Original Research   **Open Access**

Segmenting Principle Engages Pre-School Children with Multimedia Learning Material

Ariffin Abdul Mutalib*
1School of Multimedia Technology and Communication, Institute of Creative Humanities, Multimedia, and Innovation, Universiti Utara Malaysia, 06010, Sintok, Kedah, Malaysia

Yusof Jaafar
G-Elite Holdings Sdn. Bhd., Megan Corporate Park, Taman Desa Petaling, 57100 KL, Malaysia

Abstract
Segmenting principle promotes designers to chunk contents into small structured pieces. It sounds helpful for users, but literatures reporting its application in multimedia application is scarce. As a response to that, this study applies it in a multimedia learning material for pre-school children, called Dr.Beary's. The aim of this paper is to describe the elements of segmenting principle applied in Dr. Beary's, and to illustrate users engagement with Dr.Beary's. This study involves various techniques including walkthrough, design and development, and user observation and interview. In the end, a user experience study was carried out involving 32 pre-school children from three pre-schools. They were first let to experience the application, in which the sessions were video recorded, followed with an interview. Data were recorded using video recorder and diary. It has been discovered that users interact actively with the application and with their peers. They are also able to practice what they have learned confidently. These are some demonstrations of engagement with Dr.Beary's.

Keywords: Segmenting principle; Multimedia principle; Interactive learning content; User engagement.

1. Introduction

Developing interactive multimedia learning materials is easy. However, ensuring users engage with the developed multimedia learning materials is another story (Clark and Mayer, 2016; Zhou and Yadav, 2017). If they are not well designed, users may feel unhappy to use the learning materials and eventually will neglect using them (Brünken *et al.*, 2003; Preece *et al.*, 2007).

An interactive learning material is formed by its content and user interface. The user interface part is the one that connects users with the content. It also the one that determines the way users interact and experience the learning material. In ensuring that users feel happy using the learning material, designers have to always consider users needs in their design (Lee *et al.*, 2006; Low and Sweller, 2014; Lusk *et al.*, 2009). Regarding this, Lawrence and Tavakol (2006) recommends designers to carefully consider usability and aesthetic aspects. Both aspects work hand-in-hand in satisfying users (Cox and Dale, 2002; Flavin *et al.*, 2009). In contrast, when stressing too much on usability and leaving aesthetic unattended, it may impact in unhappy experience, and vice versa (Cawthon and Moere, 2007; Sonderegger and Saucer, 2010; Tractinsky, 2006). They have to be well-considered, appropriate for the purpose of the learning material, including the users, contents, and context of use (Duarte, 2008; Ginns, 2005; Preece *et al.*, 2007).

In supports of satisfying both usability and aesthetic aspects, (Mayer, 2009) proposes that designers could consider applying multimedia principles. Generally, multimedia principles consists of twelve principles (Mayer, 2014).

One of the principles designers could apply in their design is segmenting principle. This study believes, the segmenting principle is able to cater the needs of both usability and aesthetic aspects, so that users' cognitive load is minimized (Hasler *et al.*, 2007; Hassanabadi *et al.*, 2011).

The education sector has been affected by computers greatly. At all levels, from pre-school to higher learning institution, the society has absorbed technology-enhanced elements into learning process. In fact, learning contents have been widely developed for use in schools. At the same time, computer technology has been commonly used by children at home. Besides playing games, they also watch videos on YouTube.

However, their engagement with the contents while dealing with non-learning and learning materials is different. This study observed that through a study in three pre-schools. Particularly, it involved a pre-school in Kuala Lumpur (21 children), Penang (18 children), and Kedah (23 children). In the study, each child in every pre-school, who was good at reading, was given a computer with the Internet. They were asked to browse the Internet and play with it, with helps of their teachers. It was observed that everyone was deeply engaged with the contents, which among others were online games, movies in YouTube, and Instagram. Their engagement with the contents was obviously seen through their facial expressions and body languages. Obviously, they also involved peers in their experience. The session was lively. The next day, they were asked to read any ebook from the Internet. This study

did not specify any book for them, to let them decide one that they are happy with. With help of their teachers, everyone was able to find a book of their interest. They did read-aloud the books.

However, their reading was not conveyed appropriately through intonation, emphasis, and stress. Of course, there was a variation in their performance, depending on the book they read. When asked about the story they read, the children did not enthusiastically answer. In fact, after they read the book, they quickly asked for permission to dismiss.

Based on such scenario, this study believes that the way information is designed for the children really matters. Through the observation, it was found that children are more engaged with contents when the contents are not too bulky. Also, it was observed similarly when contents are grouped according to themes or point of discussion. Such finding is very interesting, and therefore, this study believes that applying segmenting principle in learning content for children in pre-school could make them engaged with learning contents.

As a response to such finding, this study designs and develops an interactive multimedia learning material for use by pre-school children. The learning material is named Dr.Beary's, taking advantage of a common name all children know. This is one way to quickly attract their attention, in which they do not have to recall or guess what a bear is (Dix *et al.*, 2004; Sweller *et al.*, 2011). For the purpose of engaging the children with the contents, Dr.Beary's applies segmenting principle.Based on the discussed background and the statement of problem, this paper aims to describe the way segmenting principle is applied in Dr. Beary's.

Generally, this section establishes the background of study, which includes also the problem regarding user engagement. Based on the problem, the aim of this paper is stated, which is to describe the application of segmenting principle in an interactive multimedia learnig material. The next section further discusses the way segmenting principle has been applied in engaging users. It is followed with a description on the research procedure. Further, the results are discussed before being concluded in the final section.

2. Methodology

This study has gone through a three stage research methodology as illustrated in Figure 1. The teachers requested that this study kicks off with English, because it is a foundation skill that children use in entire learning process. Then, the contents in Dr. Beary's are taken from the existing books being used in pre-schools. Therefore,there is no issue regarding the selection of the contents. Referring to Figure 1, the process begins with identifying the most appropriate technique (element) in applying the segmenting principle in Dr. Beary's.Identifying the most appropriate technique for applying segmenting principle was done through a focus group discussion.

Fig-1. Research process
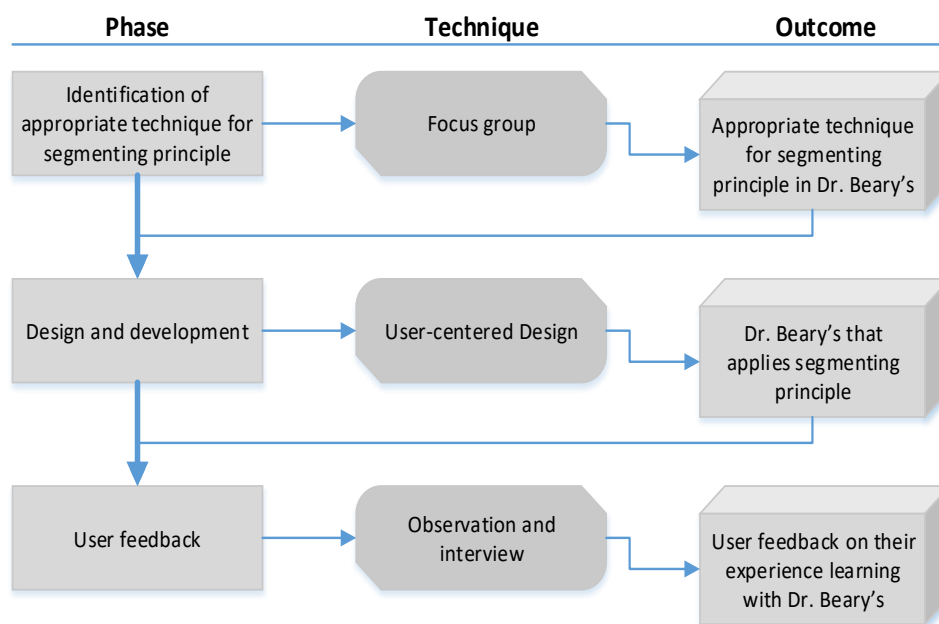
The focus group was carried out consistingof four experts; an HCI expert, a pre-school teacher, a designer in the industry, and a children specialist; who did a walkthrough on a sample of five interactive multimedia storybooks. The objective of the focus group was to identify techniques that help segmentizing the contents in Dr. Beary's. It was carried out in a systematic procedure: (1) this study explained the purpose of the focus group, (2) every expert explained their expertise, (3) every expert went through five interactive multimedia storybooks, (4) every expert noted down the strengths and weaknesses of every storybook, (5) all experts discussed their findings and (6) this study concluded the session with a list of techniques for segmenting principle for Dr. Beary's.

Having carried out the focus group, this study managed to gather a set of techniques for segmenting contents in Dr. Beary's. For this study, the techniques should be tailored for children and for self-paced learning. On that consideration, the experts have scrutinized their concerns to a narrow list. Eventually, they agree on the following techniques for application in Dr. Beary's: (1) the canvas is segmented into appropriate panes using contrasting

colors, (2) contents in a book are chunked into several appropriate topics as necessary, (3) in a topic, contents are chunked into several modules as necessary, (4) in a module, contents are chunked into small parts, (5) every modul uses standard color, (6) text changes color as being narrated (when necessary), and (7) contents are also segmented using shapes.

The findings in the first phase was utilized in designing and developing Dr. Beary's (second phase). The objective of this phase is to apply the segmenting principle in Dr. Beary's. The process in this phase adapted the action research method (as applied by Hayes (2011); which iterates the plan-act-observe-reflect cycle (Figure 2) (Elliot, 1991). In every cycle, in which users involved in giving recommendations and feedbacks, it begins with a storyboard. Regarding the users in this stage, a group of similar five pre-school children were involved from start to finish. They persistently involved in the study to ensure they are clear about the study, and participate well in every iteration. This ensures this study obtains reliable recommendation and feedback, as applied by Landoni et al. (2018). It was iterated with an improvement on the design in every cycle, until the reflection stage showed no more room for improvement. In the end, Dr. Beary's has been fully developed, with a careful application of segmenting principle. Details on the elements of segmenting principles applied in Dr. Beary's are described in the result section.

Fig-2. Adapted action research technique
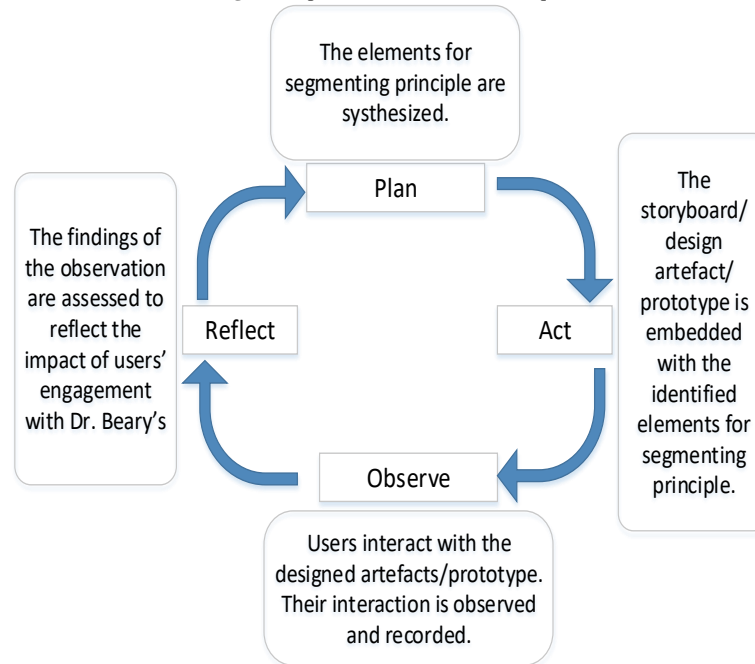
Then, this study preceeded with the third phase; gathering users' feedback; which aims at gathering users feedbacks on their experience in learning with Dr. Beary's. This phase involved the similar schools as in the problem identification exercise, which is a school in Kuala Lumpur (11 children), Penang (10 children), and Kedah (11 children). In total, 32 users participated in the user feedback session. The number is sufficient, because this study carries out a deep study, through direct observation and interview techniques as recommended by Preece et al. (2007).

The procedure in gathering users' feedback began with letting them deal with Dr. Beary's. While they were experiencing Dr. Beary's, this study recorded the session on video. With between 10 and 11 children in every school (carried out in their respective school), this study successfully managed to have everyone recorded on video, in which on top of that, manual diary was also used. The interview was carried out right after the observation. The observation was focused on three aspects, the children's behavior, errors/success they make, and their emotion expressions.

These were synthesized (done after the sessions completely ended) through both the recorded video and diary. While the observation was focused on those three aspects, the interview was intended to get answers on (1) their experience on using Dr. Beary's as opposed to experience using other learning materials, (2) their willingness to use Dr. Beary's, and (3) their willingness to promote Dr. Beary's to their peers. Users' feedbacks through both observation and interview are generally interesting, which are discussed in the remaining sections.

3. Result

The previous section describes the systematic process this study has gone through. This section continues with the results of phases 2 and 3. Having gone through phase 2, Dr. Beary's that incorporates segmenting principle is obtained. Figures 3 through 9 show snapshots of Dr. Beary's with elements of segmenting principle that support user engagement.

Fig-3. The main page that welcomes users
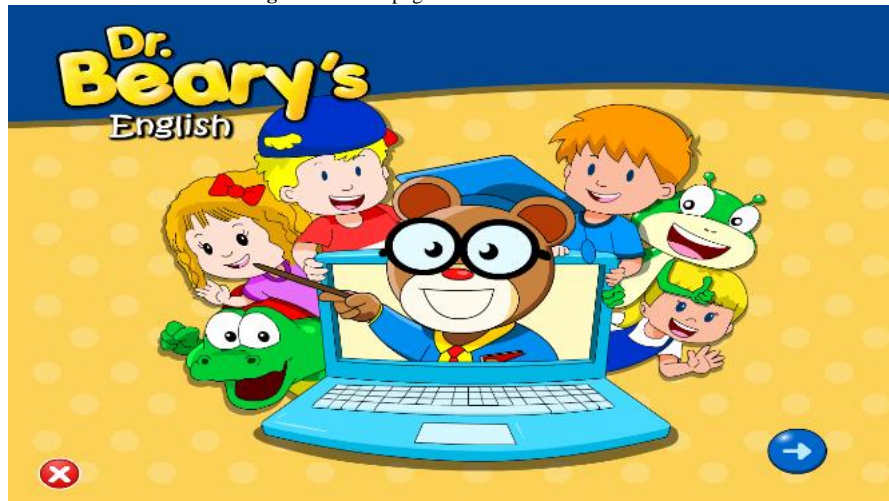
The main page conveys the actors in Dr. Beary's, in their enthusiastic friendly faces. They are ready to bring users into the learning material with them.

Fig-4. Segmentation of modules

Fig-5. Segmenting elements in a module

| More contents segmentized in this button | Title telling the content segment | Segmenting the activities with buttons | Segmenting contents for each activity wih buttons |

Fig-6. Segmenting modules through colors
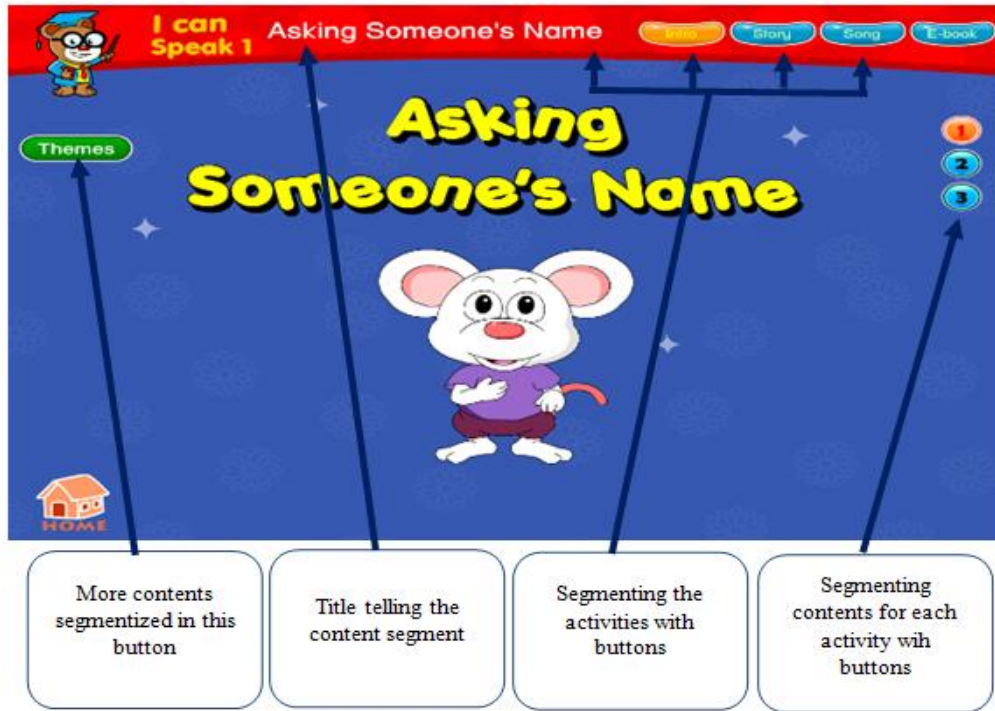
| Colors are used for segmenting. The "intro" module uses blue, "story" uses green. | Story normally contains much contents, so they are segmented into more buttons. |

Fig-7. Segmenting modules through colors

For song, the lyric is not listed in full, but line by line. Words are segmented using colors.
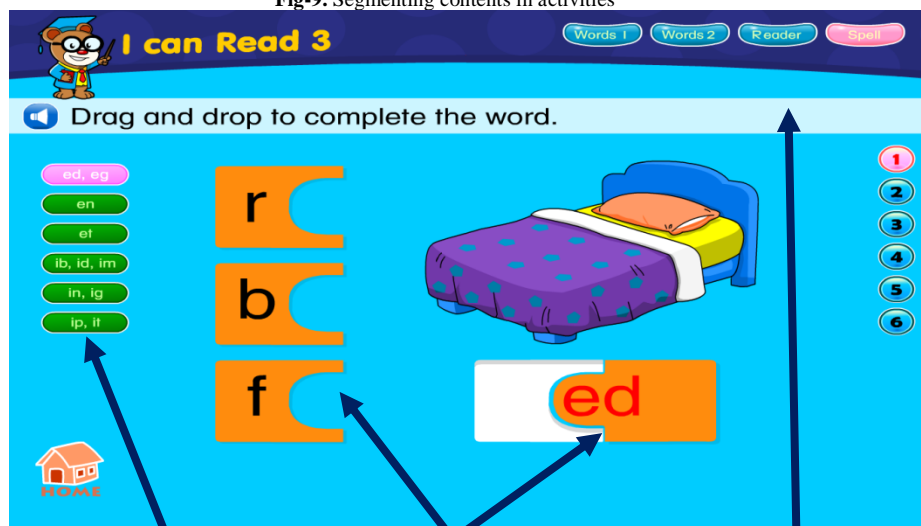
Fig-8. Segmenting text through colors

Song and conversation are segmented in different pages.

Contents for practice are segmented into different pages.

Fig-9. Segmenting contents in activities

When there are much contents for activities, segment them into buttons.

Segmenting between the clue and answer space through colors and shapes.

Segmenting the instruction line with colors.

Figures 3 through 9 depict the elements of segmenting principle applied in Dr. Beary's. This paper showcases them, as representatives in the whole content. As color is used as one of segmenting strategies, the selection of colors was critically considered. Obviously, bright colors are used, ensuring contrast colors appear on every page. Although contents are segmented using buttons, the use of buttons is standardized across the whole contents. The navigation style and convention are made straight-forward and simple to ensure users (pre-school children) feel confident upon their interaction with Dr. Beary's. These are considered to support both usability and aesthetic aspects.

4. Result from Observation

The observation was focused on three aspects; childern'sbehavior while using Dr. Beary's, errors/success they make, and their emotional expression while using Dr. Beary's. Results are obtained through analyzing the video clips and diary using Gounded Theory approach (Glaser and Strauss, 1967).

4.1. Observed Behavior

Five major tasks children need to do in Dr. Beary's are finding the main menu, locating content, reading text, interacting with interactive contents, and interacting with peers while using Dr. Beary's. Each of the task was carefully observed.

4.2. Finding the Main Menu

The main menu is a place where users can select the main modules in a book. Hence, it is very important for users to know how to get there. Having observed all users through the recorded video and the diary, users are found uncertain in the beginning. However, after the first time getting there, they are confident already. This is because, while segmenting the navigation structure, the 'home' button that takes to the main menu is always made visible, and at the exactly similar location. This totally avoids cognitive load, because they do not have to recall. That makes them enjoy when shifting contents through the main menu.

4.3. Locating Content

Every book contains eight topics. They are arranged from low complexity to high complexity, according to Bloom's Taxonomy. Contents for every topic are provided in various forms including stroy, song, e-book, and practices. This study segments the contents in a standard form across the topics in all books, so that users could have a transparent mental model. Through the recorded video and diary, in the beginning users are found not so sure about the location of their intended content. Obviously, because it was the first time they used the learning material. Hence, many of them clicked all modules and see the contents briefly. After that, they stick to the topic that they intend to focus. As a result, when they intend to change to another topic, they did it that very confidently.

4.4. Reading Text

There are text in Dr. Beary's, especialy at 'story' and 'e-book' modules. Through the recorded video and diary, users are found to be able to read the text confidently. Text are segmented into chunks. This makes users engaged in reading them, because in between the content, they need to click a button. Besides, the text are also segmented with different colors, in which active text are colored with red (non-active is in black). In 'story' module, the text are read-aloud, and users read together. Meanwhile, in 'e-book' module, users are provided with a button to ask Dr. Beary's reads the text for them. Otherwise, the text are not read-aloud.

4.5. Interacting with Dr. Beary's

In 'practice' module, users are required to actively interact with Dr. Beary's. Besides, in other parts, users are also required to interact with. Through the video and diary, users are found able to go through all items in the practice module easily. Although for things they first met, they know how to interact with. Dr. Beary's segments the contents in 'practice' module into a few tasks, depending on the topic and level of knowledge taxonomy, to support children learning ability. With that, the children (the users) are able to associate their required actions with the visul representation.

4.6. Social Aspect While Interacting

While interacting with Dr. Beary's, the children also interact with their peers. For groups that are on similar topics, they communicate on their topics, and discuss on the same topic. For groups on different topics, they keep inform each other about what they are interacting with. The sessions were lively, exhibiting them challenging each other, supporting each other, communicating about their experience, and other sort of social interaction. For this study, such interaction really exposes an engagement with Dr. Beary's.

4.7. Observed Errors

This study also observed they way the users interact with Dr. Beary's. The purpose of observing their interaction is to identify whether they make errors that crucially need improvement.

4.8. In Selecting Right Modul

In Dr. Beary's, selecting modules is important because all contents are segmented into modules. Hence, this study observes user interaction from such aspect. Through the recorded video and diary, some users did mingle around and click the buttons in the beginning. They perhaps were learning about the organization of the content structure. However, after noticing that the structure in all topics (in all books) is standard, they understand it well. As a result, having learned about the structure, it is clear that almost all users were able to very confidently select their intended contents at any time. Not only they know the module structure, getting there was also very easy for them. No matter at what point they are, getting to the right module in any topic is just easy and everyone did that very easily.

4.9. In participating in Dr. Beary's

In Dr. Beary's, user interaction is core. There are segments of contents, not only through modules, but also on a page. This is one way of ensuring users are engaged with the contents in Dr. Beary's. Hence, this study also analyzes whether users interact actively or passively with the application. Obviously, through the video and diary, the users are seen very actively interacting in Dr. Beary's. In Dr. Beary's, this study composes all modules with contents related to the topic, including the song. It is seen that, in 'intro' module, users speak together with the character in Dr. Beary's. In 'story' module, the users are seen responding to the contents through their facial expression and body language. Their expressions are congruent with the contents in Dr. Beary's. In 'song' module, they sing together with the character. In fact, they also make body laguage as the character demonstrates. Then, in 'e-book', the users

read the text well. In case they are stuck, they click on the speaker icon and listen to the lines read by Dr. Beary's. In overall, the users are looking forward to continue interacting with Dr. Beary's until they are instructed to end their sessions. This is geared by their deep engagement with Dr. Beary's, not only through its contents, but also through the way Dr. Beary's interact with them.

4.10. Observed Emotional Expression

Users' interaction with Dr. Beary is a paramount observation for this study, because it reveals whether users really does the tasks or not. On top of that, analysing their emotional expression while interacting with Dr. Beary's is also very important. Hence, through the video and diary, it is also analyzed. Obviously, they are impressed with the opening page. The color and character segments really make them positive. It is seen through the way they smile when seeing the characters. Not only they smile, but they also show off impressed hand and body gesture.

4.11. Individually

In the beginning, while learning about the structure in Dr. Beary's, the users were quite anxious. They keep clicking the topics and return to the main menu. This study realizes that their anxious is only on identifying the contents for each topic. However, the tool-tips on the buttons help them identify topics right. Although they were anxious, when they got any answer, they celebrate it through body and oral expression. Expressions like "yeay...", "I got it..", and "OK, there it is..." are always heard.

When they are confident about the contents for topics, more positive expressions are seen in the sessions. Reading the text together with the characters in Dr. Beary's is entertaining for them. It is because the way the text is segmented (with colors and chunks) enables them to express their facial and body expressions. When they sing together with Dr. Beary's, they really enjoy it. They imitate the character in Dr. Beary's while singing, make facial and body expressions appropriately with the content. In fact, they also make aural expressions, showing their positive emotions.

4.12. While Interacting with Peers

While interacting with Dr. Beary's, the children also interact with their peers. Some of them are on similar topic. In this scenario, they read together, and react physically together. They connect their emotion together, sometimes seeing at each other and talk to one another.

In another scenario, they are on different topics. In this, they keep tell what they are with, sometimes they shift to their peer's screen to see what makes the peer excited. Most of the times, they repeat a content segment to show to their peer (similarly in asking their peer to repeat for them). This is a result of segmentation, which provides high user-control over the application (Scheiter, 2014).

5. Result from Interview

The interview was carried out to extend the findings of the observation. Findings from the interview are clustered into three.

5.1. Their Experience on Using Dr. Beary's as Opposed to Experience Using Other Learning Materials

Obviously all chldren have experienced using other applications before Dr. Beary's. Some are on CD and some are on the Internet. From their responses, this study deduces that they are happy with all multimedia learning contents they have used previously. However, they appreciate Dr. Beary's more because it segments the contents. With that, it is easy for them to repeat any content they want to.

5.2. Their Willingness to use Dr. Beary's

Having experienced using Dr. Beary's, the children were happy to express that they are willing to use the application in their learning process. For them, although there are many multimedia learning applications, Dr. Beary's is easier to use and it makes them learn swiftly. One important aspect that they are impressed is their ability to repeat desired content, which is a result of segmenting the contents into chunks. With that, they could improve their enderstanding and ability to practice.

5.3. Their Willingness to Promote Dr. Beary's to Their Peers

In fact, they also expressed that they want their other friends to also learn with Dr. Beary's. It is normal for children to promote what they feel good to their peers. For them, when there are more people using Dr. Beary's, they will have more people to practice the skills they learn in the application.

6. Discussion

The design of Dr. Beary's by applying segmenting principle is to satisfy the needs of usability (Nielson, 1993) and to consider the affordance (Norman, 2002). They are mixed together, to accommodate with technology advancement (Suchman, 1987) and the needs of the users (Preece *et al.*, 2007). As a result, the observation and interview reveal that the children are able to carry out their tasks smoothly. Not only that, they also experience using Dr. Beary's highly positively.

Their positive experience going through Dr. Beary's means that they are engaged with the application. Besides visual consistency, the way the segmentation is made is an influencial factor. This agrees with the findings by (Ayres, 2006); (Boucheix and Guignard, 2005); and Boucheix and Schneider (2009). As this was done with user engagement in the UCD process, it eventually results in a highly-desired scenario.

Through the proper segmentation, it promotes active interactions between the users and the application, as emphasised by Mayer (2011). Such active interactions then promotes interaction among peers. In fact, such segmentation promotes users to apply what they have learned, such as asking one's name, and introducing friends, agreeing with Mayer and Chandler (2001) and Mayer et al. (2003). They are able to do that on the effect of segmentation. Through segmentation, they can store what they learned in a block structure, which reduces their cognitive load (Moreno, 2007). As a result, it is easy for them to apply when necessary, as found by Plass et al. (2010).

The effect of color segmentation is undeniably influencial for children. Careful selection of colors between forground and background and between panes is impactful for the effect of cognitive engagement. If colors are not well segmented, it may fail in supporting cognitive ignition. This agrees with part of previous studies such as by Mayer and Fiorella (2014) and Mayer and Pilegard (2014).

The application of segmenting principle has to be carefully decided. For this study, including users in the designing process, through UCD approach is really helpful. It is troblesome, and costly, but results in a desired impact. The process although tedious and tiring especially in ensuring the children participates well, managed to outcome recommendations that meet user expectations.

7. Conclusion

This paper describes a study that observes the impact of segmenting principle upon children's engagement towards a multimedia learning content, Dr. Beary's. The elements of segmenting principle for Dr.Beary's were identified through a walkthrough over five samples of other interactive learning materials. The design of Dr.Beary's that incorporates the identified elements of segmenting principle was carried out through UCD cycles, in which users involved directly in the design process. Through a series of observations and interviews in users actual contexts, this study discovers that the application of segmenting principle in Dr.Beary's is able to promote active interaction between users and the application. It also promotes active social interactions among peers while learning with Dr.Beary's. Not only that, users are also able to practice what they have learned confidently. This really supports the development of children's critical thinking skills (Djamas et al., 2018). In accordance to that, this study promotes or designers to carefully apply segmenting principle in their design. Besides, modality and redundancy principles are also impactful, as found by Liu et al. (2018). In future, this study wil analyze the impact of those principles over children's interaction experience with Dr. Beary's.

Regarding that, it is important to note that there is no single answer for the best design. It is highly subjected to the context of use, and the target users. The key to the design is understanding users and their needs. Based on the experience of this study, UCD is an approach that could assist in understanding the actual user desire.

References

Ayres, P. (2006). Impact of reducing intrinsic cognitive load on learning in a mathematical domain. *Applied Cognitive Psychology,* 20(3): 287-98.

Boucheix, J.-M. and Guignard, H. (2005). What animated illustrations conditions can improve technical document comprehension in young students? Format, signaling and control of the presentation. *European Journal of Psychology of Education,* 20(4): 369-88.

Boucheix, J.-M. and Schneider, E. (2009). Static and animated presentations in learning dynamic mechanical systems. *Learning and Instruction,* 19(2): 112-27.

Brünken, R., Plass, J. L. and Leutner, D. (2003). Direct measurement of cognitive load in multimedia learning. *Educational Psychologist,* 38(1): 53-61.

Cawthon, N. and Moere, A. V., 2007. "The effect of aesthetic on the usability of data visualization." In *In Proceedings of 11th International Conference on InformationVisualization.*

Clark, R. C. and Mayer, R. E. (2016). *E-learning and the science of instruction.* Wiley: New York.

Cox, J. and Dale, B. G. (2002). Key quality factors in website design and use: an examination. *International Journal of Quality and Reliability Management,* 19(7): 862-88.

Dix, A., Finlay, J., D., A. G. and Beale, R. (2004). *Human-computer interaction.* 3rd edn: Pearson Education Limited: England.

Djamas, D., Tinedi, V. and Yohandri (2018). Development of interactive multimedia learning materials for improving critical thinking skills. *International Journal of Information and Communication Technology Education,* 14(4): 66-84.

Duarte, N. (2008). *Slideology, The art and science of creating great presentations.* Sebastopol, CA.: O'Reilly.

Elliot, J. (1991). *Action research for educational change.* Open University Press: Buckingham.

Flavin, C., Gurrea, R. and Orus, C. (2009). Web design, A key factor for the website success. *Journal of System and Information Technology,* 11(2): 168-84.

Ginns, P. (2005). Meta-analysis of the modality effect. *Learning and Instruction,* 15(4): 313-31.

Glaser, B. and Strauss, A. (1967). *The discovery of grounded theory.* Strategies for Qualitative Research: Chicago.

Hasler, B. S., Kersten, B. and Sweller, J. (2007). Learner control, cognitive load and instructional animation. *Applied Cognitive Psychology,* 21(6): 713-29.

Hassanabadi, H., Robatjazi, E. S. and Savoji, A. P. (2011). Cognitive consequences of segmentation and modality methods in learning from instructional animations. *Procedia - Social and Behavioral Sciences,* 30: 1481-87.

Hayes, G. R. (2011). The relationship of action research to human-computer interaction. *ACM Trans. Comput.-Hum. Interact,* 18(3): 15.

Landoni, M., Rubegni, E. and Nicol, E. (2018). A comparative study into how pupils can play different roles in co-design activities. *International Journal of Child-Computer Interaction,* 17: 28-38.

Lawrence, D. and Tavakol, S. (2006). *Balanced website design, Optimising aesthetics, Usability, And purpose.* Springer Science & Business Media.

Lee, H., Plass, J. L. and Homer, B. D. (2006). Optimizing cognitive load for learning from computer-based science simulations. *Journal of Educational Psychology,* 98(4): 902-13.

Liu, Y., Jang, B. G. and Roy-Campbell, Z. (2018). Optimum input mode in the modality and redundancy principles for university esl students' multimedia learning. *Computers and Education,* 127: 190-200.

Low, R. and Sweller, J. (2014). *The modality principle in multimedia learning.* 2nd ednThe Cambridge Handbook of Multimedia Learning. 227-46.

Lusk, D. L., Evans, A. D., Jeffrey, T. R., Palmer, K. R., Wikstrom, C. S. and Doolittle, P. E. (2009). Multimedia learning and individual differences, Mediating the effects of working memory capacity with segmentation. *British Journal of Educational Technology,* 40(4): 636-51.

Mayer, R. E. (2009). *Multimedia Learning.* 2nd edn: 1-304.

Mayer, R. E. (2011). *Applying the science of learning.* Pearson: Boston, MA.

Mayer, R. E. (2014). *Cognitive theory of multimedia learning.* 2nd ednThe Cambridge Handbook of Multimedia Learning. 43-71.

Mayer, R. E. and Chandler, P. (2001). When learning is just a click away, Does simple user interaction foster deeper understanding of multimedia messages? *Journal of Educational Psychology,* 93(2): 390-97.

Mayer, R. E. and Fiorella, L. (2014). *Principles for reducing extraneous processing in multimedia learning, Coherence, Signaling, Redundancy, Spatial contiguity, And temporal contiguity principles.* 2nd ednThe Cambridge Handbook of Multimedia Learning. 279-315.

Mayer, R. E. and Pilegard, C. (2014). *Principles for managing essential processing in multimedia learning, Segmenting, pre-training, And modality principles.* 2nd ednThe Cambridge Handbook of Multimedia Learning. 316-44.

Mayer, R. E., Dow, G. T. and Mayer, S. (2003). Multimedia learning in an interactive self-explaining environment: What works in the design of agent-based microworlds? *Journal of Educational Psychology,* 95(4): 806-13.

Moreno, R. (2007). Optimising learning from animations by minimising cognitive load, Cognitive and affective consequences of signalling and segmentation methods. *Applied Cognitive Psychology,* 21(6): 765-81.

Nielson, J. (1993). *Usability engineering.* Academic Press: Cambridge, MA.

Norman, D. (2002). *The design of everyday things.* Basic Books: New York, NY.

Plass, J. L., Moreno, R. and Brünken, R. (2010). Cognitive load theory. 1-275.

Preece, J., Rogers, Y. and Sharp, H. (2007). *Interaction design, Beyond human-computer interaction.* 2nd edn: John Wiley& Sons, Ltd: England.

Scheiter, K. (2014). *The learner control principle in multimedia learning.* 2nd ednThe Cambridge Handbook of Multimedia Learning. 487-512.

Sonderegger, A. and Saucer, J. (2010). The influence of desin aesthetics in usability testing, Effects on user performance and perceived usability. *Applied Ergonomics,* 41(3): 403-10.

Suchman, L. A. (1987). *Plans and situated actions, The problem of human-machine communication, Learning in doing, Social, cognitive and computational perspectives.* Cambridge University Press: Cambridge, UK.

Sweller, J., Ayres, P. and Kalyuga, S. (2011). *Cognitive load theory.* Springer: New York.

Tractinsky, N. (2006). Aesthetics in information technology, Motivation and future research directions. *Human-Computer Interaction In Management Information Systems Foundation,* 6: 330-47.

Zhou, N. and Yadav, A. (2017). Effects of multimedia story reading and questioning on preschoolers' vocabulary learning, story comprehension and reading engagement. *Educational Technology Research and Development,* 65(6): 1523-45.