



Promote Higher Order Thinking Skills in Designing Interface

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Abstract: Higher Order Thinking (HOT) skills encourage three cognitive domains which are the analysis, synthesis and evaluation thinking domains. In designing Interface HOT skills, it requires learners to analyze, synthesize and evaluate students' design decisions. Activities such as recognizing design claims, examining usability problems, pointing out usability problems required specific analysis skills. Choosing significant features and functions for the non-working prototype, incorporate alternative design ideas and propose design suggestions requires synthesis thinking skills. Whereas evaluation thinking is needed to justify the prototype, defend the modification and evaluate peer's design. The "Prototype Valuation System (PROVAS)" was used to explore the HOT skills in designing Interface. This research will present the findings on how PROVAS was used by a group of 14 diploma students in a private higher education institution in Malaysia which has encouraged HOT skills in designing Interface. Data were collected from online observation, student's journal and heuristic evaluation. The findings have indicate that PROVAS can encourage HOT skills in designing Interface.

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1. Introduction

Higher Order Thinking (HOT) skills encourage three cognitive domains which are the analysis, synthesis and evaluation thinking domains (Bloom, 1968, 1976; Bloom et al., 1956). HOT skills in designing Interface required learners to analyze, synthesize and evaluate their design decisions. The analysis thinking actions are focused on recognizing design claims, examining usability problems and pointing out usability problems. The synthesis thinking are designing the non-working prototype, incorporating alternative design ideas and proposing design suggestions. Lastly the evaluation thinking actions are to justify the prototype, defend the modification and evaluate peer's design. The online learning has become a new learning trend and a convenient way to acquired learning (Primoradi, 2013; Sadighi & Bozorgmanesh, 2011; Salmon, 2004; Sluijsmans et al., 2006; Talkhabi, 2011). Hence, an online system named "Prototype Valuation System (PROVAS)" was used to encourage HOT skills in designing Interface. PROVAS is designed with effective features and functions to enhance HOT skills at blended setting.

The research problem for this study was identified from a pilot study conducted in a private higher learning in Malaysia in 2012. The learners in diploma level were found failed to develop HOT skills which emphasized how to analyze, synthesize and

evaluate usability guidelines into their design. Added to this, in a blended setting it is quite difficult to identify the learner's ability on HOT skills due to lack of interaction time during face-to face sessions. Hence, there is a need to use an appropriate online learning application which has features and functions to help students seek appropriate solution to enhance HOT skills. The focus of this study is to learn how activities in PROVAS promote higher order thinking among learners. This will provide solutions to encourage learners to analyze, synthesize and evaluate their design decisions and permits the educators to source effective features and functions that can enhance HOT skills in blended setting.

2. Literature Review

Bloom's mastery learning model is a sequential lesson plan framework consisting of a six step lesson model that begins with lowest end of the cognitive hierarchy to the higher order thinking level (Block, 1971; Block & Anderson, 1975; Block & Burns, 1985; Bloom, 1968, Cantu & Warren, 2003). Bloom (1956) has divided knowledge into a hierarchical scheme that distinguishes between psychomotor skills, the affective domain and the cognitive domain (Dalkir, 2005). According to Cantu and Warren (2003) achievement levels in mastery are referred as Bloom's mastery learning syntax which is

knowledge, comprehension, application, analysis, synthesis and evaluation. Each teaching step in the cognitive domain is focused on the central components that engage students in a learning activity that allow them to accomplish certain tasks. The knowledge level activities appoint students to recognize or recall information while the comprehension level allows the students to demonstrate an ability to translate, interpret, or manipulate material. The application level encourages students to apply previously learned materials to other contexts or situations (Gordon, Ponticell, & Morgon, 1991, 1998). The analysis level engages the students to think critically and breaking down materials into their component parts. The synthesis level promotes students to think creatively and re-assemble knowledge. Lastly, the evaluation level engages students to offer opinion or judge the value of materials for a given purpose. According to Cantu and Warren (2003), the uniqueness of Bloom's mastery learning lesson concludes with an evaluation activity requiring students to offer their opinion or judgment. It is vital to obtain their opinion on certain issues especially in designing Interface.

3. Methodology of Research

This study is based on the Design and Development Research (DDR) (Richey & Klein, 2007; Richey, Klein, & Nelson, 2004). The Type 1 DDR was focused to explore how activities in PROVAS promote higher order thinking among learners. A private tertiary institution was located 30 kilometers from Malaysia's capital city, Kuala Lumpur was choose and the purposeful sampling was used Creswell (2002). A module named Internet and Web Technologies (IWT) was selected from the Information Technology (IT) diploma program. The teaching hours consist of 2 hours of lecture and 1 hour of lab session and the assessment breakdown includes of 50% is assessed on design usability and 50% on programming skills.

Three data collection techniques used which are online observation, student's journal and heuristic evaluation. The online observations were conducted for 6 weeks. The observation protocol and checklist adapted from Creswell (1998, 2002 & 2003). A coding scheme according to the observation categories were created. The online observation categories were focused on analysis, synthesis and evaluation thinking skills (Refer Table 1). Each category and the sub-categories were observed online and the frequency of each activity was recorded in tables. From the data from the online observation were separate according to the pre, post and peer evaluation.

The students were asked to keep a journal on their activities online and own reflection on those activities. The documentation review techniques were

adapted from Creswell (2002). The student journals were reviewed according to the activities and the excerpts were numbered. The extracted excerpts for all 14 journals were sent to the auditors for confirmation. These excerpts were used to support the findings. The heuristic evaluation method of expert review is used to identify and eliminate usability problems (Badre, 2002, Nielsen, 1992, 1993, 1994, 2000, 2004; Nielsen & Molich, 1990; Nielsen & Phillips, 1993). This method is adapted to evaluate the student's non-working prototype before and after evaluation, which is named "Design 1" (Evaluation 1) and "Design 2" (Evaluation 2). The outcomes of the heuristic evaluations are gathered to confirm the activities during pre, post and peer evaluation obtained in PROVAS and to support the findings. The internal and external auditors have checked the findings for all three methods collected for each student.

4. Findings

The following are a summary of findings pertaining to the activities in PROVAS which promote HOT skills among learners. The findings on HOT skills are presented based on three main phases which are during pre, post and peer evaluation phases.

4.1 Pre- Evaluation Activities

During the pre-evaluation period, three main activities that promote analysis thinking were documented and the first activity is conducting claim analysis. Activities such as recognizing the root concepts, extracting relevant key features and functions, correcting design flow and real-time design layout were evident. The students were able to recognize the root concepts by conducting claim analysis with listing down the design claims from the scenario to extract the features and functions. Various techniques such as double confirming the claims with the scenarios, listing, numbering and marking the claims were used thus making the students familiar and confident in conducting the claim analysis. The students have extracted the features and functions from the given scenarios by listing down, organizing and arranging them according to the core task and its importance. The evidence has revealed that the students were able to design their non-working prototype with correct design flow. They have used different methods to ensure correct design flow such as creating a plan in a flow chart form and sketching the design before designing the prototype. The students have designed their non-working prototype to match the real time design layouts according to the scenarios given. They were emphasizing on consistency of the design layouts and design trends which are current.

Table 1: Online Observation Categories

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|--|
| Analysis Thinking Skill |
| Claim Analysis |
| <i>Root design concept matches the scenario</i> |
| <i>Key Features and functions are relevant</i> |
| <i>Represent correct design flow</i> |
| <i>Real time design represents</i> |
| Recognize Usability Problems |
| <i>Identify usability problems</i> |
| <i>Clarify the usability problems</i> |
| <i>Provide solution for the usability problems</i> |
| Point out usability problems during Peer evaluation (Evaluation 1). |
| <i>Point out usability problems based on design ideas.</i> |
| <i>Point out usability problems based on external criteria (web usability heuristics).</i> |
| <i>Point out usability problems based on internal criteria (scenario).</i> |
| Point out usability problems during Peer evaluation (Evaluation 2). |
| <i>Point out usability problems based on design ideas.</i> |
| <i>Point out usability problems based on external criteria (web usability heuristics).</i> |
| <i>Point out usability problems based on internal criteria (scenario).</i> |
| Synthesis Thinking Skill |
| Functional Creativity Attributes |
| <i>Novelty</i> |
| <i>Relevance</i> |
| <i>Elegance</i> |
| <i>Geminal</i> |
| Incorporate alternative design concept |
| <i>Incorporate alternative design ideas for usability problems</i> |
| <i>Incorporate alternative design ideas by referring the internal criteria (scenarios)</i> |
| <i>Incorporate alternative design ideas by referring to the external criteria(web usability heuristics)</i> |
| Propose design suggestions during peer evaluation (Evaluation 1) |
| <i>Propose design suggestions for the usability problems</i> |
| <i>Propose design suggestions based on external criteria (web usability heuristics)</i> |
| <i>Propose design suggestions based on internal criteria (scenario)</i> |
| Propose design suggestions during peer evaluation (Evaluation 2) |
| <i>Propose design suggestions for the usability problems</i> |
| <i>Propose design suggestions based on external criteria (web usability heuristics)</i> |
| <i>Propose design suggestions based on internal criteria (scenario)</i> |
| Evaluation Thinking Skill |
| Justify Non-working Prototype |
| <i>Justify the prototype by supporting the design ideas</i> |
| <i>Justify the prototype using internal criteria (scenario)</i> |
| <i>Justify the prototype using external criteria (web usability heuristics)</i> |
| Defend the non-working prototype after modification |
| <i>Defend the modification by referring to the usability problems</i> |
| <i>Defend the modification by referring to the internal criteria (scenarios)</i> |
| <i>Defend the modification by referring to the external criteria (web usability heuristics)</i> |
| Evaluate peer's design (Evaluation 1) |
| <i>Evaluate the prototype by referring to the design ideas</i> |
| <i>Evaluate the prototype using internal criteria (scenario)</i> |
| <i>Evaluate the prototype using external criteria (web heuristics)</i> |
| Evaluate peer's design (Evaluation 2) |
| <i>Evaluate the prototype by referring to the design ideas</i> |
| <i>Evaluate the prototype using internal criteria (scenario)</i> |
| <i>Evaluate the prototype using external criteria (wed heuristics)</i> |

The second activity of incorporating the functional creativity attributes which consist of novelty, relevant features, elegance and germinal attributes were evident. The students have incorporated novelty attribute in their non-working prototype using their own design ideas and referred to the current websites. They have to propose a new design layout as solutions for the problems indicated in the scenarios. The students have also incorporated relevant and effective features to fit the design claims given in the scenario and proposed solutions for the problems described in the scenarios. Two techniques were revealed that helped to identify the relevant features were sketching the interfaces before designing and using trial and error method. The students were found keen to incorporate the design interfaces which are simple and can be recognized easily, were commonly used, straightforward and uncomplicated interfaces. The evidence collected reflected the lack in germinal attribute. Although two of the students have elaborated on their new design concepts and their importance, it was found that some of the students were not confident in incorporating the germinal attribute in their design.

The third activity discovered is students have justified their non-working prototype based on their design ideas, by referring to the internal criteria (scenario) and using the external criteria (web usability heuristics). The students have justified the prototype by supporting their design ideas on their layout, content, navigation, screen importance and design trends. Other evidence also revealed that students have referred the requirements given in the scenarios against the web usability heuristics. The students have justified their design by referring at least 2 to 3 web usability heuristics which was found lacking in their design.

4.2 Post Evaluation Activities

There are three main activities identified as post evaluation activities, of which the first activity is recognizing the usability problems. The students were able to identify, clarify and provide solution for the usability problems highlighted in the evaluation 1. The students have related the usability problems from the evaluation result with their interfaces. The common method of identifying the usability problems from the evaluation result were reading, marking and listing down and using the template.

The second activity is about incorporating alternative design ideas. Various methods were applied such as self and cross checking with external source such as the existing websites, Internet resources, books and peers. The evidence proved that the students have referred to the web usability heuristics to decide on the alternative design concepts. They have used the web usability heuristics to obtain positive comments from

the evaluators and were watchful for non-compliance with other web usability heuristics. The evidence gathered also shows that the students have referred the scenarios to support their design alternatives to ensure that their modification matched the claims given in the scenarios.

The third activity is on defending the modification based on the usability problems, external criteria (web usability heuristics) and the internal criteria (scenario). The design ideas were used to defend the students' modification and to inform the evaluators and peers that the students have enhanced the interfaces to better layout and designed consistently. The students have used their design ideas when the evaluators have highlighted specific problems on their interfaces. The evidence has proved that the students have referred to the web usability heuristics to defend their prototype. Various techniques such as templates to maintain consistency, manually examining on the information displayed, redesigning the buttons, including realistic links and referring to the Internet were used. The students found they have defended their prototype using internal criteria (scenarios) to make sure that the interfaces remain the solutions for the given scenarios and to counter check with the claims from the scenarios.

4.3 Peer Evaluation Activities

Three activities were found during the peer evaluation. The first activity is pointing out the usability problems. The evidence collected has proven that the students have pointed out the usability problems based on their peer's design ideas during peer evaluation. The evidence also revealed that the students have found fewer usability problems on evaluation 2 compared to evaluation 1. Evidence found shows that the students have used the web usability heuristics to point out the usability problem during evaluation 1 and 2. They have indicated the problem/s supported by their points to certain heuristic which they have found lacking in the design. The students have referred to the scenarios to point out the usability problems. They have matched the peer's interfaces with the claims given in the scenarios, to check if the peers have designed their non-working prototype considering the users and to include different error prevention for different type of layout.

The second activity found is proposing design suggestions during peer evaluation. The students have proposed design suggestion for the usability problems to their peers. Various ideas were suggested based on the usability problems that they have found such as on navigation options, content filtering technique, offered user control by changing the background and music, maintained consistency by using template and referring

to current websites to improve the design. Evidence also revealed that the students have referred to the web usability heuristics when proposing suggestions to their peers. Although the numbers of students who have related the suggestions with the web usability for evaluation 2 were fewer compared to evaluation 1, this could be attributed to other factors such as there were no errors found or the peers who have designed the interface well. It was revealed that the students have used the web usability heuristics as primary reference to propose the suggestions on their peer's design. There was also evidence showing that the students have referred to the scenarios when proposing suggestions to their peers but only little evidence of this was reflected in students' journals and interviews. The researcher has explored further on why the students have suggested based on the scenarios and found that they want to ensure that the peer's interfaces matches the claims given in the scenarios.

As for the third activity the students have conducted evaluation on the peer's design by referring to the design ideas for evaluation 1 and 2. The students have referred to their peer's design concepts to evaluate their design. This has made them refer their initial comments to recall the usability problems they have highlighted, to make sure that the peers modify the shortcomings in their design and to cross check if the peers have added new ideas base on the comments and suggestion given. The findings revealed that the students have evaluated their peer's design by referring to the scenarios. However, the numbers show the students have evaluated their peers by referring the scenarios were lesser for evaluation 2 compared to evaluation 1. They have referred the scenarios to ensure that their peers' designs layouts were adequate, the interfaces were organized and the features matched the claims. The facts have revealed that the students have also referred to the web usability heuristics while evaluating their peers. The students were able to indicate the usability problems by referring to a particular heuristic which they have found lacking. There was evidence showing that the student did expect the peer to refer his/her comments for each heuristic before modification.

5. Conclusion

The findings of this study are discussed based on three themes which are 1) PROVAS encourages analytical thinking, 2) PROVAS encourages synthesis thinking and, 3) PROVAS encourages evaluation thinking.

5.1. Theme 1: PROVAS encourage analytical thinking.

The first activity is, PROVAS has encouraged students to conduct claim analysis to identify 1) the root

design concept; 2) features and functions; 3) design flow and 4) design layout. The students were familiar and confident in conducting claim analysis after using PROVAS. They were able to recognize the root concepts by listing down the design claims from the scenarios and deciding on the features and functions. Techniques such as list, number and mark the claims were used. The students have organized and arranged the features and functions according to the importance mentioned in the scenarios. Methods such as creating a flow chart and sketching were used to ensure the non-working prototypes were designed in correct flow. The real time design layout concept was emphasized on consistency of the design layouts and current design trends.

Secondly, PROVAS has encouraged the students to recognize the usability problems from the evaluation result for Design 1 by 1) identifying usability problem/s, 2) clarifying the usability problem/s, and 3) providing solution/s for the usability problem/s. The students have identified the usability problems by reading, marking and listing the usability problem/s. It was evident that the student has rationalized the usability problems whether it requires modification or not. Another unique finding revealed that a template was used to identify the usability problems. The students have clarified the usability problems in their design justification after modifying their design. However, some of them felt it is not necessary to explain the lacking/s but the most important is to justify their modification/s. The students have provided solutions for the usability problem/s by referring to the scenarios, providing links from the Internet and re-evaluating their design lacking/s. The researcher found the usability problems indicated were too general and for that reason the students have referred other resources to support the lacking/s.

Thirdly, PROVAS has promoted analytical thinking by supporting students to point the usability problems during peer evaluation referring to 1) design ideas, 2) external criteria (web usability heuristics), and 3) internal criteria (scenario). The evidence revealed that the students have found fewer usability problems on evaluation 2 compared to evaluation 1. The researcher found the students have settled most of the usability problems found in evaluation 1 before uploading their design 2. The students have used the web usability heuristics to point out the usability problem. They have indicated the problem/s by supporting their feedback accordingly to heuristic/s which they have found lacking in their peers' design. A few of them have used the claims from the scenarios to point out the usability problems. They have ensured the peers' interfaces matches with the claims from the scenarios, user centered and incorporate significant error prevention method/s that suit the peers' layout.

5.2. Theme 2: PROVAS encourages synthesis thinking.

The first activity that shows PROVAS has encouraged synthesis thinking is by encouraging students to incorporate the functional creativity attributes in their non-working prototype which consist of 1) Novelty Attributes, 2) Relevance Attributes 3) Elegance Attribute and 4) Germinal attributes. The novelty attribute was focused by including the student's own design idea/s and referred to the exciting websites. The relevant features were included according to the design claims. They have proposed as solutions for the problems described in the scenarios by sketching the interfaces before designing the non-working prototype and using trial and error method. The students were keen to design interfaces which are simple, recognized easily, commonly used, and direct. The evidence on germinal attribute was not clear where only two of the students have elaborated on their new design concepts and their importance. Some of the students were not confident to incorporate the germinal attributed to their design because they were unsure whether their new approaches will be accepted by the evaluators or not.

The second activity is students have incorporated alternative design ideas by referring to 1) the usability problems, 2) the internal criteria (scenarios) and 3) the external criteria (web usability heuristics). The students have incorporated alternative design ideas for usability problems by conducting self check, cross check with existing websites, Internet resources, books and brainstorming with their peers. Some of the students felt they should not discuss their alternative design ideas in their design justification because this might confuse the evaluators. The scenarios were used to incorporate alternative design ideas to make sure that the design matches the claims from the scenarios. Some of the students also have referred the web usability heuristics to decide on the alternative design concepts as guidance, to obtain good comments from the evaluators and were watchful for non-compliance with other web usability heuristics.

The third activity that shows PROVAS has encouraged synthesis thinking is by motivating the students to propose design suggestions during peer evaluation based on 1) the usability problems, 2) external criteria (web usability heuristics), and 3) internal criteria (scenario). The numbers of students who have related the suggestions with the web usability for evaluation 2 turn out to be lesser compared to evaluation 1. This could be due to other factors such as fewer usability problems found on peer's design. The students have proposed design suggestions during peer evaluation such as on navigation options, content filtering technique, offer user control, maintain consistency by using template and refer to current websites with improved design. There was also

evidence that students have referred to the web usability heuristics when proposing suggestions to their peers as primary reference, whereas, few other evidence has revealed that students have referred to the scenarios to make sure that the peers' interfaces matches the claims.

5.3. Theme 3: PROVAS encourages evaluation thinking.

Firstly, PROVAS promotes evaluation thinking by encouraging the students to justify their non-working prototype referring to 1) design ideas 2) internal criteria (scenarios) and 3) external criteria (web usability heuristics). The students have justified the prototype by supporting their design ideas on their design layout/s, content, navigation, screen importance or design trends. Other evidence also reveal students have referred the claims given in the scenarios and used the web usability heuristics to justify their design. The students have justified their design by referring at least 2 to 3 web usability heuristics which was found lacking in their design.

Secondly, PROVAS has supported students in defending their non-working prototype after modification by referring to 1) the usability problems, 2) the internal criteria (scenarios) and 3) the external criteria (web usability heuristics). The students have defended their modification to inform the evaluators and peers that they have enhanced the interface layout or consistency. The evidence has proved that the students have referred to the web usability heuristics to defend their prototype using various techniques such as using templates to maintain consistency, manually examining on the information displayed, redesigning the buttons, including realistic links and referring to the other Internet resources such as online articles or samples. The students were also found to have defended their prototype using internal criteria (scenarios) to make sure that the interfaces remain as the solutions for the given scenarios or to counter check with the claims.

Thirdly, PROVAS has encouraged the students to evaluate their peers by referring to 1) the design ideas, 2) internal criteria (scenarios) and 3) external criteria (web usability heuristics). The students have referred the initial comments to recall the usability problems that they have highlighted to their peers to make sure that the peers have modified any lack in their design or to cross check if the peers have added new ideas based on the comments or suggestions given. The scenarios were used by the students to make sure that their peer's design layouts were adequate, the interfaces were organized or the features matched the claims. On the other hand, some of the students have also referred to the web usability by relating their comments to the heuristics which they found lacking in PROVAS.

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