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Cognitive learning and motivation of 1st year secondary school students using an interactive and multimedia-enhanced e-book made with iBooks Author

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Abstract

In this study, multimedia and interactive e-book content was explored to determine the impact on 1st year Irish secondary school students, specifically looking at cognitive learning and student motivation. To achieve this, a controlled experiment was undertaken using a comparison between a test group and a control group. The test group was given an interactive and multimedia enhanced e-book, developed with interactive widgets of the iBooks Author for the iPad. The control group was presented with the same material, but the widgets were replaced with static materials. The study found that some widgets were more successful for learning than others, and that the ibook format indicates a high level of motivation in students.

Keywords: Cognitive learning, Interactivity, iBooks Author, E-books, iPads, Multimedia, Motivation, Secondary schools

Introduction

In the introduction, the impact of e-books in schools is described, and an explanation is provided for how multimedia technology enhances learning and motivation based on literature across three areas: cognitive multimedia learning, computer interactivity and technology enhanced motivation.

E-books in Education

The development of the tablet PC has provided a new medium for publishing books, as it is now possible to read the printed word in e-book format. Schools are increasingly adopting e-books as a replacement for traditional textbooks (Gleason, 2012), and according to the Horizon Report (2012), increasingly institutions are providing students with iPads that are pre-loaded with course materials. Publishers of Irish schoolbooks now provide the primary and secondary school curriculum in e-book format for all major mobile operating systems. There have been many studies with positive reports on e-book platforms in schools. Larson (2009) conducted a case study in which second grade students were observed learning from e-readers in schools. He concluded that there were high levels of engagement with the interactive features of the e-book as the subjects consistently enjoyed using the interactive features such as the digital dictionary, note-taking and highlighting features.

"Multimedia instruction rather than 'flat resources', such as static text documents, have been identified as an important element of high-level interactive engagement and student satisfaction" (Slinger-Friedman & Patterson, 2013, p.1) and the exploration of usability and functionality are crucial for the adoption of e-books for education (Berg *et al.,* 2010). School e-books are digital copies of the printed version and come with a set of tools to enhance the traditional book as a learning format, such as digital highlighters and note-taking functionalities. Other functionalities include linking to sections and quick access to pages and

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DOI: 10.21427/D79424

chapters. The course material itself is not presented in an interactive format and in terms of content delivery, is a replica of the printed format. Coyle (2008) noted that the e-book industry is primarily concerned with digitizing printed books rather than considering new ways to support learning. Woody *et al.* (2010) claims that changing the design of an e-book from a printed book allows for a more constructive learning experience.

iBooks Author

Research in the field of e-learning has found that multimedia can foster cognitive change and motivation (Alessi & Trollip, 2001; Clark & Mayer, 2011; Moreno & Valdez, 2005; Kennedy, 2004). This indicates that a school e-book that is built with multimedia components may result in better learning and motivation by students. Many projects globally are investigating the pedagogical affordances of iPads, with the goal of improving lessons through interactive use (Huber, 2012).

iBooks, which are enhanced e-books, provide a new digital publication standard that easily integrates multimedia technology in the form of animation, audio, video and interactivity through the use of widgets in the form of easily customisable learning objects. Apple's iBooks Author® is an e-book development software for the iOS operating system that enables authors and instructional designers to create multimedia-rich e-books for the iPad. Teachers in second level schools have observed greater student interest and engagement with novels, plays and short stories when accessed through iBooks and Kindle® applications (Twyla, Williams-Rossi, Johnson & McKenzie, 2011). Also, in a longitudinal study by Houghton Mifflin & Harcourt, 20% more of middle school algebra students using an e-book made with the iBooks Author achieved 'proficient' or 'advanced' when compared to other students who were using a standard text book (Bonnington, 2012).

Cognitive Interaction Model of Multimedia Interactivity

The Cognitive Interaction Model of Multimedia Interactivity (Figure 1) illustrates the structure by which motivation and learning outcomes are achieved through cognition when learning from a multimedia-enhanced interactive source. Kennedy (2004) states that previous classifications of interactivity do not consider cognitive processes of the user, and that interactivity in learning should not be researched without incorporating the significance of cognition. It describes interactivity as the continuous interplay between instructional events, functional interactivity, and cognitive interactivity. *Functional interactivity* proposes a bidirectional relationship between the events of instruction and the users' behavioural processes. *Cognitive interactivity* proposes that the relationship between instructional events, and users' cognitive processes are mediated by their behavioural processes. The model states that two potential benefits of interactivity are increased intrinsic motivation and more favourable learning outcomes. Kennedy proposes that this model be used as a basis for future interactivity research, and it is on this model that exploration of cognitive learning through multimedia-enhanced instructional events within interactive e-books in this research is based.

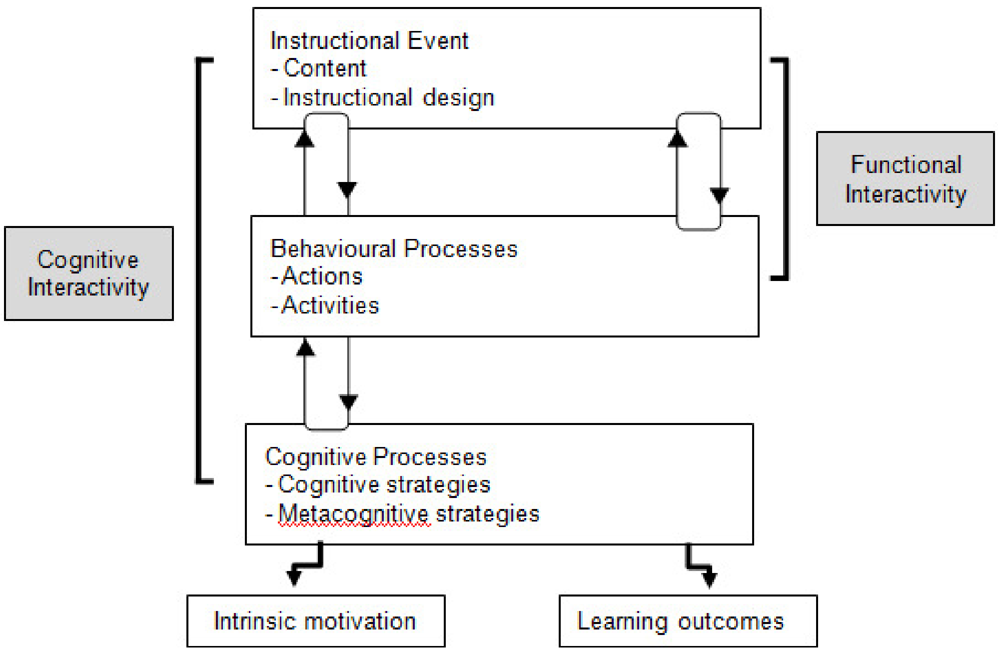

Figure 1 Cognitive Interaction Model of Multimedia Interactivity (Kennedy, 2004)

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Cognitive Multimedia Learning

Cognitive learning is based on the distribution of objective knowledge among individuals who are receiving and processing information independently (Sorensen, & Ó Murchú, 2006). Mental models are representations of information in the limited working memory of the learner, used to understand, solve and predict (Alessi & Trollip, 2001). Some psychologists believe mental models to be internal images, and others purpose that a concept is only a mental model if it is being run in the working memory by the learner. Nevertheless, Hagmann, Mayer, & Nenninger (1998) state that good models can be developed by the learner when good conceptual models are presented to them.

Cognitive Load Theory

Cognitive load refers to the information that is processed in the limited short term memory during learning. There are three types of cognitive load defined within Cognitive Load Theory (Sweller, 1988). *Intrinsic cognitive load* is the natural complexity of information that is presented to the learner. If the interactivity between elements in working memory is high then the intrinsic cognitive load is high (Sweller, 2010). *Extraneous cognitive load* refers to elemental activity that does not serve the instructional goal, and needs to be reduced by the instructional designer. *Germane cognitive load* allows generative and constructive processing, through which the learner makes connections between the information and prior knowledge. Cognitive overload occurs when the demands of the learning task exceed the processing capacity of the cognitive system. Information and activities should be designed in ways that optimise cognitive processing and lead to better formation of mental models and better retrieval of the information by the learner (Tzanavari & Tsapatsoulis, 2010).

Mayer & Moreno (2003) distinguish among three kinds of cognitive demands. *Essential processing* refers to the five core processes in the cognitive theory of multimedia learning:

selecting words, selecting images, organizing words, organizing images, and integrating. The instructional designer must allow for as much free space in the working memory as possible for essential processing to be maximised. *Incidental processing* refers to processing that is not required for making sense of the presented information. *Representational holding* refers to holding verbal or visual representations in the working memory in order to understand the information.

Dual Channels in the Cognitive Theory of Multimedia Learning

Dual Coding Theory (Clark & Paivio, 1991; Paivio, 1986, 2006) suggests that learning is enhanced by complementary sources of information that are received simultaneously, such as a picture and text and that the memory consists of two representational processes for both pictorial and verbal information that function independently but interact, enhancing retention and retrieval (Mayer, 2009). The theory is strongly criticised by researchers who support propositional theories. A propositional description of a mental image is an inner description, while according to Dual Coding Theory it is an inner picture. Dual Coding Theory has been contested against for decades but defended and elaborated on by Paivio (Thomas, 2010). Dual coding, nevertheless has provided basis for much instructional design research (Tzanavari & Tsapatsoulis, 2010).

Mayer (2009) utilises a dual channel assumption in his Cognitive theory of Multimedia Learning. He outlines that the channels can be conceptualised by the presentation mode approach, whereby there is a channel for verbal material and a channel for pictorial material or the sensory modality approach, in which there is a channel for auditory and one for visual information. The Cognitive Theory of Multimedia Learning uses both of the modalities, during which knowledge is constructed based on verbal and pictorial mental models by a cross referencing process between the two channels. This referential processing will have

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DOI: 10.21427/D79424

additive effect on recall. The Information Delivery View states that pictures and words are just the same information being delivered twice and the multimedia designer need not be repetitive, whereas from a cognitive multimedia learning perspective, the dual channels strengthen the mental models formed by the multiple representations (Mayer, 2009).

Principles for Reducing Extraneous Processing

The Cognitive Theory of Multimedia Learning is based on three assumptions; the dual channel assumption, the limited capacity assumption, and the active processing assumption (Mayer & Moreno, 2003). In this context, proven principles that can be implemented through instructional design are suggested for reducing overload in the working memory of the learner.

The following five principles are concerned with the reduction of extraneous and incidental processing.

1. The *Coherence Principle* states that the exclusion of extraneous material from a multimedia lesson enhances learning as overload is reduced.
2. The *Redundancy Principle* refers to the waste of cognitive processing that occurs when the learner processes identical information in different forms, such as words presented as both narration and on screen-text.
3. The *Signalling Principle* refers to drawing the learner's attention to the instructionally relevant area of the screen, thereby reducing incidental processing and extraneous load.
4. The *Spatial Contiguity Principle* states that corresponding words and pictures should be placed closely on a screen so that the learner can hold them both in working memory simultaneously and incidental processing is thus reduced.
5. The *Temporal Contiguity Principle* is concerned with representational holding and

states that connections between pictures and text occur more efficiently if the representations appear in the working memory simultaneously rather than successively. Synchronising corresponding information thereby frees cognitive capacity. When the presentation of audio and visual data is successive, representational holding occurs in one of the channels, resulting in cognitive overload.

Three principles that manage essential processing are as follows:

1. The *Segmenting Principle* allows the learner to process the information in bite-size segments as pieces of instruction are chunked to manage essential processing.
2. The *Pre-training Principle* dictates that learning is better from a multimedia presentation when learners have already cognitively processed some of the components.
3. The *Modality Principle* describes how learners understand a multimedia explanation better when words are presented as audio narration rather than text. This is because the visual channel is not overloaded with essential processing while the learner is simultaneously processing pictorial information and on screen text. This is referred to as a split-attention effect (Sweller, 1999).

Finally, the following two principles foster generative processing in multimedia learning:

1. The *Multimedia Principle* states that better learning occurs from words and pictures than from words alone.
2. The *Personalisation Principle* describes that learning is better when the spoken word is in conversational style rather than formal.

Criticisms of the cognitive theory of multimedia learning are that it does not incorporate motivation as a consideration, when it is believed that motivational factors affect learning and

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DOI: 10.21427/D79424

consume memory, thereby affecting the cognitive load (Kennedy, 2004; Astleitner & Wiesner, 2004). It has also been mentioned that that there is a lack of explanation of the integration process into long term memory regarding representation formats of the information (Reed, 2006).

Interactivity and Cognition

The term interactivity is so broad that it eludes consensus for a definition (Domagk, Schwartz & Plass, 2010; Kennedy, 2004). Interactivity has been commonly classified by two broad distinctions, which are the instructional approach, and the functional approach (Alrich, Rogers & Scaife, 2000). The instructional approach is typified by Thompson & Jorgensen's (1989) Interactive Model, which represents the relationship between the instructional source and the learner. The learner exists on a continuum either as a reactive and passive receiver of information, or a proactive constructor of knowledge. Interactivity exists between the reactive and proactive poles. Here, the focus is on mapping behaviourist or constructivist models of learning to the interface. The second common classification of interactivity, the functional approach, deals with the affordances of the interface. Interactivity is defined here by the physical actions of the user and the purposes of their actions (Sims, 1997). An example of this is Sims' (1997) eleven interactive concepts, which outline different functionalities of an interface that can allow learners to achieve certain instructional goals.

According to Kennedy (2004, p.51) however, both of these classifications fail to consider the user's cognitive processes, which is an important component of interactivity: "Interactive learning can only be understood by knowing how functional and cognitive interactivity work together." It is the cognitive activity that occurs during this interaction, rather than the behavioural activity, that is important in predicting and describing the resultant learning (Dalgarno *et al*., 2006; Kennedy, 2004). When learners are interacting with different media "whether they are observing an animation, browsing a book, answering a quiz ... or constructing a model, there are different kinds of cognitive activities going on" (Aldrich, Rogers & Scaife, 1998, p.325).

Mayer presented, but did not test the "*Active Processing Assumption*", stating that students engage in more meaningful learning by selecting relevant words and pictures, and organising them coherently into verbal and pictorial models (Slinger-Friedman & Patterson, 2013).

Interactivity and Constructivism

The constructivist approach to learning describes learning as activity-based, and not just a case of information transmission. Learning is more successful when students make meaning rather than take it (Moreno & Valdez, 2005). Piaget, in his theory of cognitive development argued that cognitive development and change occur due to interaction with the environment. This led to the advent of *discovery learning* in classrooms whereby learning was constructed via exploration and discovery (Jordan, Carlile, & Stack, 2008). Discovery learning and virtual manipulatives of computer-based instruction sit within a context with three advantages; idealised environments can be created, materials can be dynamically linked and continuous transformation of objects can occur (Reed, 2009). Interactions with representations allow the user to act upon an element and get feedback and hence build their own mental models (Rowhani & Sedig, 2005). Interactive learning environments are viewed as a promising option for presenting information and allowing the learner to engage actively in the learning process (Renkl & Atkinson, 2007). e-Books offer new opportunities and possibilities for interpretation and engagement with material (Hancock, 2008; Larson, 2009). This sort of engagement should be more enhanced with interactive e-books in the form of the ibook.

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DOI: 10.21427/D79424

Interactivity and Multimodal Theories

Zheng *et al.* (2009) claim that the manipulative function in multimedia facilitates processing by reducing the cognitive load through self-efficacy, allowing learners to engage in higher cognitive activity. The manipulable objects enable the germane load to be enhanced and confidence to be increased, which facilitates learning. In their study to measure the effects of multimedia on cognitive load, self-efficacy and problem-solving they found that manipulable objects and the involvement of motor cognition had a positive effect on cognitive load and self-efficacy.

Zheng *et al.* (2009) & Reed (2009) claim that motor manipulation is mentally coded in a way that allows information to be efficiently retrieved later, as is illustrated by Englecamp's multimodal model of action-based learning (1998). It is suggested that manipulative learning is encoded differently to visual or aural learning as performed and observed actions have different encoding systems (Englecamp, 1998; Reed, 2009). Englecamp found that enactment enhances recall compared to just reading. Zheng *et al.* (2009) extend this principle of different encoding systems to interactive multimedia.

Englecamp's assumption that sensory and motor processes exert an influence on each other but can also be independent mirrors Paivio's (1986) Dual Coding Theory, whereby two opportunities for recall are provided (Zheng, 2009). Observations encode visual information about movement, but performance and action encodes motor information as is illustrated in Figure 2 below. The enactment effect, which is the finding that acting out terms results in better recall than reading forms the basis of the multimodal model and the inclusion of manipulative objects in multimedia instructional design (Reed, 2009). Several researchers used Dual Coding Theory as a basis to expound on the enhancement of learning through haptic engagement (Jones *et al.*, 2006; Singapogu & Burg, 2009). A competing theory is that haptics increase the cognitive load placed on working memory (Moore *et al*., 2013).

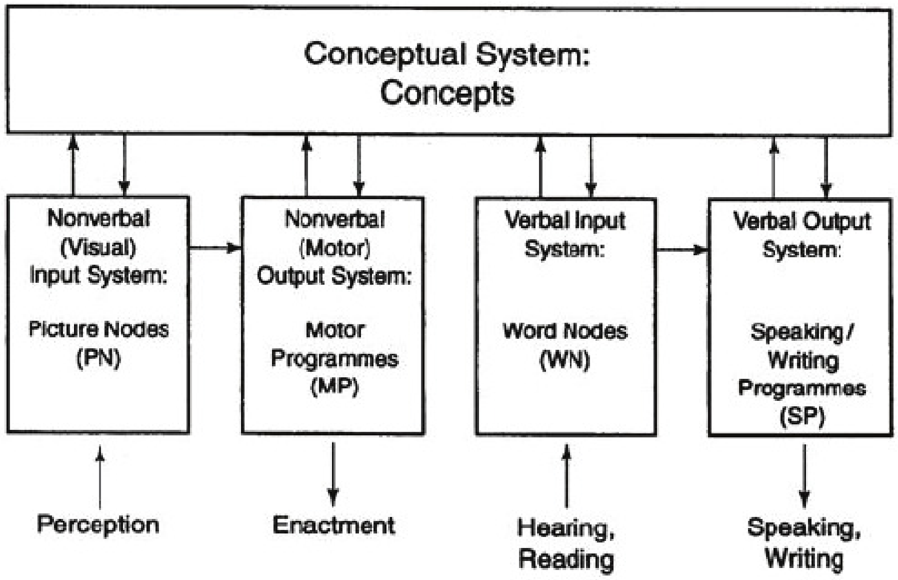

Figure 2 Multimodal Model (Engelkamp, 1998)

Motivation

A learner's motivation will affect their level of engagement with learning materials (Domagk *et al.,* 2010). Multimedia resources have been found to be a significant element of high-level engagement, student satisfaction and motivation (Murray *et al.,* 2012; Moore *et al.,* 2013). Students reported that haptically enhanced devices in education provide excitement and additional motivation to learn (Lopes & Carvalho, 2010; Christodoulou *et al.,* 2008; Comai *et al.,* 2010). Motivation in education is broadly classified into extrinsic motivation and intrinsic motivation. Learning through extrinsic motivation is learning that is based on an external goal or reward, while learning through intrinsic motivation is learning for its own sake (Malone & Lepper, 1987).

According to Keller's (2008) ARCS model of motivational design there are four steps to promote and sustain motivation during the learning process: *Attention*, *Relevance*, *Confidence* and *Satisfaction* (Keller, 2008). Eliciting attention from a student requires building curiosity

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424

and sustaining engagement. Research on curiosity and arousal indicates learner attention should be maintained by a variety of contrasting approaches in the form of interesting graphics or animation and events that introduce incongruity (Kopp, 1982; Keller, 2008; Mayer, 2008). The concept of relevance in the model ties learners' goals, experiences and styles to the instructional material. Presenting material as useful and allowing choice are elements to engender relevance. Confidence relates the students' feelings of personal control and expectancy for success. Much motivational research on confidence and self-efficacy illustrates that students are more productive when focused on task completion rather than focusing on outcomes (Keller, 2008; Zheng, 2009). Finally, satisfaction is necessary to incur intrinsic motivation in the learner. Providing learners with opportunities to apply the learned material supports this intrinsic satisfaction. Many empirical studies find that each component could be varied independently of one another in instructional design, and that students' motivational reactions vary accordingly in both traditional learning settings and e-learning environments (Keller, 2008).

Malone & Lepper (1987) in their Model of Motivational Multimedia, identified four major components that make multimedia environments motivating. These are challenge, curiosity, control and fantasy. *Challenge* evades boredom or frustration. *Cognitive curiosity* can be aroused via audio visual devices (Astleitner & Wiesner, 2004). Malone & Lepper (1987) distinguish between cognitive and sensory curiosity. While the former deals with higher level cognitive structures, the latter involves attention-attracting audio-visual or educational manipulatives, which is what makes a multimedia platform intrinsically motivating. *Control* in a responsive environment engenders a sense of ownership over it. According to Domagk *et al.* (2010), control facilitates or even enables the learner's cognitive and metacognitive activities. Finally, *make-believe* and *fantasy* situations remove the learner from their reality, resulting in intrinsic motivation. Astleitner & Wiesner (2004) claim that this theory merely summarizes and categorises motivationally relevant factors in multimedia learning as prescriptive for instructional designers without being incorporated in psychological model.

Astleitner & Wiesner (2004) propose an expansion of Mayer's (2008) Cognitive Theory of Multimedia Learning to provide a more cohesive model as it has led to many well proven principles in multimedia learning but is lacking consideration of a motivational aspect. They suggest that there are elements of a multimedia environment that do not just contain cognitive elements. For example, they identify video and audio as having motivational qualities. They claim that motivational instructional elements are important because motivation influences learning, motivational processes require memory processes and thus decrease the cognitive load and also cognitive and motivational variables have elements in common, for example, attention. Motivational parameters of working memory include expectancies and incentives which control the internal and external resource management of human learning. In the context of motivational multimedia features, Harp & Mayer (1997, p.95) distinguish between emotional interest cognitive interest. An emotional interest adjunct is defined as “added material that is entertaining but irrelevant to explanation” but increases retention and transfer. For example, 'seductive illustrations', which are interesting and entertaining details, increase student interest. Slinger-Friedman & Patterson (2013) state that despite some claims of positive results from multimedia learning environments, there is a lack of strong empirical research on students' perceptions and the motivational impact of multimedia environments.

Research Questions

Q1. Will there be increased learning outcomes for the test group because of the multimedia design?

Q2. Will there be increased motivation due to multimedia design?

Q3. Do the ibook widgets increase learning and motivation?

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DOI: 10.21427/D79424

Methodology

The methodology used in this research was an exploratory case study. "A case study is an empirical study that investigates a contemporary phenomenon in depth and within its real-life context" (Yin, 2009, p.18). In an exploratory case study, fieldwork and data-collection are undertaken before the end definition or procedure (Yin, 2009). This research explores the usage and effectiveness of an ibook in terms of learning and motivation when compared to learning from a standard e-book. Thus the experiment is using a scientific control approach by dividing the class into a test group and a control group.

The research was carried out with a group of first year secondary school students (n=50) in an Irish school in February, 2013. Since September 2012, each student in the first year group, in a pilot program had been using personal iPads as a replacement for physical books. The students of the first year group have developed a comfortable level of proficiency on iPads. The group was split into two groups; a test group (n=25) and a control group (n=25).

Procedure

Each participant in the test group downloaded an e-book built with widgets to their iPads, and each student in the control group downloaded an e-book built without widgets. The participants were allocated a duration of 30 minutes to explore the content in the e-books from start to finish. Mixed methods; quantitative and qualitative, were used for the collection of data. Each group took an identical recall test on the iPad, which consisted of thirty questions; some questions were multiple choice, others required text input. The test group then completed an opinion-based questionnaire on how they found using the interactive and multimedia enhanced e-book compared to the e-books they used regularly at school, and on how they enjoyed using the individual widgets. The test and questionnaire were built using online polling software at Kwiksurveys.com, and the results were stored in a database.

e-Book Design

The e-books were designed using the iBooks Author application, and the topic of these lessons was coral reefs. The two books developed; one with the interactive widgets and the other without, were identical in content. The book with the interactive widgets was given to the test group, and the book without was given to the control group. Functionality shared between the e-books was a touch screen page slider at the bottom of each page. The widgets used are as follows:

Interactive gallery: The learner presses images on a row of thumbnails that produce an enlarged image with text. This widget presented six labelled pictures of different types of coral. Each labelled picture is presented independently of each other. The content is differentiated from that of the control group by interactivity and also by invoking the coherence and segmenting principles, which reduce cognitive load in working memory.

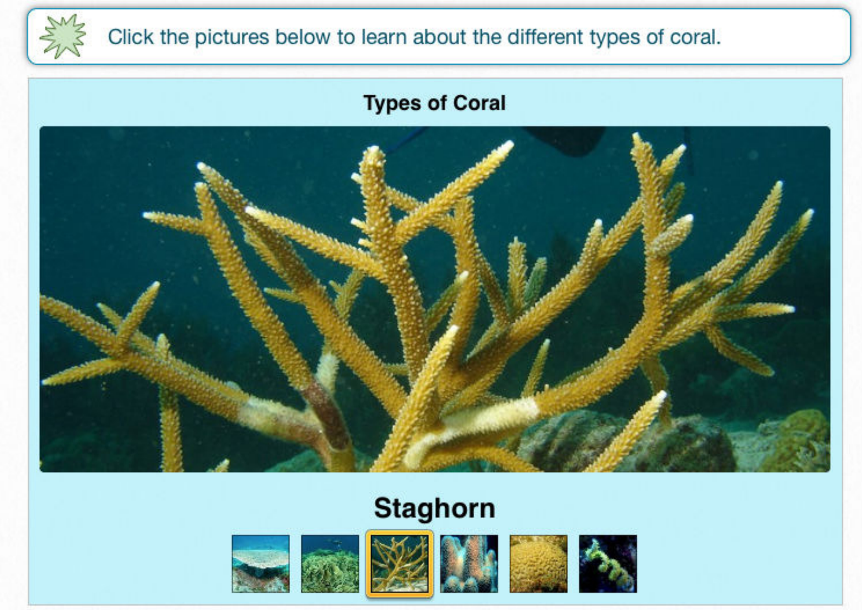

Figure 3 Interactive Gallery

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Interactive images: The learner presses labels on an image, zooms to that image, and descriptive text appears. This widget was used in two instances to show and describe a matrix of creatures in the coral reef. The content is differentiated from the control group by interactivity and by invoking the coherence and segmenting principles.

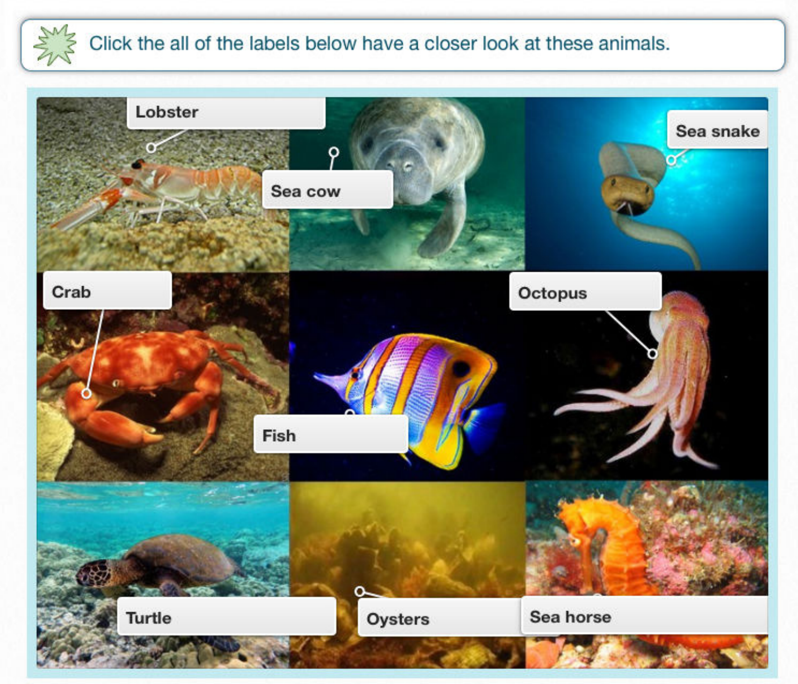

Figure 4 Interactive images

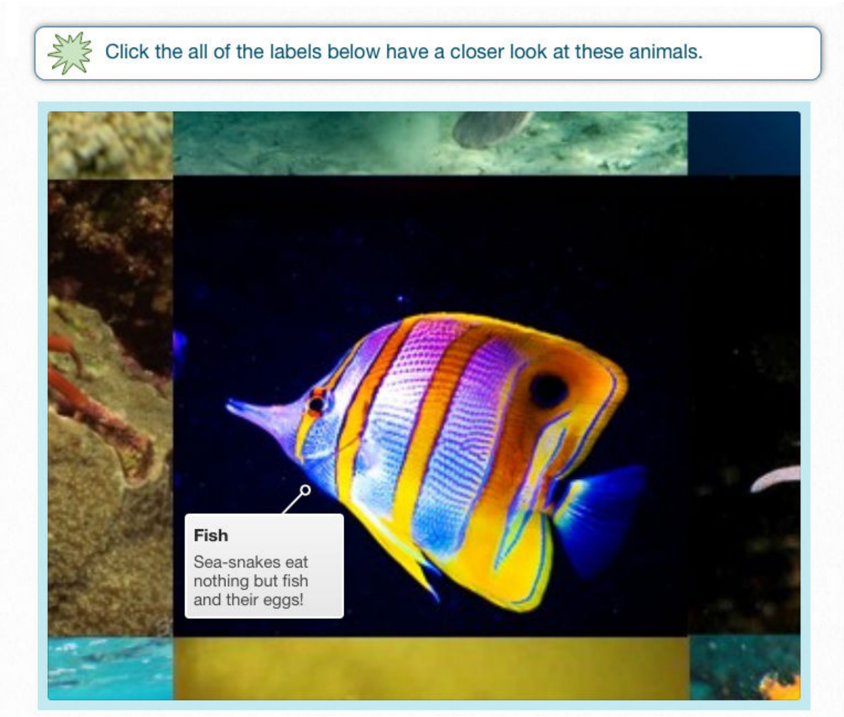

Figure 5 Interactive images

Chapter review: The learner can test their knowledge by selecting multiple-choice options to

17

a question and receive feedback. A review was placed at the end of each of the six sections. The control group viewed non-interactive versions of the questions without feedback. Feedback promotes rehearsal and recall (Domagk *et al.*, 2010).

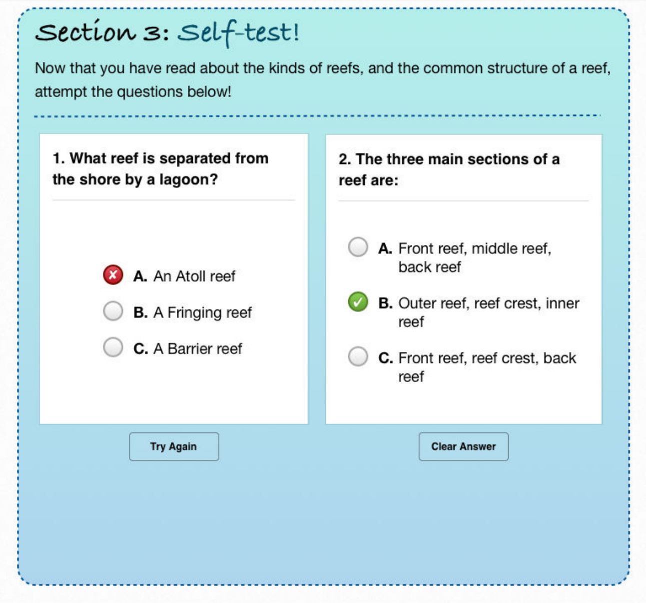

Figure 6 Chapter review

Keynote presentation*:* The learner views a Keynote presentation, which is a PowerPoint presentation made with Apple software Keynote. It was used to deploy three different animations with audio narration about coral reef structures. Reef shapes and arrows appear in time with audio narration. The modality principle to reduce a redundancy effect, and temporal contiguity principles are employed for better cognitive learning through the animation.

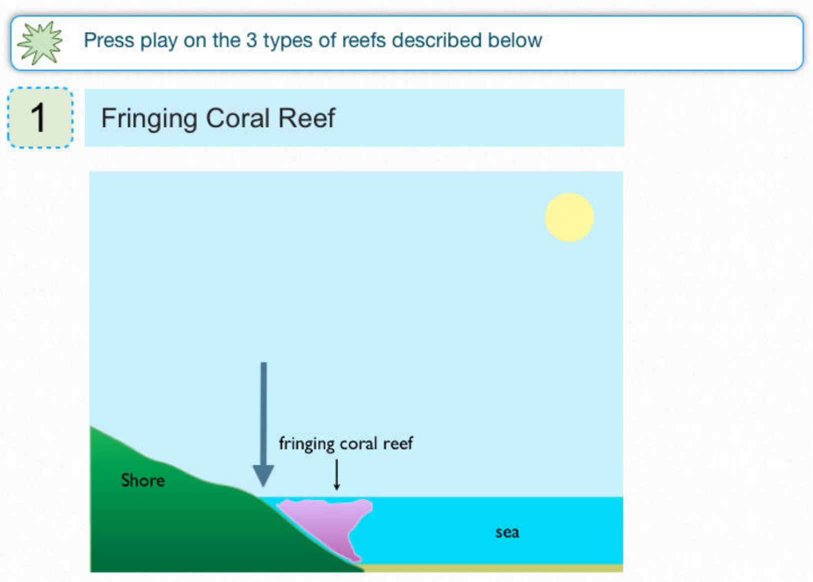

Figure 7 Keynote presentation - animation

A second instance of this widget was utilised to allow the learner to click through Keynote slides about the history of coral reefs. Haptic engagement and the multimedia principle are employed here.

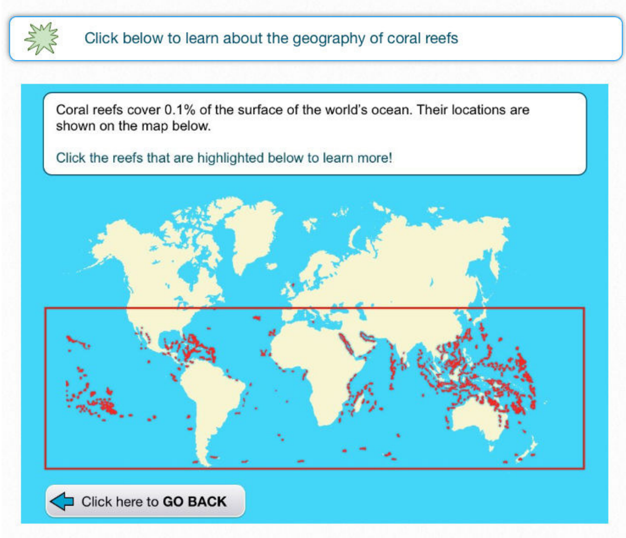

Figure 8 Keynote presentation

***3D Object**:* The learner interacts with a 3D object by swiping and rotating. Google Sketchup is the 3D modelling software that was used to employ this widget for the e-book. There were two instances of 3D learning objects in the e-book. The first was a model with labels of the structural zones of a typical reef. It had supporting text information within the object and was supported by a 2D labelled graphic of the structural zones. The second was a simpler model of a sea snake, which had supporting text information next to the object. This widget is conducive to germane processing and haptic learning.

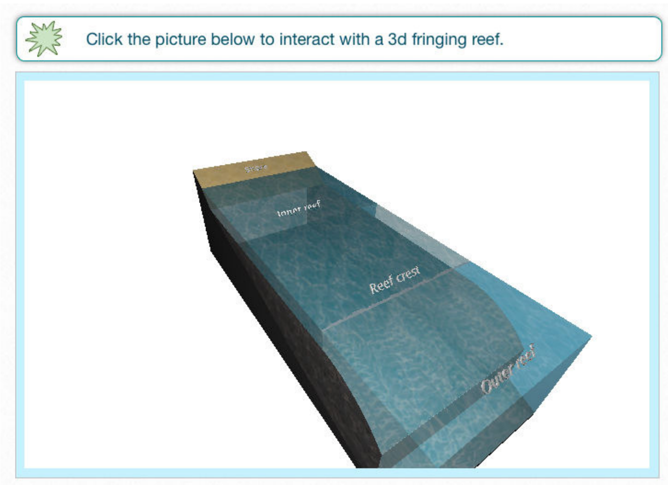

Figure 9 3D Object (1)

19

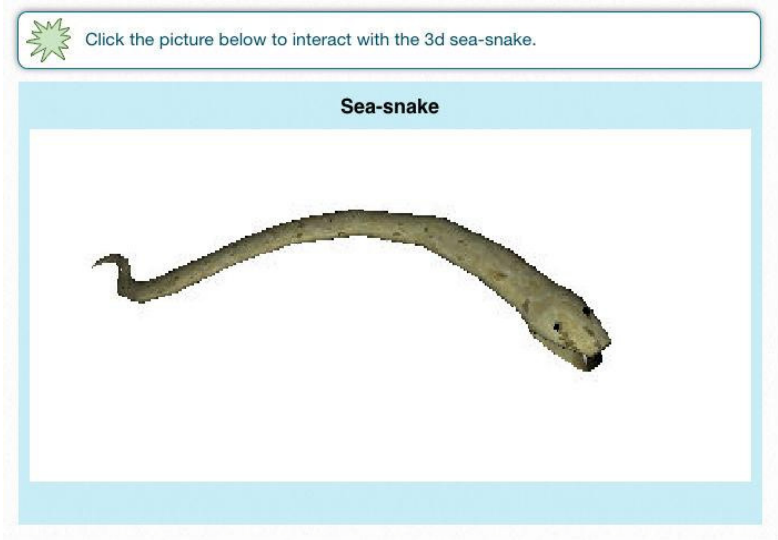

Figure 10 3D Object (2)

Popover: The learner presses an image that produces a window containing textual information. There were three instances of this presentation mode in the e-book, which are assumed to elicit haptic engagement and invoke the coherence principle.

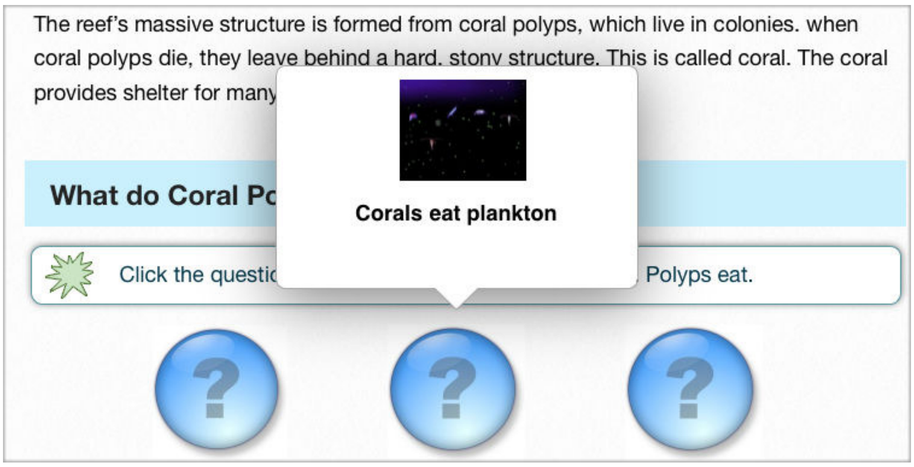

Figure 11 Popover

Media: Learners can view and listen to video based content. The participants viewed a video of a narrator with some illustrative pictures and which was two minutes in duration. The modality principle and the personalisation principles are employed.

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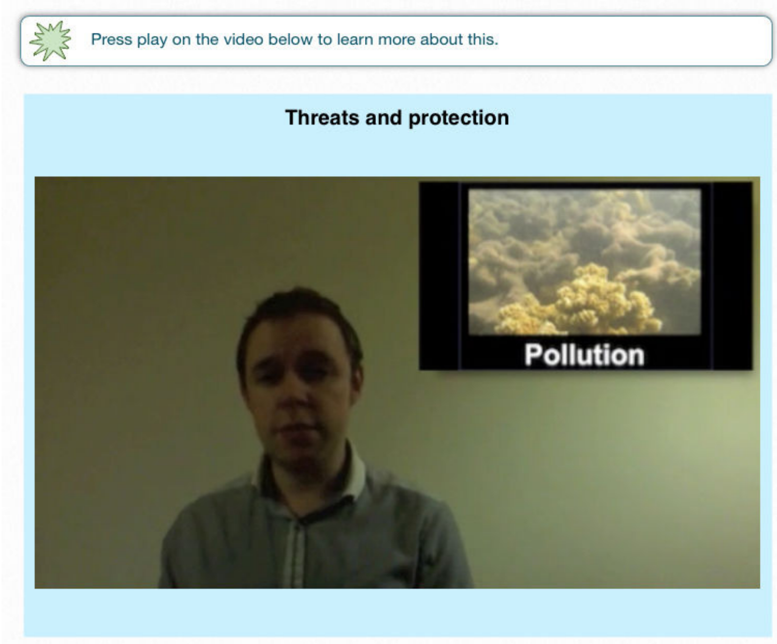

Figure 12 Media

It is important to note that all of the information provided interactively, was also presented as text and images throughout the control group's e-book to ensure that there was no difference in learned material.

Results

Quiz Results

The results of the quiz are presented in Table 1 overleaf:

Table 1 Recall Test Results

Widget	Control Group (Percentage with correct answer)	Test Group (Percentage with correct answer)	Difference
Interactive gallery	71%	47%	-24%
Interactive images	57%	42%	-15%
Keynote	71%	70%	-1%
Keynote - Animation with Audio	46%	64%	18%
3D Object (1)	72%	64%	-8%
3D Object (2)	48%	60%	12%
Popover	70%	80%	10%
Media	50%	51%	1%

As can be seen above, the widgets with the most significant increase in performance are: *Keynote - Animation with Audio* (18%), *3D Object (2)* (12%), and *Popover* (10%). Those widgets that show little significant change in performance are: Keynote (-1%), and Media (1%). Those widgets with the most significant decrease in performance are: *Interactive gallery* (-24%), *Interactive images* (-15%), and *3D Object (1)* (-8%).

Responses to the Widgets

23 out of the 25 participants submitted their responses to the questionnaire. The participants were asked to rate how they found using each widget on a Likert scale containing the options: *'love'*, *'like'*, *'dislike'* and *'hate'*.

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424

Table 2 Widget Feedback

	Love	Like	Dislike	Hate
Interactive gallery	5	17	0	1
Interactive labels	5	15	1	2
Animation with audio	7	13	2	1
Keynote Presentation	2	14	5	2
3D Object	12	10	0	1
Popover	6	13	2	2
Video	6	9	6	2

The intention of the research was to select the top three most widgets that received the most positive feedback on the Likert scale, but because of matching scores, four were selected. These were the 3D object (n=22), interactive gallery (n=22), animation with audio (n=20), and interactive labels (n=20).

Table 3 Positively Rated Widgets

Widget	n=students that gave a positive rating
3D object	22
Interactive gallery	22
Animation and audio	20
Interactive labels	20
Popover	19
keynote	16
Video	15

There were very few negative responses to the widgets. The widgets that received the most amount of negative ratings were video (n=8), keynote (n=7), and popover (n=4).

Table 4 Negatively Rated Widgets

Widget	n=students that gave a negative rating
Video	8
keynote	7
Popover	4
Animation with audio	3
Interactive labels	3
Interactive gallery	1
3D object	1

Overall, the responses to using the e-book were positive and demonstrated an eagerness to learn from such a format. When asked "Do you prefer learning information from the multimedia e-book, or from the e-books that you use in school?" 19 respondents (82.6%) chose the multimedia e-book and just 4 respondents (17.4%) said they prefer regular e-books.

When asked to respond to the following question on a Likert scale "Do you think that the multimedia e-book made you want to continue learning more about the Coral Reef, compared to if it was a regular e-book?", 8 respondents (34.7%) chose *'definitely'*, 14 respondents (60.87%) chose '*Sometimes*', 0 respondents chose '*Not really*' and 1 respondent (4.35%) chose '*Not at all*'. Here, the majority of students did not choose the answer that represents e-book as most favourable, which illustrates some dissatisfaction with the e-book format.

When asked to reply to the statement "I think that I would remember more information if I learned it from a multimedia e-book", 83% responded '*true*' and 17% responded '*false*'. Among the reasons for responding *'true'* were "It is more interesting", "you are waiting to see what is on the next page", "It was more interesting when you have to click on the pictures and 3D objects", "It was an easier and more fun way of learning" and "It makes you want to learn more." Among the reasons for responding '*false*' were "It is easier to learn with normal e-

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424

book" and "It is a distraction."

Discussion

The top three widgets to incur the best learning were the animation with audio, popover, and 3D object. The top widgets to receive positive feedback were 3D object (n=22), interactive gallery (n=22), animation with audio (n=20) and interactive labels (n=20). Therefore, the widgets that motivated the participants most did not always incur the best learning, for example, interactive labels and interactive gallery widgets. Those that incurred the best learning did not always have positive feedback, for example, the popover widget. The mixed results from the opinion survey and the recall test are discussed below.

3D Object: The 3D object received the highest amount of positive ratings and the lowest amount of negative ratings. It also received the highest number of *'love'* ratings. The feedback demonstrates a high motivation to learn through this widget. Opinions expressed by participants were that it is 'nice to see it as it would be', 'It was really interesting' and 'The 3D part was cool'. However, learning was worse for the test group for the first instance of the 3D object, and learning was better for the test group for the second simpler 3D object. The lack of learning in the first instance could be attributed to the seductive details (Harp & Mayer, 1998) of the elaborate 3D design, which cause split attention in learning, thereby distracting the learner away from the core instructional content resulting in cognitive overload. The participants may also have been distracted from the core instructional content as this was their first encounter with an interactive 3D object, and so their cognitive resources were not primarily occupied by the instructional content, but the novel and fun experience. This novelty may have been reduced for the second instance of the 3D object which is associated with better learning about the subject. It has to be clarified in future research the extent to which motivational strategies are seductive, and how to implement these strategies in multimedia without running the risk of being seductive, and thus counterproductive to learning (Harp & Mayer, 1998). The successful learning in the second instance may be accounted for by the lack of seductive details, minimal information to be learned, and the simpler shape of the model, thereby reducing the cognitive load. The 2D diagram for the first instance provided for better learning by the control group, demonstrating that is important for the designer to make appropriate use of available tools.

Interactive gallery: The interactive gallery received the most positive ratings from the participants in conjunction with the 3D object: "I think it was a more fun way of learning". However, it did not generate high levels of learning, with the control group who learned from rows of pictures and text having more successful learning. This illustrates that although the widget received positive feedback, interactivity and the principles of cognitive multimedia learning did not foster better learning.

Interactive images: Similarly, the interactive images widget was popular with the participants, but was not conducive to better learning. Rasch & Schnotz (2009) found that students do not have higher learning outcomes from interactive pictures than non-interactive pictures. They postulate that interactive pictures elicit different cognitive functioning in the learner. However, Interactivity does not automatically create understanding and may impose an unnecessarily high cognitive load due to large amounts of information that needs to be processed or the generation of the split attention effect can interfere with learning. (Domagk *et al,*. 2010) One student during the research announced that she was not able to use this particular widget. Hutchings *et al*. (1993) found that interactivity and seeking behaviour can be to the detriment of learning.

Popover: The popover widget was in the top three of the negatively rated widgets. However,

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424

it did account for better learning by the test group. This is supported by comments such as "It was easier to remember" and "Makes you want to look for it". According to Malone & Lepper (1987), uncertainty and hidden information can make learning more intrinsically challenging. The coherence principle may also have accounted for the better learning due to the isolation of the text and picture when interactively engaging with the widget.

Keynote: The animation with audio presentation mode received the second highest 'love' rating, and is in the top three positively rated widgets. Within-channel redundancy, according to the redundancy principle, creates cognitive overload when text and pictures occur rather than pictures and audio. (Clark & Mayer, 2007; Vetere & Howard, 1999). This modality principle may have accounted for better learning in this instance. Also, static pictures only include structural information, whereas animations present the information in a both a structural and temporal format allowing for the construction of dynamic mental models. This is based on perceptual schemata that allow humans to recognise complex dynamic patterns in their natural environment. The animation triggers these perceptual schemata in a way that static pictures do not (Rasch & Schnotz, 2009). The second Keynote presentation mode yielded no significant difference in learning and received negative feedback, perhaps because it is not as engaging as the other interactive widgets and while it conveniently limits space used for information, it may suggest more gratuitous interactivity (Aldrich, Rogers, & Scaife, 1998) by not supporting more effective learning.

Media: In this instance there was no significant difference in learning from the video, and it received the most negative feedback. Mayes (1993) found that the use of video may impede learning with not all learners attending to multiple representations, while Astleitner & Wiesner (2004) claim that cognitive curiosity can be aroused via audiovisual devices.

Chapter review: Smeets & Bus (2012) suggest that children learn more words from content in which they must complete MCQs. They claim that questions facilitate in-depth processing which promotes the meanings of words by semantic differentiation. Moore *et al.* (2013) however, found limited evidence of the positive learning effects of haptic feedback, but found significant motivational effects. This study did not isolate this widget for testing learning, but participants reported learning. Higher motivational effects were not reported. 70% of participants agreed that the MCQ questions reminded them of the correct answer, but only 13% agreed that they wanted to learn more because of it.

It should be noted that learners are not a homogenous group and have different cognitive styles. Riding & Douglas (1993) found that learning performances was affected if information is not presented in a learner's preferred type. For example, multimedia learning is more beneficial for imagers than verbalisers (Mannion & Cairrcross, 2010), and for field independent learners than field dependent learners (Smith & Woody, 2000; Almekhlafi 2006). Also, according the VARK model, learners can be primarily visual, aural, read/write or kinaesthetic and may not be suited to all of the modes delivered on this e-book platform.

Conclusion and Future Work

There were increased learning achievement for content associated with the widgets; popover, 3D object (2) and keynote (animation with audio). Learning achievement was less noticeable on content associated with the widgets; interactive gallery, interactive labels, and 3D object (1). Widgets that were rated highly by the students were not always the widgets that engendered better learning. For example, the interactive labels and interactive gallery widgets and one instance of the 3D object were rated highly and did not account for better learning. The animation with audio narration and one instance of a 3D object were the only presentation modes that were rated highly by the students and also accounted for better

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424

learning. This indicates that in this research, interactive and multimedia enhanced e-books do incur high levels of motivation. It also indicates that certain widgets were conducive to better recall by the participants comapred to just text, due to superior modes of presentation and interactivity.

It would be useful to repeat the study with participants who have had prior exposure to all of the widgets to eliminate possible cognitive overload during processing. With some prior exposure to the formats, invoking the pre-training principle, these widgets may be more successful tools in the classroom given the high levels of motivation, reported and demonstrated by the participants as illuminated by the models of motivation. A repeat of the study with a different group of students would also be useful to confirm lack of superior cognitive learning through the lesser successful widgets. It would also be useful to repeat this study in a longitudinal context to ascertain learning and motivation levels over the course of an authentic school term.

References

Aldrich, F., Rogers, Y., & Scaife, M. (1998). Getting to grips with "interactivity": Helping teachers assess the educational value of CD-ROMs. *British Journal of Educational Technology,* 29(4), 321-332.

Alessi, S., & Trollip, S. (2001). *Multimedia for Learning - Methods And Development (3rd ed.).* Massachusetts: A Pearson Education Company.

Almekhlafi, A. (2006). Effectiveness of interactive multimedia environments on language acquisition skills of 6th grade students in the United Arab Emirates. *International Journal of Instructional Media,* 33(4), 427-441.

Astleitner, H., & Wiesner, C. (2004). An Integrated Model of Multimedia Learning and Motivation. *Journal of Educational Multimedia and Hypermedia,* 13(1), 3-21.

Berg, S. A., Hoffmann, K., & Dawson, D. (2010). Not on the same page: Undergraduates' information retrieval in electronic and print books. *The Journal of Academic Librarianship,* 36(6), 518-525.

Bonnington, C. (January 20th 2012). *iPad a solid education tool study reports.* Retrieved: 18, November 2012 from http://www.wired.com/gadgetlab/2012/01/ipad-educational-aid-study/

Chesebro, J.L., & McCroskey J.C. (2000). The relationship between students' reports of learning and their actual recall of lecture material: a validity test. *Communication Education,* 49(3), 297-301.

Christodoulou, D., Garyfallidou, G., & Papatheodorou, T. (2008). Interactive education based on haptic technologies and educational testing of an innovative system. *International Journal of Educational Technology,* 3(2), 4-19.

Clark, R., & Mayer, R. (2011). *e-Learning and the Science of Instruction: Proven Guidelines for Consumers and Designers of Multimedia Learning.* California: Pfeiffer.

Comai, S., & Mazza, D. (2010). A Haptic-Based Framework for Chemistry Education: Experiencing Molecular Interactions with Touch. In M.D. Lytras, P. Ordonez De Pablos, D. Avison, J. Sipior, Q. Jin, W. Leal, L. Uden, M. Thomas, S. Cervai & D. Horner (Eds.), *Technology Enhanced Learning. Quality of Teaching and Educational Reform Communications in Computer and Information Science* (73), 338-344: Berlin: Springer.

Coyle, K. (2008). E-Reading. *The Journal of Academic Librarianship,* 34(2), 160-162.

Dalgarno, B., Kennedy, G., & Bennett, S. (2006). Using fMRI to explore interactivity and cognition: A methodological case study. Proceedings of the 23rd Annual Ascilite Conference: *Who's learning? Whose technology?* (pp.189-198), September 3-6, 2006, University of Sydney.

Deci, E.L., & Ryan, R. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum.

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424

Domagk, S., Schwartz, R., & Plass. J.L. (2010). Interactivity in multimedia learning: An integrated model. *Computers in Human Behavior,* 26(5), 1024-1033.

Engelkamp, J. (1998). *Memory for actions.* East Sussex, UK: Psychology Press.

Gall, J. E., & Lohr, L. (2004). Review of the book *Multimedia Learning*. By R.E. Mayer. *Educational Technology Research and Development,* 52(3), 87-90.

Gleason, B. (2012). The Unlimited Textbook- Schools in the Age of the e-book. *Proceedings of the International Conference on Technology and Business Management,* UOWD-Dubai, March 27, 2012.

Hagmann, S., Mayer, R. E., & Nenninger, P. (1998). *Using structural theory to make a word-processing manual more understandable. Learning and Instruction,* 8(1), 19-35.

Hancock, M.R. (2008). The status of reader response research: Sustaining the reader's voice in challenging times. In S. Lehr (Ed.), *Shattering the looking glass: Challenge, risk, and controversy in children's literature* (pp.97-116). Norwood, MA: Christopher-Gordon.

Huber, S. (2012). iPads in the Classroom- A Development of a Taxonomy for the Use of Tablets in Schools. *Internet-Technology and Society, 2*. Books on Demand GmbH: Norderstedt.

Hutchings, G., Hall, W., & Colbourn, C. (1993). Patterns of students' interaction with a hypermedia system. *Interacting With Computers,* 5(3), 295-313.

Harp, S., & Mayer R.E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology,* 90(3), 414-434

Keller, J.M. (2008). First principles of motivation to learn and e3 learning. *Distance Education,* 29(2), 175-185.

Jones, M.G., Minogue, J., Tretter, T.R., Negishi, A., & Taylor, R. (2006). Haptic Augmentation of Science Instruction: Does Touch Matter? *Editorial, Science Education*, 111-123. Retrieved: 18, November 2012 from http://search.ebscohost.com/login.aspx?direct=true&db=a9h&AN =19935616&site=ehost-live

Jordan, A., Carlile, O., & Stack, O. (2008). *Approaches to learning for teachers.* Berkshire: Open University Press.

Kalyuga, S. (2007). Enhancing instructional efficiency of interactive e-learning environments: A cognitive load perspective. *Educational Psychology Review*, 19, 387-399.

Kennedy (2004). Promoting cognition in interactivity research. *Journal of Interactive Learning Research,* 15(1), 43-61.

Kopp, T. (1982). Designing the boredom out of instruction. *Performance & Instruction,* 21(4), 23-32.

Kuhl, J. (1985). Volitional mediators of cognition-behavior consistency. Self-regulatory processes and action versus state orientation. In J. Kuhl & J. Beckmann (Eds.), *Action* *control. From cognition to behavior* (pp.101-128). Berlin: Springer.

Larson, L.C. (2009). Reader response meets new literacies: Empowering readers in online learning communities. *The Reading Teacher,* 62(8), 638-648.

Lopes, D., & Carvalho, C.V. (2010). Simulation and Haptic Devices in Engineering Education. *Electronics and Electrical Engineering,* 6(102), 159-162.

Mannion, M. & Cairrcross, S. (2010) Interactive Multimedia and Learning: Realizing the Benefits. *Innovations in Education and Teaching International,* 38(2), 156-164.

Malone, T.W., & Lepper, M.R. (1987). Making learning fun. A taxonomy of intrinsic motivations for learning. In R.E. Snow & M.J. Farr (Eds.), *Aptitude, learning, and instruction. Cognitive and affective process analyses* (pp.223-253). Hillsdale, NJ: Lawrence Erlbaum Associates.

Mangan, A. (2008). Hypertext fiction reading: haptics and immersion. *Journal of Research in Reading,* 31(4) 404-419.

Martens, R.L., Bastiaens, T., & Kirschner, P.A. (2007). New learning design in distance education: The impact on student perception and motivation. *Distance Education,* 28(1) 81-93.

Martens, R.L., Gulikers, J., & Bastiaens, T. (2004). The impact of intrinsic motivation on e-learning in authentic computer task. *Journal of Computer Assisted learning,* 20, 368-376.

Mayer, R.E (2009). *Multi-Media Learning (2nd ed.).* New York: Cambridge University Press.

Mayer, R.E., & Moreno, R. (2003). Nine Ways to Reduce Cognitive Load in Multimedia Learning. *Eucational Psychologist,* 38(1), 43-52.

Mayes, J.T. (1993). Commentary: impact of cognitive theory on the practice of courseware authoring. *Journal of Computer Assisted Learning, 9,* 222-228.

Moore, D., Williams, R.L., Luo, T., & Karadogan, E. (2013). Elusive Achievement Effects of Haptic Feedback. *Journal of Interactive Learning Research,* 24(3), 329-347.

Moreno, R., & Valdez, F. (2005). Cognitive load and learning effects of having students organize pictures and words in multimedia environments: The role of student interactivity and feedback. *Educational Technology Research and Development,* 53, 35-45.

Murray, M., Pérez, J., Geist, D., & Hendrick, A. (2012). Student Interaction with Online Course Content: Build It and They Might Come. *Journal of Information Technology Education: Research*, 11, 125-140.

Johnson, L., Adams, S., & Cummins, M. (2012). *The NMC Horizon Report: 2012 Higher Education Edition.* Austin, Texas: The New Media Consortium. Retrieved: 16, September 2012 from http://www.wired.com/gadgetlab/2012/01/ipad-educational-aid-study/

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424

Rasch, T., & Schnotz, W. (2009). Interactive and non-interactive pictures in multimedia learning environments: Effects on learning outcomes and learning efficiency. *Learning and Instruction,* 19*,* 411-422.

Reed, S. K. (2006). Cognitive architectures for multimedia learning. *Educational Psychologist,* 4(2) 87-98.

Reed, S. K. (2009) Manipulating Multimedia Materials. In R.Z. Zheng (Ed.), *Cognitive Effects of Multimedia Learning* (pp.51-66). New York: Information Science Reference.

Renkl, A., & Atkinson, R.K. (2007). Interactive learning environments: Contemporary issues and trends. An introduction to the Special Issue. *Educational Psychology Review,* 19, 235-238.

Rieber, L.P. (2005). Multimedia learning in games, simulations and microworlds. In R.E.Mayer (Ed.), *The Cambridge Handbook of Multimedia Learning* (pp.549-567). New York: Cambridge University Press.

Riding, R., & Douglas, G. (1993). The effect of cognitive style and mode of presentation on learning environment. *British Journal of Educational Psychology,* 63, 297-307.

Rowhani, S., & Sedig, K. (2005). E-books plus: Role of interactive visuals in exploration of mathematical information and e-learning. *Computers in Education,* 24(3), 273-298.

Sims, R. (1997). Interactivity: A Forgotten Art? *Computers in Human Behavior,* 13(2) 157-180.

Singapogu, R.B., & Burg, T.C. (2009). Haptic virtual manipulatives for enhancing K-12 special education. Paper presented at the Proceedings of the 47th Annual Southeast Regional Conference, Clemson, South Carolina, March 19-21.

Samaras, H., Giovanakis, T., Bousiou., D., & Tarabanis, K. (2006). Towards a new generation of multimedia learning research. *AACE Journal,* 14(1), 3-30.

Slinger-Friedman, V., & Patterson, L. (2012). Writing in Geography: Student attitudes and assessment. *Journal of Geography in Higher Education,* 36(2), 179-195.

Slinger-Friedman, V., & Patterson, L. (2013). Student Learning and Student Perceptions of Learning from Interactive Modules. *eLmL 2013:* The Fifth International Conference on Mobile, Hybrid, and On-line Learning. Nice, France, February 24 - March 1.

Smeets, D., & Bus, A. (2012). Interactive electronic storybooks for kindergartners to promote vocabulary growth. *Journal of Experimental Child Psychology,* 112, 36-55.

Smith, S.M., & Woody, P.C. (2000). Interactive effect of multimedia instruction and learning styles. *Teaching of Psychology,* 27(3), 220-223.

Sorensen, E., & Ó Murchú, D. (2006). *Enhancing Learning through Technology.* Hershey, PA: Information Science Publishing.

Sweller, J. (2010). Element Interactivity and Intrinsic, Extraneous, and Germane Cognitive Load. *Educational Psychological Review,* 22*,* 123-138.

Thomas, N. (April, 2010) *The Stanford Encyclopedia of Philosophy (Fall Edition).* Retrieved: 5, September 2012 from http://plato.stanford.edu/archives/fall2010/entries/mental-imagery

Twyla, M., Williams-Rossi, D., Johnson, K.,& McKenzie, N. (2011). Reluctant Readers in Middle School: Successful Engagement with Text Using the EReader. *International Journal of Applied Science and Technology,* 6(1), 81-91.

Tzanavari, A., & Tsapatsoulis, N. (2010). *Affective, Interactive and Cognitive Methods for E-learning Design.* Hershey. PA: Information Science Reference.

Vetere, F., & Howard, S. (1999). Redundancy Effects in Instructional Multimedia Systems. In M. Sasse, & C. Johnson (Eds.), INTERACT 99: Proceedings of *Seventh IFIP Conference on Human Computer Interaction* (pp.589-596), August 30-Sept 03, Edinburgh, Scotland.

Woody, W.D., Daniel, D.B., & Baker, C.A. (2010). E-books or textbooks: Students prefer textbooks. *Computers & Education,* 55(3), 945-948.

Yin, R. (2009). *Case study research: design and methods.* Thousand Oaks, CA: Sage Publications.

Zheng, R., McAlack, M., Wilmes, B., Kohler-Evans, P., & Williamson, J. (2009). Effects of multimedia on cognitive load, self-efficacy, and multiple rule-based problem solving. *British Journal of Educational Technology,* 40(5), 790-803.

https://arrow.tudublin.ie/ijap/vol3/iss1/5
DOI: 10.21427/D79424