactive learning material. Figure 19 depicts the results from their responses. 22 percent encountered no errors, 72 percent encountered 1 or 2 errors, 6 percent encountered many errors and 0 percent encountered too many errors to count. To summarise, 94 percent of students experienced none to two errors with the functional design of the artefact. Students were asked (question 4) to briefly explain the problems they experienced with the interactive learning material. Their responses are recorded in Table 4.

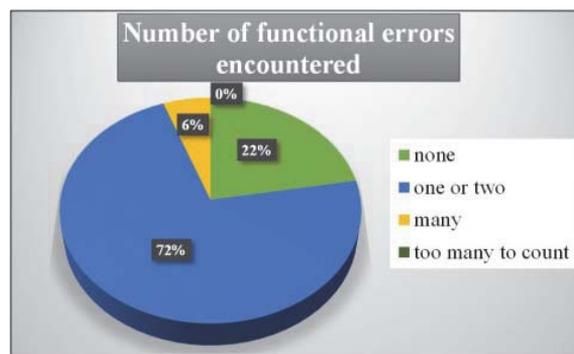


Figure 19. Number of functional errors that students encountered while using the interactive learning material.

Table 4. Functional problems experienced with the SmartGuide (interactive learning material) by students.

Problems experienced with ITSP113 SmartGuide (interactive learning material)	
Code assigned to data	Example answers
Buffering for extended periods of time (16 occurrences)	"It takes time to load." "Some aspects of the responsiveness of the "previous" and "next", the rate of responsiveness is a bit slow." "it sometimes take time to respond or doesn't respond at all"
Navigation issues in study unit 4 (9 occurrences)	"On the fourth chapter, the efundi version of the smart guide has a broken link. The "next" button freezes the guide and I'd have to reload the efundi web page in order to regain access to the smart guide." "when I tried reading through Study Unit 4 in the school labs, it refused to work but when I download it to my laptop it work." "In study unit 4, only 4.1 was accessible the rest of the study unit couldn't load."
Video links not working (2 occurrences)	"the video links were not working" "Couple of links did not work towards the end of the semester"
Layered information sometimes missed (1 occurrence)	"Not much that I experience except the first time I was using it always pressing next yet am leaving most information behind"
Offline accessibility (1 occurrence)	"Its only disadvantage to get some things when offline"

5.3 Section 3: Finding information

The researcher believes that one of the key factors that good design can be measured by is the efficiency and rate at which the user can find the information that they are looking for. The responses to question 5 (Figure 20) indicated that 83 percent of students were satisfied that they could easily find information. 17 percent of students could not easily find the information that they were looking for, these students were asked to make suggestions towards improving the design in this regard. Their responses are recorded in Table 5.

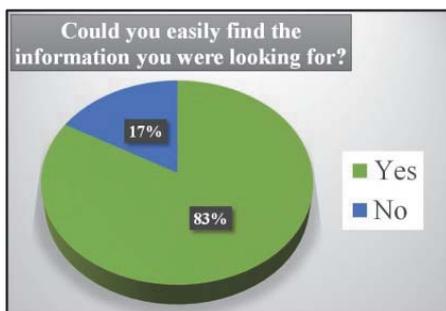


Figure 20. Student responses on the simplicity of finding information that they were looking for.

Table 5. Suggestions made by students for improving the efficiency and rate at which information can be found.

Suggestions made towards improvement: Increasing the efficiency and rate at which the user can find the information that they are looking for.
Add a search box function so that a user can search for specific words instead of having to read through all of the information to find what one is looking for
There is a table of contents button on each page that the user can use to navigate to each study unit. The suggestion is to create sublinks in each study unit so that one can directly navigate to a subsection instead of having to navigate through the whole study unit until you find the section you are looking for.

6. Findings from Study

This section reports on the findings discovered in the results in Section 5. Firstly, students were asked to indicate which

HCI principles they thought were used as design guidelines for the interactive learning material used in this study. Students also had to report on which HCI principles they thought all interactive learning material should adhere to. Furthermore students reported on functional errors encountered during the use of the interactive learning material. Students also made suggestions towards improving the efficiency and rate at which one can find information in the interactive learning material.

6.1 Recommendations for using HCI principles to design interactive learning material

This section provides recommendations for future designers of interactive learning material. In this study the initial design of the interactive learning material was illustrated using three HCI principles that the researcher believes to be appropriate namely consistency, familiarity and responsiveness. The interactive learning material was then evaluated by its users and it was found that six HCI principles were found appropriate for the design of interactive learning material. Students ranked consistency, recoverability, responsiveness, predictability, familiarity and dialog initiative as the six most important HCI principles that interactive learning material should adhere to. Students also evaluated the interactive learning material used in this study and suggested the HCI principles they believed the design of the ITSP113 'SmartGuide' adheres to which, even though in a different order, yielded the same 6 HCI principles which are recoverability, responsiveness, predictability, consistency, dialog initiative and familiarity. It may then be suggested that these HCI principles are good design rules to follow for the design and creation of interactive learning material. Shortly, Dix et al. (2004:261) define the aforementioned six principles as:

- *Consistency* refers to the resemblance of behavior that may arise from situations or tasks that are similar, and is the most used principle in literature.
- *Familiarity* refers to "the correlation between the user's existing knowledge and the knowledge required for effective interaction".
- *Responsiveness* "measures the rate of communication between the system and the user".
- *Recoverability* "is the ability to reach a desired goal after recognition of some error in a previous interaction".
- *Predictability* "of an interactive system means that the user's knowledge of the interaction history is sufficient to determine the result of his future interaction with it".
- *Dialog initiative* is important to consider when one sees the interaction between the user and the system as a dialog between partners.

6.2 Recommendations toward improving the functional errors encountered

This section reflects on the functional errors encountered by the users (Table 5) and makes suggestions towards improvement.

6.2.1 Functional issue 1: Buffering for extended periods of time

Unfortunately this issue is not related to the artefact but to the network capabilities of the NWU VTC as the students can access the interactive learning material online. If this issue is repeatedly experienced it is advised to the user to download the artefact for offline viewing.

6.2.2 Functional issue 2: Navigation issues in study unit 4

A number of students encountered a problem while accessing the online version of the interactive learning material in study unit 4. Section 4.1 would in some instances not allow the user to proceed to section 4.2 when selecting the 'next' option at the bottom of the Articulate player. This problem was not encountered when students used the offline version of the artefact. This problem might be with the Articulate player itself, as this is a custom control of the software or there may have been a problem during the file upload to its hosting location. It is suggested to remove the current files in the hosting location and to reload all of the files of the artefact to determine whether this might solve the problem.

6.2.3 Functional issue 3: Video links not working

After the complaint was received all video links were checked again and found to be working in good order. The problems

experienced may again have been network related –the videos may not have opened because of poor network connectivity.

6.2.4 Functional issue 4: Layered information sometimes missed

Some slides in the artefact contain multiple layers of information that can only be viewed when one selects the interaction that expands it. These interactions are sometimes missed and consequently students struggle to find some of the information. A suggestion would be to add a descriptive icon named "Interaction" to indicate to the user that there is an interaction on the slide.

6.2.5 Functional issue 5: Offline accessibility

One complaint was that the information is not accessible if the user does not have an Internet connection. This issue can easily be resolved when the student downloads the artefact for offline viewing.

6.3 Recommendations toward improving the efficiency of finding information

The researcher believes that one of the key factors good design can be measured by is the efficiency and rate at which the user can find the required information. Students were asked to indicate whether they had trouble finding the information that they were looking for. 83% of students were satisfied that they could easily find information and 17% of students could not easily find the information that they were looking for. The students that experienced problems were asked to make suggestions towards improvement in this regard.

Information finding issue 1: Add a search box function so that a user can search for specific words instead of having to read through all of the information to find what one is looking for.

As suggested there is no search function in the interactive learning material. The solution would be to add the traditional search box as a permanent feature in the design of the interactive learning material so that the student can search for information at any time during the interaction.

Information finding issue 2: There is a table of contents button on each page that the user can use to navigate to each study unit. The suggestion is to create sublinks in each study unit so that one can directly navigate to a subsection instead of having to navigate through the whole study unit until you find the section you are looking for.

Presently, the user can only navigate to, for example, section 3.7 in the interactive learning material by choosing study unit 3 from the table of contents, and then selecting the 'next' option until the user reaches the slide for section 3.7. The suggestion towards improvement would be to hyperlink the subsection headings in the table of contents in each study unit so that the user can navigate to a specific subsection from there.

7. Conclusion and Future Research

In this study a design science research framework is used for the creation of interactive learning material translated from the traditional paper-based study material for a module named Human-Computer Interaction. The artefact is initially designed according to three HCI principles found appropriate for the creation of interactive learning material namely *consistency*, *familiarity* and *responsiveness*. The artefact was then evaluated by its first group of users in the form of a questionnaire pertaining to their interaction with said artefact. Students indicated HCI principles that all interactive learning material should adhere to as well as the HCI principles that they thought the artefact in question adhered to. Their responses yielded the same 6 HCI principles for both instances, just in different orders. The six HCI principles then suggested in this study as good design rules for interactive learning material are recoverability, responsiveness, predictability, consistency, dialog initiative and familiarity. Students also reported on functional issues encountered and these were addressed in Section 5 and 6.2. Lastly, students had to suggest improvements if they were experiencing any trouble with finding information and these are addressed in Section 5 and 6.3.

As there were some errors encountered with the artefact, the DSR framework process cannot conclude as of yet and needs to reiterate back into the development step. This constitutes future research for this artefact as the required changes obtained from the feedback of the evaluation need to be addressed by redesigning some components of the interactive learning material artefact. After the artefact has been redesigned it will need to be evaluated again for any possible issues. This process may repeat until a satisfactory, fully functional artefact is achieved.

A suggestion made to other researchers that may conduct similar research is to evaluate the effect of the eight HCI

principles from Dix et al. (2004) that were not chosen for this study. Alternatively, other researchers can find different HCI principles from other sources and evaluate their impact on the design of interactive learning material.

The interactive learning material artefact that was evaluated in this study can be found at: <https://fe9b9d0e4aa3553bf976aa720303b96bbc11dd50.googledrive.com/host/0BzaPxcjtRLLwdFFUT1RMExhUMk0/>

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