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Animation-Aided Learning and Educational Technology Self-Efficacy in a College Population

An Honors Thesis (PSYSC 499)
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April, 2008

Expected Graduation Date: May 3, 2008

Abstract

As computer resources become more readily available to educational institutions, the ways in which students gather information using computers should be examined. This study compares educational content presented through a learner-controlled animation, continuous animation and static graphics and gauges any learning differences while measuring any moderating effects of educational technological self-efficacy. Participants in the continuous animation condition performed better on the post-test than participants in the learner-controlled condition, who performed better on the post-test than participants in the static graphics condition. Condition predicted performance on the post-test recall questions but did not reach significance on the comprehension or analysis questions. Except for the educational functioning sub-scale, the self-efficacy measure did not find efficacy levels as a predictor of test performance.

Animation-Aided Learning and Educational Technology Self-Efficacy in a College Population

Undoubtedly, environmental cues such as the presence of computers in public libraries, schools and universities have primed current college-aged students to integrate and embrace technology unlike other generations. The current 18-22 year-old demographic of college students were in elementary school when major technology initiatives started boosting the presence of technology in libraries and classrooms. Initiatives such as Bill Gates' $404 million contribution to improve the computer resources for the Libraries Online! program, AT&T's $150 million donation to public libraries and President Bill Clinton's Challenge Grants for Technology and Education all occurred between 1996 to 1997 (St. Lifer & Rogers, 1996; Kniffel, 1997; Vandenberg, 1995).

Now 12 years later, it is important to consider the finer mechanics of learning through the internet and computers due to the high amount of technology use in school systems and colleges. By experimentally determining the best design interaction for learners (i.e. animation or static graphics), only then will educational technologies fully serve the users.

Why use multimedia?

Sun & Cheng (2007) state that more abstract and difficult material is better for subject performance when presented with rich media such as animations, visuals, and audio compared to test-only instruction. Their data suggests that this finding is a good rationale to not only justify multimedia use in learning, but to encourage it. The literature is divided on the effectiveness of learning using multimedia and animation (Anglin, Vaez & Cunningham, 2003; Betrancourt & Tversky, 2000). However, there is some support saying learner-controlled animations are better for learning as compared to continuous animations which are played like a movie clip (Hasler, Kersten & Sweller, 2007; Moreno &Valdez, 2005; Mayer. 2005).

Several theories from various fields apply to multimedia learning. Many studies in educational technology and media employ Cognitive Load Theory to validate and underscore their research. An example of Cognitive Load Theory (CLT) is the provision of simple learning materials in multimedia learning which are not visually or aurally distracting from the task (Clark & Choi, 2005). CLT considers a variety of factors that influence human performance, such as working memory, problem solving and short term memory (Sweller, 1988). Media richness theory is often used in educational technology literature and illustrates that more abstract and difficult material is better for participant performance when presented with "rich media" such as animations, visuals and audio versus "lean media" such as text (Sun & Cheng, 2007). While both the CLT and Media Richness Theory certainly apply to multimedia learning, neither theory is as expansive in their explanation of multimedia learning as Mayer’s (2005) Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning uses a selection of basic cognition principles such as dual coding (Paivio, 1986), limited capacity as found in Cognitive Load Theory (Sweller, 1999) and active processing (Wittrock, 1989) to explain and predict the findings of learning through multimedia. The Cognitive Theory of Multimedia attempts to describe how people learn using words, pictures and animations in order to better facilitate the learning process, all the while considering cognitive science principles (Mayer 2005).

Three sections of Mayer's (2005) Cognitive Theory of Multimedia Learning closely resemble established cognitive science principles. The Limited Capacity Assumption holds that a set amount of information can be processed at one time. This is similar to Sweller's (1988) Cognitive Load Theory in its application to the design of multimedia learning tools. Mayer's

Dual-Channel assumption describes the relationship between auditory and visual encoding processes and optimum learning. The ideas presented are similar to Paivio's (1986) landmark study illustrating the dual-coding theory. The third assumption Mayer presents is the active processing of information by learners, meaning that those who learn the material must actively select, process, organize and integrate the information in order for it to become meaningful to them. The assumption is based in Wittrock's (1989) active processing theory of cognition.

Multimedia learning primarily uses working memory in the deciphering and organization of learning material. However, the processing of multimedia first occurs in the sensory perception of the multimedia material, usually consisting of words (spoken or in textual form) and pictures (either animated or static). This information is held in sensory memory in which the ears and eyes then select the appropriate material to remember. Once the appropriate material is selected, the information is held in working memory. The sound and visual material is organized into verbal and pictorial models of the information and then integrated together with prior knowledge from long term memory (Mayer, 2005).

What it means

Hasler, Kersten and Sweller (2007) produced a study similar in design to the present one in which young male participants were asked to interact with educational computer modules. The participants were measured on knowledge transfer and their use of the module was recorded. Two conditions (modules) were learner-controlled in which one of these had a play/pause button and the other condition had 11 segments in which the content was broken into segments which would stop after approximately 20 seconds. The learner had no control over the other two conditions other than to start them. One of the no-control conditions contained the animation and audio commentary found in the control conditions and the other no-control condition contained only the audio commentary. The learner-controlled conditions produced higher information transfer rate in a multiple-choice test performance even though the interactivity of one learner-controlled condition was rarely utilized (the stop/pause button). The authors cited germane cognitive load as the cause for this finding. It is suggested that the participants monitored their knowledge understanding more closely because they were given the ability to pause the module if needed, thus assisting in schema development. The study focused primarily on the difference in test performance on high interactivity questions (where the participant must monitor 3 or more pieces of information) and low interactivity questions (participant must monitor 1-3 pieces of information). Participants performed significantly better on the high interactivity questions in the learner-controlled condition.

A possible issue with this finding is Hasler, Kersten and Sweller's (2007) method of having their participants interact with the module for exactly 10 minutes. This cannot be generalized to the way a student would actually interact with a module when studying for a test and could have possible mediating effects on the resulting outcome. Because participants performed no better in the narration only condition than in the continuous animation condition, Haster et. al. conclude that "animation without learner control is as effective as no animation," (p. 724).

Educational Technology Self-Efficacy

Self-efficacy is the level of confidence one has to attain a goal (Bandura, 1977). Educational technological self-efficacy in a learning environment is a variable that is relatively unexplored in college populations (Diemann & Keller, 2006; Ketelhut, 2007).

Those who use the computer more often do not experience as much computer anxiety and had a higher satisfaction rate with their computer interaction than those who use a computer less.

A significant positive correlation has also been found between reported self-efficacy and use of the internet, prior experience with the internet and expected outcomes of internet use (Compeau & Higgins, 1995; Eastin & LaRose 2000). Further research is suggested to determine self-efficacy levels of “particular types of outcomes through the use of the Internet” which can be directly applied to the specific use of educational media on the Internet and computer (Eastin & LaRose). Not accounting for a factor such as internet self-efficacy could lead to contrasting results in studies. Bucy and Tao (2007) state "third variables" can make a difference in the outcome of a study and merit measurement when conducting multimedia research. They also suggest the relatedness of self-efficacy to perceived interactivity which influences the overall media effects. Technological self-efficacy has been explored (Miltiadou & Yu, 2007) however these scales were measuring basic computer functions such as emailing and could not be generalized to computer-aided learning.

As no two computer learning modules are the same, it is necessary to measure what the subject thinks his or her ability is to work with a computer and a program that is initially unfamiliar. Self-efficacy scales should be derived from the individual context of what one is measuring, (Bandura, 1977; Bandura, 2006; Ketelhut, 2007), so no preexisting scale is appropriate for this study. Also, no other self-efficacy measure encompassed the use of the Internet, unfamiliar computers, and ability to use educational media. All of the aforementioned concepts are essential in the subject’s self-efficacy level of educational technology use.

Gender differences in computer self-efficacy have previously been examined (Hsu & Huang, 2006; Kay, 2006; Murphy, Coover & Owen, 1989) with the results favoring males. Minor differences between the ability and comfort levels of males and females have been found in past years and more exposure to computer experience by females was shown to narrow this difference (Hsu & Huang, 2006; Kay, 2006). However, the issue needs constant revisiting due to the ever permeating nature of technology.

The US Census Bureau (2003) reported that the percentage of females between the ages of 3 and 17 had surpassed the percentage of males in their use of a computer at home, work or school. The males surpassed the females in the percentage of computer use in the older age bracket (18 and over). As the 3 through 17 demographic respondents are now 8 through 22 and are the main consumers of educational technology, it is necessary to examine if the equal population use of technology has led to an equal self-efficacy level in technological resource use.

Experiment Design

Mayer (2005) indicates in the Cognitive Theory of Multimedia Learning that an essential part of learning is the ability to select, organize and integrate relevant material. Because learners select and organize the information presented in small chunks as the information is being presented to them, segmented animation would be more conducive to the learner's information processing and overall knowledge retention level. For learners who had a high amount of prior knowledge about the subject material, less guidance (such as segments), more learner control and learning by trial and error equaled more knowledge and transfer (McNamara & Shapiro, 2005; Sun & Cheng, 2007).

Clark and Choi (2005) state that studies must have equal media elements across all conditions or the results are skewed. Thus, the design of the instructional materials should not favor one condition over another and as many elements should be constant across all conditions as is possible. This is addressed in the current experiment by using all of the same graphic elements, but also by providing numbers which direct the subject's attention through the static graphic condition in lieu of animation. Many studies suggest the varied findings in the instructional media literature are due to unreported methodological variations in the materials used because the degree of interactivity will influence subjects (Bucy & Tao, 2007; Rieber, 1990; Zhu & Grabowski, 2006). In order to control for these variations, research isolating specific variables is needed to determine the true effects of multimedia learning.

Considerations such as conversational tone, auditory samples and pertinent information were taken into consideration when constructing the materials for this study (Clark & Choi, 2005; Mayer 2006). The audio and visual elements are also presented near each other in time and in space when applicable which is consistent with Mayer's Contiguity Principle. Minimal text is present for the static graphic condition and no text is present for the remaining two other conditions, thus implementing the Mayer's redundancy principle. Condition 3 consists of static graphics to determine any differences in the learning outcome between using animated versus non-animated modules (Clark & Choi, 2005). Mayer's interactivity principle is integrated into the research design due to the segmented, interactive nature of the learner-controlled condition and the principle is to be examined to determine whether subjects learn better as compared to continuous animation. Many have stated the importance of design and its contribution to overall media effects (Bucy & Tao, 2007; Clark & Choi). Therefore, it is necessary to be as thorough in the explanation of the construction and appearance of the materials used in the study as it is the theory behind it.

This study will provide insight into past studies on animation and will investigate whether learner control and educational technological self-efficacy explain the varied findings. This will also help researchers in the future hold self-efficacy constant if it is found to be correlated with test performance. This experiment specifically compares learner-controlled animation, continuous animation and static graphics and considers the potential moderating effects of educational technological self-efficacy, sex, and prior exposure to the content in the modules. The purpose of the study is to determine the relationship of animated learning modules and technological self-efficacy to college students' learning. The study examines two issues. We hypothesize participants will perform better on the post-test after having interacted with the learner-controlled condition versus the continuous and static graphic conditions. We also hypothesize a positive correlation between technological self-efficacy and post-test performance level.

Method

Participants

This study included 60 participants who received research participation credit in an introductory psychology course at a Midwestern university. The subjects consisted of 37 women and 24 men with 57 of those participants being Caucasian, along with 3 Asian participants and 1 participant reporting as "Other." Thirty-seven of these subjects were freshman, 15 were sophomores, 7 were juniors and 2 were seniors. The age range of the participants ranged from 18 to 45 (M = 19.54, SD = 3.49). The mean age for women was 19.73 (SD = 4.38) and the mean age for men was 19.25 (SD = 1.23). The participants were also to report their current grade point average (GPA) on a 4.0 scale. Two participants reported their GPA as ranging from 0.0 - 1.0, 8 reported have a GPA ranging from 2.1- 2.5, 24 held a 2.6- 3.0 GPA, 17 reported having a 3.1-3.5 GPA and 10 reported holding a 3.6-4.0 GPA.

Twenty-six of these participants had covered the material included in this experiment before in other settings at the university, 27 participants reported they had not covered the material, and 8 participants did not know if they had covered the material. Because the material included in the experiment is also taught in the other Psychology classes, the participants reported if they had previously taken any other psychology classes. Thirty participants reported they had taken a psychology course in high school, 2 participants reported they had taken a psychology course at this university, 29 participants reported they had never taken a psychology course before and 0 participants reported having taken a psychology course at another university. The participants received 1 hour of credit in their General Psychology class for participating in this experiment.

Materials

All animations and audio recordings were produced by the principal investigator using Macromedia Flash MX 2004. Condition 1 contained 7 segments of animation with an average time of 12 seconds per segment and had dimensions of 550 pixels wide and 350 pixels tall. Condition 2 contained a continuous animation without segments and had the same dimensions as Condition 1 (550 pixels by 350 pixels). Condition 3 containing the static graphics had larger dimensions to accommodate the information presented. It was 450 pixels wide and 675 pixels tall. All of the conditions filled only part of the screen. The background on the rest of the screen was a solid color and contained no patterns, pictures or shapes. The text labeling the graphics was size 12 in Rockwell font.

The instructions at the beginning and the end of the lesson were size 13 in Rockwell font. When the subject opened one of the conditions, the placement of the animation was slightly different than it had been the time before, due to the idiosyncratic nature of the program. However, the subject was able to drag and place the condition stimulus where ever was most comfortable for them. The condition stimuli were always entirely visible. The participant was also able to use either an external, wired mouse or the finger pad available on the laptop.

The beginning of the lesson about the action potential process started at the release of sodium into the soma and the voltage changing. The participants then saw the sodium ions sent through the axon and the potassium released out of the cell body. The last step in the animation was the sodium ions travel down the axon, slowing down when they reached the myelin sheaths and speeding up during the saltatory conductions.

All three modules were made from the same graphic and animation materials and all graphics were in color. The animations were always presented on the same computer so there was no variation in color. Two of the conditions (continuous and segmented) were the same animation. The segmented condition was divided into 7 separate sections in which the animation stopped after a segment and the user could either use the “go on” button to continue through the animation or could use the “restart” button to play the segment again (Fig. 1.1). The continuous animation was the same animation as in the segmented condition, but once the participant hit “play,” the animation did not stop until its end (Fig. 1.2). Condition 3, the static graphic condition, did not contain any moving or interactive elements other than the “Start” button. It contained all of the same graphic elements from Conditions 1 and 2 but instead of slides or animations, the graphic elements were labeled with their appropriate names and numbers indicating the order of the action potential process (Fig. 1.3). As with the previous two conditions, the participants were able to replay condition 3 as many times as needed. The audio narration on all three conditions was the same and consisted of a verbal explanation of the action potential process occurring in the condition at that given moment.

Instructions explaining how to use the module preceded all of the experimental conditions. The beginning instructions for conditions 2 and 3 were the same but the instructions for condition 1 were slightly more detailed because of the presence of 2 additional buttons for the participants to use. Other than the explanation of the additional buttons for condition 1, all three introductory instructions were the same.

The participants were administered an 11 question pre-test before the experimental condition and an 11 question post-test after the condition (Appendix A and B, respectively). Both the pre-test and the post-test consisted of 5 recall questions (questions 1-5), 3 comprehension questions (questions 6-8) and 3 analysis questions (questions 9-11). The Cronbach alphas were calculated for the pre-test ($\alpha = .54$) and the post-test ($\alpha = -.20$).

The educational technology self-efficacy questionnaire consisted of 5 sub-scales. The educational functioning sub-scale contained 7 items; the internet navigation sub-scale contained 5 items; the educational module sub-scale contained 5 items; the basic computer functions sub-scale contained 5 items; and the unfamiliar computer interaction sub-scale contained 4 items (Appendix C). The educational functioning sub-scale asked participants to gauge their ability to prepare themselves for tests and assignments. The internet navigation sub-scale asked participants to gauge their ability in navigating and troubleshooting the internet. The educational module sub-scale asked participants to evaluate how they would study different concepts with an online educational module. Topics covered on the basic computer functions sub-scale were word processing and emailing. The final scale was the unfamiliar computer interaction sub-scale which contained questions to determine if participants thought they could easily use an unfamiliar computer, as might be the situation in a classroom or library.

The means, standard deviations and Cronbach alphas for the 5 sub-scales are presented in Table 1. The participants were to rate how confident they were they could accomplish the tasks listed on a scale of 0 – 100, with 0 representing it they thought they could not do the task at all, 50 if they were moderately sure they could do the task and 100 if they were highly certain they could do the task.

The participants also reported their demographic information which included their gender, ethnicity, age, class standing, GPA and major. The participants also reported if they had learned about the action potential process (the content of the manipulated conditions) in another class at the University, in high school, or in their Introductory Psychology course.

Procedure

Experimental sessions were conducted individually so the researcher could more closely observe the participant's actions. The participant was randomly assigned to one of three conditions of the animation. The researcher read preliminary instructions telling participants that there was no time limit for the activities. Further instructions were displayed on the first screen the participant viewed. Participants took an online pretest measuring their prior knowledge of action potentials before the experimental manipulation began.

At the conclusion of the pre-test, participants were told to open the appropriate file on the computer and then automatically received instructions via the instructional module. At the conclusion of all three conditions, the modules reminded the participants that they could view the condition as many times as necessary until they felt they adequately understood the material. They were also reminded that they would be tested on this information and it was important to understand the material.

There was no time limit on how long the participant was able to view the lesson. Once the participant completed the lesson, they received instructions from the researcher to begin an online posttest and to complete the two surveys. The post-test, which was very similar in content measurement to the pre-test, was given immediately after the experimental manipulation. An educational technology self-efficacy questionnaire and a personal information questionnaire were given to the participant. The subjects stated both their self-efficacy levels and demographic information by method of self-report.

Results

Effects of Condition

It was predicted that the participants in the segmented animation condition (condition 1) would perform better on the post-test than participants in the continuous animation condition (condition 2). It was also predicted that participants in the continuous animation condition would perform better than participants in the static graphic condition (condition 3).

An ANCOVA was conducted, revealing a significant effect of condition on test performance on post-test recall questions, [$F(2, 60) = 7.76$, $p < .00$], but did not reach significance on post-test analysis or comprehension questions. For the entire post-test score (recall, analysis and comprehension), comparing condition 1 ($M = 6.15$, $SD = 1.03$) to condition 2 ($M = 7.0$, $SD = 1.23$) resulted in [$t(38) = -2.49$, $p < .01$]. Comparing condition 2 to condition 3 ($M = 5.5$, $SD = 1.46$) resulted in [$t(39) = 3.4$, $p < .001$]. The difference in performance did not reach significance when conditions 1 and 3 were compared. The participants in the three conditions did not vary significantly from one another on pre-test performance (condition 1 $M = 3.9$, $SD = 2.22$; condition 2 $M = 4.3$, $SD = 2.05$; condition 3 $M = 3.0$, $SD = 2.14$).

In condition 1 there was a significant difference between participant's scores on pre and post-test recall questions [$t(19) = -3.96$, $p < .01$], and pre and post-test analysis questions [$t(19) = -2.10$, $p < .05$], but not pre and post-test comprehension questions. Condition 2 resulted in significantly higher scores on the post-test for all three questions types; pre and post recall [$t(19) = -4.04$, $p <.00$], pre and post comprehension [$t(19) = -2.79$, $p <.01$], and pre and post analysis [$t(19) = -2.79$, $p <.01$]. Condition 3 also showed significant increases in post-test scores when comparing pre and post recall [$t(20) = -4.64$, $p <.00$], and pre and post analysis

[$t(20) = -3.30$, $p < .00$], but not when comparing pre and post comprehension questions.

A post-hoc test indicated a significant difference between the segmented (condition 1) and static graphic (condition 3) on post-test recall questions [$t(39) = 2.39$, $p < .05$].

Effects of Self-Efficacy, Prior Knowledge and Sex

The self-efficacy subscales were entered as covariates into the original ANCOVA to determine their effect on test performance. The educational functioning self-efficacy sub-scale was found to have a significant effect on test performance [$F(6, 42) = 2.86$, $p < .01$]. Specifically, a Pearson product revealed a positive correlation between educational functioning sub-score and post-test performance score [$r = .399$, p < .01]. The education functioning sub-scale was a predictor of performance on both pre-test comprehension questions [$F(1, 60) = 8.72$, $p < .00$] and post-test comprehension questions [$F(1, 60) = 4.07$, $p < .04$].

Condition affected how many times participants played the module [$F(2, 61) = 6.00$, $p < .00$]. Condition 3 [M =2.24, SD = 1.04] was played more than Condition 2 [M = 1.55, SD .510] which was played more than Condition 1 [M =1.35, SD = .587].

Prior knowledge about action potential was also entered as a covariate into the analyses, and it had a significant effect on test performance for pre-test analysis [$F(1, 60) = 5.68$, $p < .02$], post-test recall [$F(1,60) = 4.37$, $p < .04$], post-test comprehension [$F(1, 60) = 4.36$, $p < .04$] and post-test analysis [$F(1, 60)= 5.63$, $p < .02$] with the participants who had prior knowledge scoring higher than those who did not have prior knowledge. Specifically, it was found to be a predictor of performance on pre-test analysis questions [$F(1, 60) = 5.68$, $p < .05$], post-test recall [$F(1, 60) = 4.37$, $p < .05$], post-test comprehension questions [$F(1, 60) = 4.36$, $p < .05$] and post-test analysis questions [$F(1, 60) = 5.63$, $p < .05$]. Participants without prior knowledge of action potentials scored the following: pre-test analysis [M =.963, SD =.807] post-test recall

[*M* =2.96, *SD* =.807] post-test comprehension [*M*=1.40, *SD* =.693] post test analysis [*M* =1.72, *SD* =.912]. Participants with prior knowledge of action potentials scored the following: pre-test analysis [*M* =1.61, *SD* =1.06] post-test recall [*M* =3.23, *SD* =.815] post-test comprehension [*M* =1.15, *SD* =.924] post test analysis [*M* =2.23, *SD* =.710].

Sex did not have an effect on either pre-test scores [$F(1, 60) = .325$, $p < .57$] nor post-test performance scores [$F(1, 60) = .031$, $p < .86$]. Similarly, sex had no effect on the educational functioning sub-scale [$F(1, 60) = .619$, $p < .43$], the internet functioning sub-scale [$F(1, 60) = 1.36$, $p < .24$], the instructional module sub-scale [$F(1, 60) = .077$ $p < .78$], the computer functioning sub-scale [$F(1, 60) = 2.30$, $p < .13$], or the unfamiliar computer sub-scale [$F(1, 60) = .773$, $p < .38$]. Finally, sex did not significantly affect the overall self-efficacy score [$F(1, 60) = .544$, $p < .46$].

Discussion

Through this study, three forms of animated modules and their effects on test performance in recall, analysis and comprehension questions were examined. The study also considered possible effects from sex, self-efficacy and prior knowledge of the test material.

Interpreting results

It was originally predicted that participants in condition 1, the segmented animation, would answer more questions correctly on the post-test performance than either of the two other conditions, which is consistent with Mayer’s (2005) Cognitive Theory of Multimedia Learning (CTML). It was also predicted that sex would have no effect on the self-efficacy scores which would be measured.

Interestingly, participants in condition 2 (the continuous animation) answered more questions correctly than participants in condition 1 (segmented animation) on the post-test.

Although these are contradictory to my original prediction and CTML, there is some support for these findings in the literature. The amount of work subjects were expected to do could have influenced their attention rate and appraisal of what they would be able to do, affecting their performance. A similar explanation for this result is the use of germane cognitive load by participants in the continuous animation condition (Hasler, Kersten & Sweller, 2007). Participants may have more consciously monitored their intake of information because they did not have control of the module. In contrast, participants in the segmented animation condition knew they could pause or replay segments of the animation, giving them less germane cognitive load. This could have resulted in the unexpected test performance rates.

Overall, participants who viewed the static graphic module, condition 3, did not perform as well as the segmented animation condition, as was predicted. This supports the pro-animation side of the debate on the merits of using animation to aid learning versus static graphics. However, though the difference in learning between the static graphic condition and the animation conditions were statistically significant, the 2 point difference in performance may not be realistically significant when considering the knowledge, time and money needed to make the animations.

The significant effects of condition should be considered in light of the significant effects of prior knowledge on participants' performance. Prior knowledge of the content covered in the modules was an additional significant influence on the participant's performance on one pre-test measure and all three post-test measures.

The apparent lack of correlation with the majority of the self-efficacy sub-scale scores and test performance is promising. This could mean that if a student's computer or internet self-efficacy is low, this would not inhibit him or her from gaining value from an educational module experience.

Previous research found sex differences in self-efficacy levels when using computers for educational purposes (Hsu & Huang, 2006; Kay, 2006). Therefore, the current lack of sex differences in self-efficacy found in this study is encouraging because it may indicate that with a younger generation and more exposure to technology as found at the Midwestern university, men and women's computer, internet and educational self-efficacy appraisal levels can finally be equal.

The participant sample consisted primarily of younger adults who have presumably had more consistent exposure to technology than previous generations and who attend a university which encourages technology usage. Therefore, I interpret the result as indicating that with a higher and consistent exposure to technology, females' educational technology self-efficacy levels can be equal to the levels of self-efficacy of males.

Broader implications

Educators should be aware of the focus of educational modules on certain higher level thinking question types, such as the emphasis on comprehension questions found in this study. Also, because of the lack of apparent effect of self-efficacy levels on test performance, modules such as the ones employed in this study would be accessible to all students, regardless of technological expertise.

Universities have relied heavily on technology to facilitate a student's learning experience. This is perhaps in part to accommodate a younger generation's demands of better, faster and more efficient technology. As younger generations continue to fill colleges and universities, they may come to expect resources available to them online which will aid their understanding of complex topics not easily explained in textbooks or large lecture halls. As technology and education continue their integration for student's benefit, it is important that professors, students and media designers are aware of inherent characteristics and effects.

Limitations and future directions

Two limitations of the study are the narrow range of ages and racial categories present in the participant demographic information. Demographics are important when considering technology usage, so the findings of this study are limited to the demographic information reported in the results section. Another limitation present in the results of the study is the technological environment of the campus on which the study was conducted. All students have 24 hour access to hundreds of computers and technology is integrated into the curriculum. Therefore, if the study was repeated at a university which did not already emphasize daily use of technology the findings could be different. The final limitation of this study would be the skewed self-efficacy scores reported by participants (Fig. 2.1 – 2.6). The statistical methods conducted in this study assumed a normal distribution, so if the study was repeated and did not have such skewed self-efficacy ratings, the statistical outcomes might vary from this study.

A suggestion for future research would be the use of the same conditions but add a segmented static graphic condition to compare the graphic and animated conditions. Perhaps if the audio is segmented and more time is allowed for information processing, the tests would yield higher transfer rate. Another possibility for future research is the highlighting of images that are relevant to the words spoken. This could possibly make it easier for the learner to select the correct relevant images (Mayer, 2005) and result in better understanding of the material. Also, given the influence of pre-existing knowledge in this study, it would be beneficial to ensure the participants had not been exposed to the material covered in the module.

Mayer (2005) suggests pre-training for optimal outcome when using multimedia as a learning device. Minimal pre-training was conducted and this could be something to be improved upon for future studies.

Other suggestions include measuring the decay of information over time to see which question type has the best long term effect and incorporating preferred learning “types” to indicate if students consider themselves visual learners. This could be a possible confounding variable to this study and others like it if the students recruited would not prefer to use the modules in order to prepare themselves for a test.

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Table 1

Descriptive Statistics and Internal Reliability of the Educational Technology Sub-Scales

Sub-Scale	M	SD	Cronbach Alpha
Educational Functions	8.32	1.11	.81
Internet Functions	9.65	1.41	.67
Computer Skills	9.13	1.86	.83
Unfamiliar Computers Skills	9.51	1.45	.83
Instructional Module Functions	8.88	1.44	.82

Table 2

Test performance scores

Condition	N	Pre-R.	Pre-C.	Pre-A.	Post-R.	Post–C.	Post–A.	Pre-All	Post-All
1	20	1.85	.850	1.20	3.10	1.25	1.80	3.90	6.15
2	20	1.95	.90	1.45	3.40	1.55	2.10	4.30	7.05
3	20	1.19	.85	1.00	2.52	1.23	1.80	3.04	5.57

Figure Captions

Fig. 1.1 A screenshot of condition 1, the segmented learning animation.

Fig. 1.2 A screenshot of condition 2, the continuous learning animation.

Fig. 1.3 A screenshot of condition 3, the static graphics.

Fig. 2.1 The frequency distribution of the participants unfamiliar computer self-efficacy sub-scale rating.

Fig. 2.2 The frequency distribution of the participants computer function self-efficacy sub-scale rating.

Fig. 2.3 The frequency distribution of the participants educational functioning self-efficacy sub-scale rating.

Fig. 2.4 The frequency distribution of the participants instructional module self-efficacy sub-scale rating.

Fig. 2.5 The frequency distribution of the participants internet functioning self-efficacy sub-scale rating.

Fig. 2.6 The frequency distribution of the participants overall self-efficacy rating.

Fig. 1.1

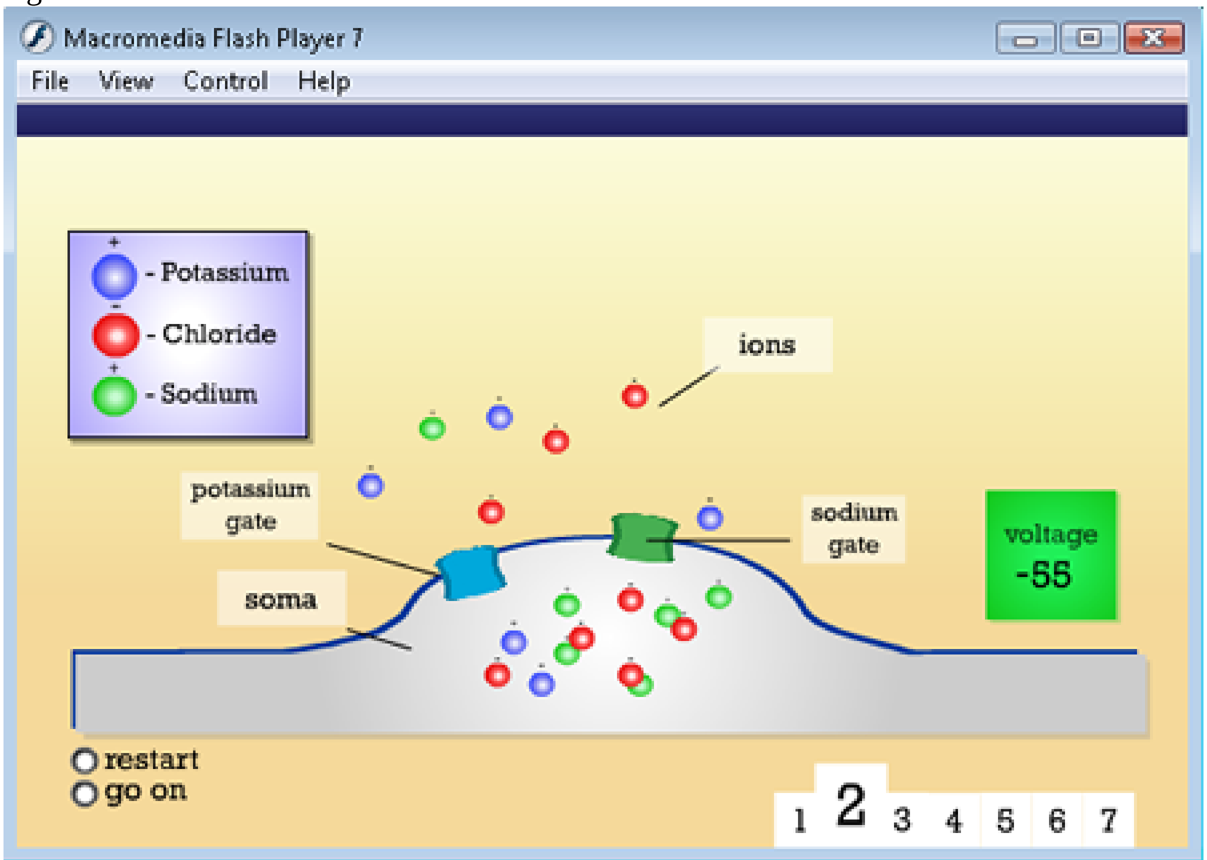

Macromedia Flash Player 7
File View Control Help
- Potassium
- Chloride
- Sodium
ions
potassium gate
sodium gate
soma
voltage
-55
restart
go on
1 2 3 4 5 6 7

Fig. 1.2

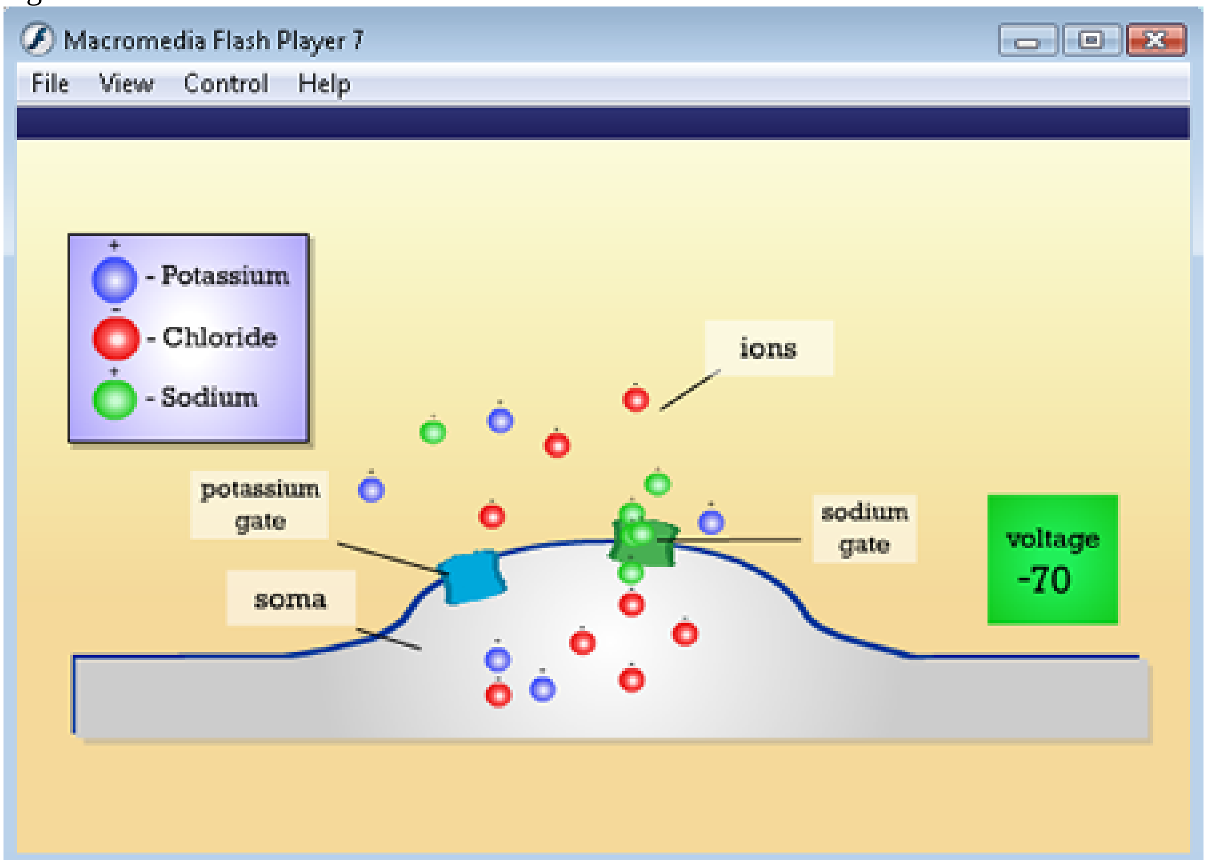

Macromedia Flash Player 7
File View Control Help
- Potassium
- Chloride
- Sodium
ions
potassium gate
soma
sodium gate
voltage
-70

Fig. 1.3

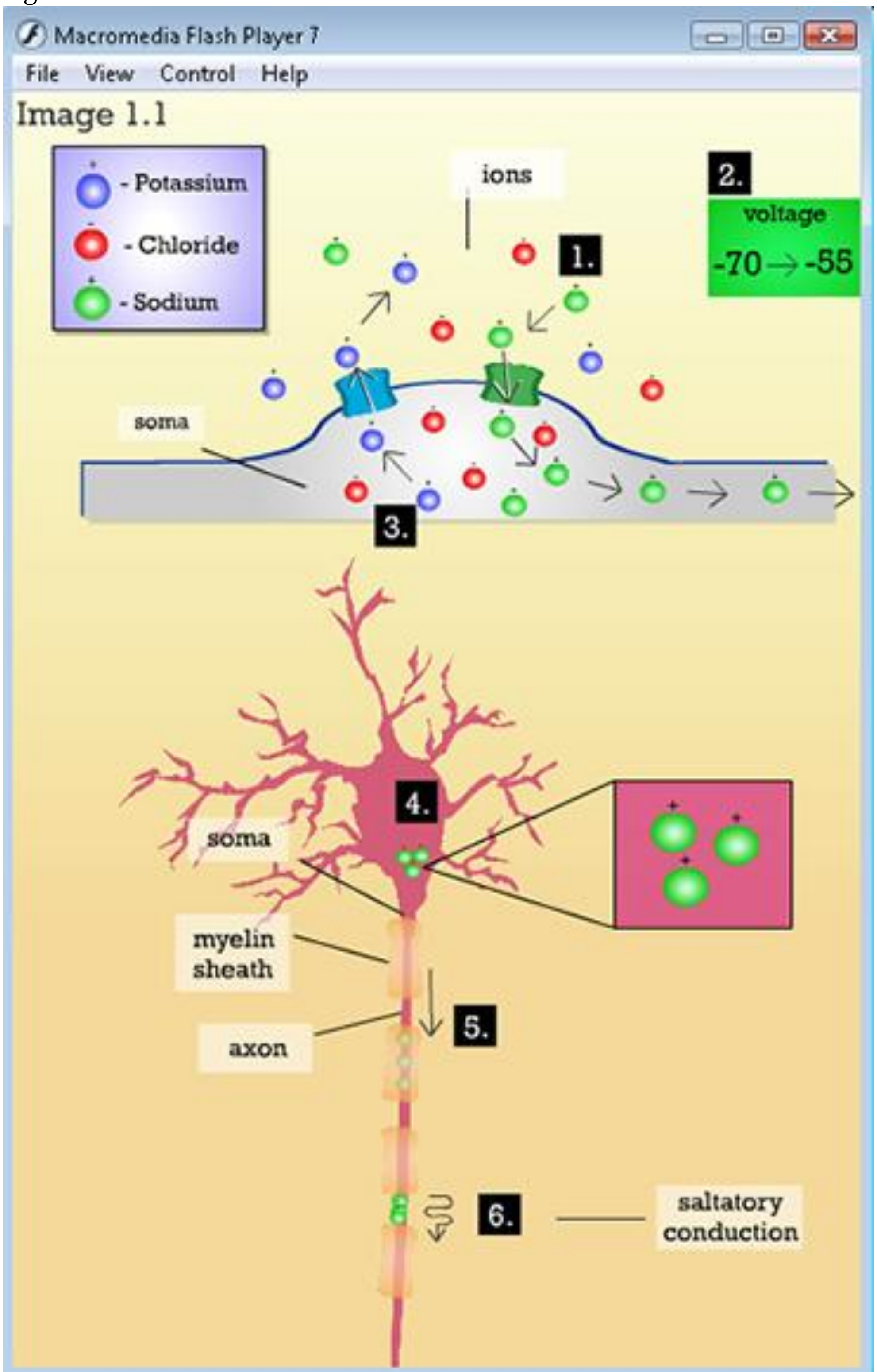

Macromedia Flash Player 7
File View Control Help
Image 1.1
- Potassium
- Chloride
- Sodium
ions
1.
2.
voltage
-70 → -55
soma
3.
4.
soma
myelin sheath
axon
5.
6.
saltatory conduction

Fig. 2.1

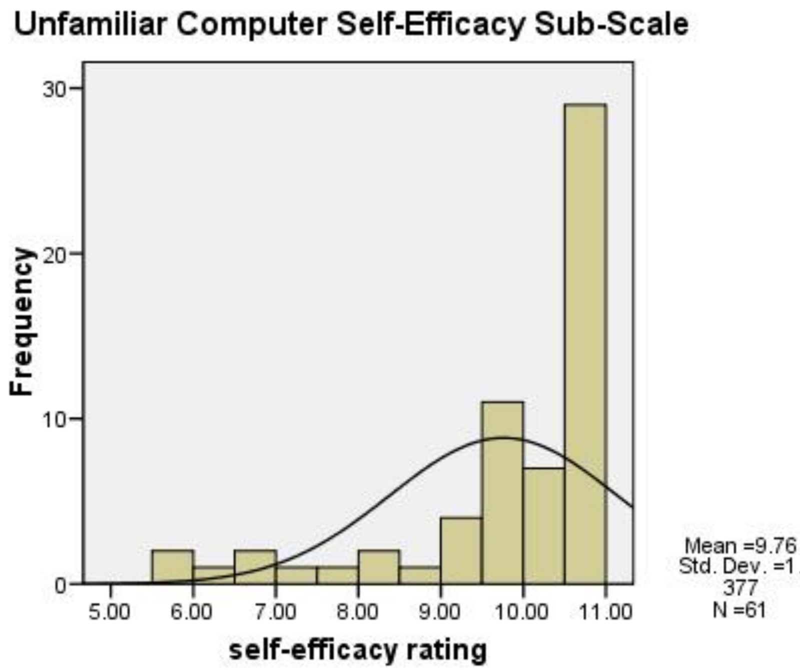

Unfamiliar Computer Self-Efficacy Sub-Scale
Frequency
30
20
10
0
5.00
6.00
7.00
8.00
9.00
10.00
11.00
self-efficacy rating
Mean =9.76
Std. Dev. =1.377
N =61

Fig. 2.2

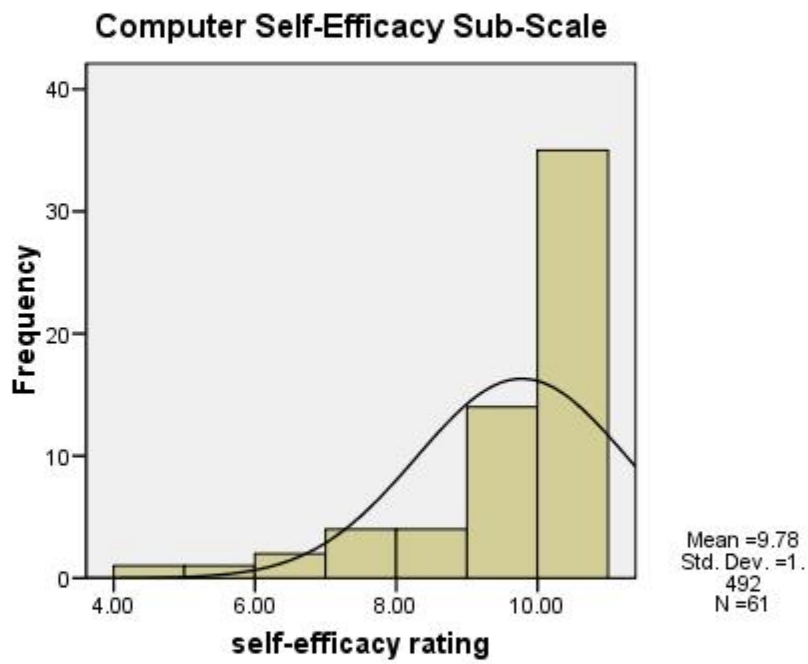

Computer Self-Efficacy Sub-Scale
Frequency
40
30
20
10
0
4.00
6.00
8.00
10.00
self-efficacy rating
Mean =9.78
Std. Dev. =1.492
N =61

Fig. 2.3

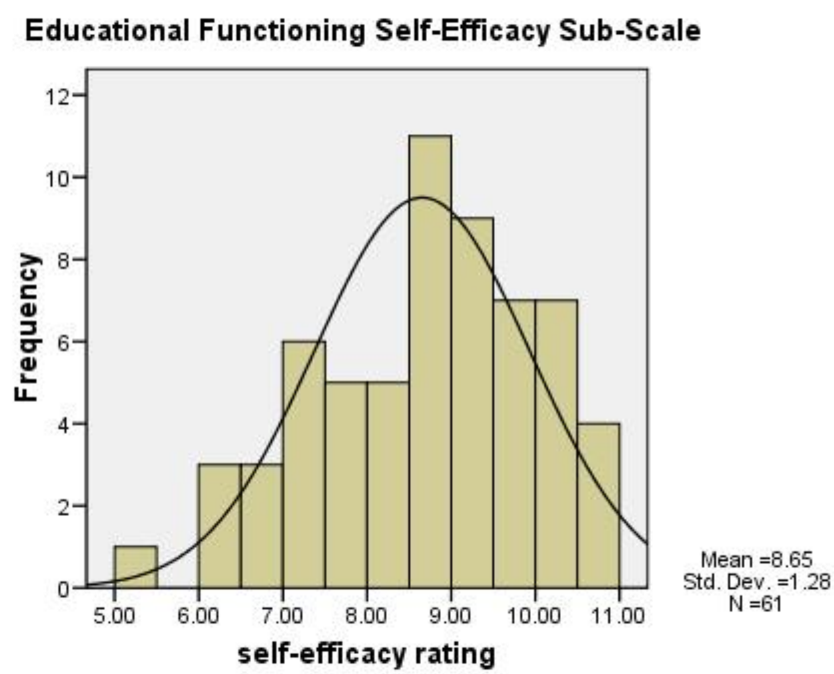

Educational Functioning Self-Efficacy Sub-Scale
Frequency
12
10
8
6
4
2
0
5.00
6.00
7.00
8.00
9.00
10.00
11.00
self-efficacy rating
Mean =8.65
Std. Dev. =1.28
N =61

Fig. 2.4

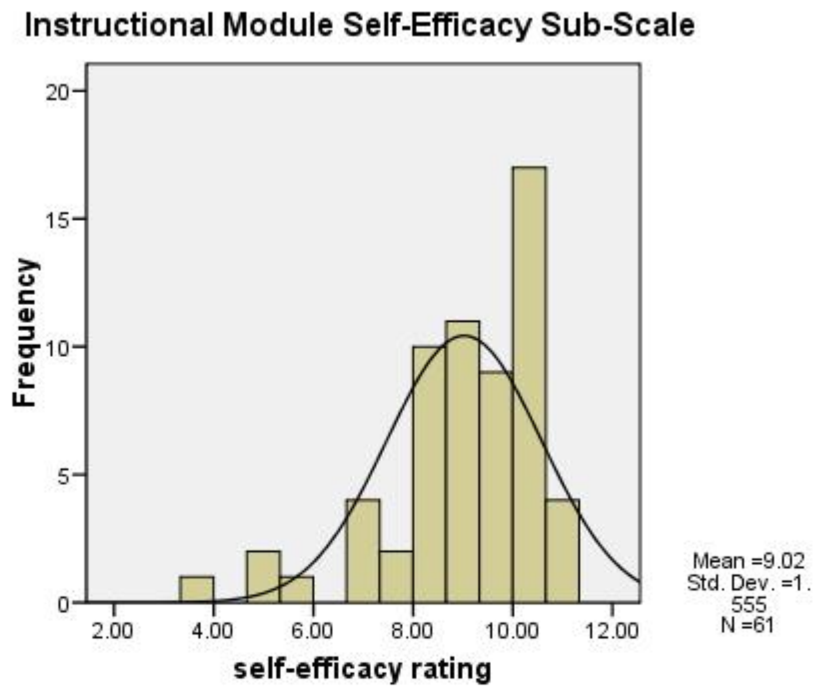

Instructional Module Self-Efficacy Sub-Scale
Frequency
20
15
10
5
0
2.00
4.00
6.00
8.00
10.00
12.00
self-efficacy rating
Mean =9.02
Std. Dev. =1.
555
N =61

Fig. 2.5

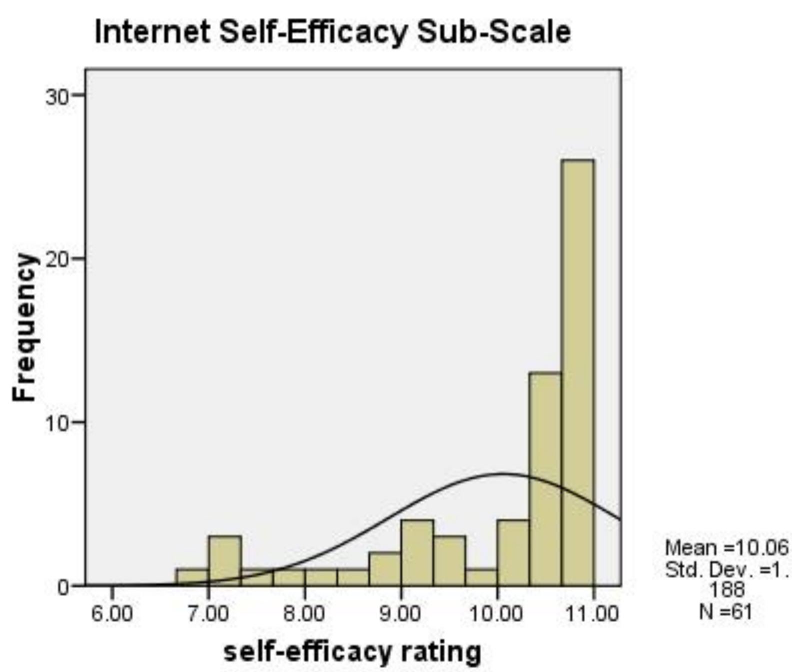
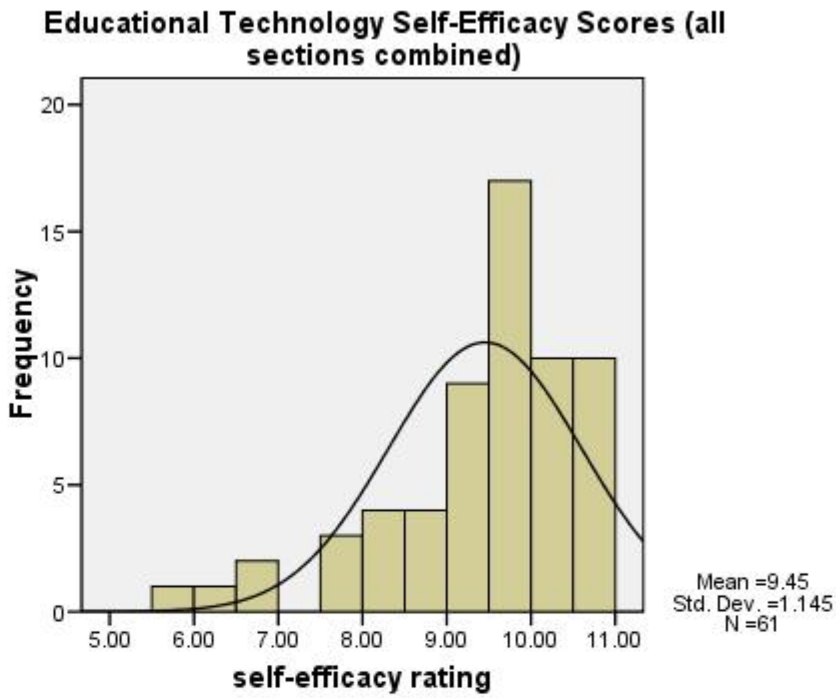

Internet Self-Efficacy Sub-Scale
Frequency
30
20
10
0
6.00
7.00
8.00
9.00
10.00
11.00
self-efficacy rating
Mean =10.06
Std. Dev. =1.
188
N =61

Fig. 2.6


Educational Technology Self-Efficacy Scores (all sections combined)
Frequency
20
15
10
5
0
5.00
6.00
7.00
8.00
9.00
10.00
11.00
self-efficacy rating
Mean =9.45
Std. Dev. =1.145
N =61

Appendix A

Pre-Test Measure

1. What is the first ion to enter the soma during an action potential?
A. sodium
B. potassium
C. chloride
D. nitrogen

2. What protects the axon and speeds up transfer of information?
A. the soma
B. dendrite sheaths
C. myelin sheaths
D. amniotic fluid

3. What is the body of the cell called?
A. dendrite
B. soma
C. axon
D. myelin sheath

4. What is the potential of a neuron before it is stimulated?
A. +55 volts
B. -55 volts
C. +70 volts
D. -70 volts

5. What process comes first in an action potential?
A. change in voltage
B. release of sodium
C. release of potassium
D. the neural impulse

6. What happens when the neuron is stimulated by another neuron?
A. The polarity is reversed thus causing an action potential
B. The polarity is reversed thus causing a resting potential
C. The polarity is restored thus causing an action potential
D. The polarity is restored thus causing a resting potential

7. Why is the salutary conduction necessary?

A. It prevents axons from having to conduct impulses too frequently
B. This speeds up the ion transfer without needing larger axons
C. It reinforces the myelin sheath around the axon
D. It prevents the terminal buttons from becoming too full of neurotransmitters

8. How does the neuron return to its original state?
A. The neuron releases the sodium ions
B. The neuron absorbs the sodium ions
C. The neuron releases the potassium ions
D. The neuron absorbs the potassium ions

9. Multiple sclerosis is a disease that results in a variety of symptoms, including muscle weakness and difficulty speaking. We know that the these symptoms arise in part from the neurons in the central nervous system not being able to conduct their messages quickly enough to the other parts of the body. Therefore, which part of the neuron is most likely affected by this disease?
A. soma
B. myelin sheath
C. dendrites
D. neurotransmitters.

10. An epileptic seizure occurs when there is an abnormal amount of neurons firing simultaneously. Which part of the neuron would carry these charges, thus possibly resulting in a seizure?
A. soma
B. sodium ions
C. myelin sheath
D. axon

11. Recent research has found that autism is characterized by neurotransmitters being released differently than how neurotransmitters are released in non-autistic individuals. Which part of the neuron is responsible for releasing these neurotransmitters?
A. dendrites
B. soma
C. synaptic cleft
D. axon

12. Ashley and John present a skit in class on how a neural impulse is formeD. Ashley plays the group of sodium ions and runs through a small tube, then into a hula hoop and then alternating running quickly and slowly out of the classroom. What part is John playing if he starts the skit in the hula hoop and runs out of the hoop through another small tube?
A. sodium

B. calcium
C. oxygen
D. potassium

Appendix B

Post-Test Measure

1. What is first released into the cell body at the start of an action potential?
a. potassium
b. nitrogen
c. chloride
d. sodium

2. This is wrapped around and protects the nerve that carries information to the next cell.
a. amniotic fluid
b. the soma
c. dendrite sheaths
d. myelin sheaths

3. What part of the cell regulates what ions are in it?
a. dendrite
b. myelin sheath
c. axon
d. soma

4. What is the voltage of the neuron after it has been stimulated?
a. -70 volts
b. +70 volts
c. -55 volts
d. +55 volts

5. How does an action potential begin?
a. there is a change in voltage
b. there is a release of sodium
c. there is a release of potassium
d. there is a the neural impulse

6. When the neuron is initially stimulated:
a. The polarity is reversed thus causing an action potential
b. A message is immediately sent along the axon
c. The polarity is restored thus causing an action potential
d. The potassium gate opens and releases excess ions.

7. What makes the saltatory conduction necessary for good brain function?
a. It prevents axons from having to conduct impulses too frequently
b. It speeds up the ion transfer without needing larger axons
c. It reinforces the myelin sheath around the axon
d. It prevents the terminal buttons from becoming too full of ions

8. What part does the potassium gate play in how a neuron returns to the resting state?
a. The neuron releases only the potassium
b. The neuron releases every ion but potassium
c. The potassium gate absorbs the potassium
d. The potassium gate absorbs every ion but potassium

9. Multiple sclerosis is a disease that results in a variety of symptoms, including muscle weakness and difficulty speaking. We know that the these symptoms arise in part from the neurons in the central nervous system not being able to conduct their messages quickly enough to the other parts of the body. Therefore, which part of the neuron is most likely affected by this disease?
a. soma
b. myelin sheath
c. dendrites
d. neurotransmitters.

10. An epileptic seizure occurs when there is an abnormal amount of neurons firing simultaneously. Which part of the neuron would carry these charges, thus possibly resulting in a seizure?
a. soma
b. sodium ions
c. myelin sheath
d. axon

11. Recent research has found that autism is characterized by neurotransmitters being released differently than how neurotransmitters are released in non-autistic individuals. Which part of the neuron is responsible for releasing these neurotransmitters?
a. dendrites
b. soma
c. synaptic cleft
d. axon

12. Ashley and John present a skit in class on how a neural impulse is formed. Ashley plays the group of sodium ions and runs through a small tube, then into a hula hoop and then alternating running quickly and slowly out of the classroom. What part is John playing if he starts the skit in the hula hoop and runs out of the hoop through another small tube?
a. sodium
b. calcium
c. oxygen
d. potassium

Appendix C

Self-Efficacy Questionnaire

This questionnaire is designed to help determine what college students are comfortable doing while interacting with computers. Please rate your degree of confidence that you can do these activities on a scale of 1-100, with 0 meaning you cannot do this activity at all, 50 meaning you are moderately certain you can do it and 100 meaning you are highly certain you can do it. As always, your answers are kept confidential.

0 ---- 10 ----- 20 ----- 30 ----- 40 ----- 50 ----- 60 ----- 70 ---- 80 ---- 90 ---- 100

Cannot do at all — Moderately certain can do — Highly certain can do

"I feel confident that I can…"

	10	20	30	40	50	60	70	80	90	100
See that I need an extra review source in addition to the textbook/class										
Am able to consistently prepare myself adequately for a test										
Able to know if I am prepared for a test, based on my perception before the test and the result afterwards										
Use resources outside of the classroom										
Use resources that are not readily available to me in a classroom or at home (ie – library)										
Use resources that are discussed in the textbook, but in which I must go to a computer type them in										

Starting an Internet browser such as Internet Explorer or Safari										
Finding an unfamiliar website on the Internet										
Use a search engine to find a website's address (such as Google, Yahoo Search)										
Navigating an unfamiliar website										
Downloading plug-ins necessary for using tools on the internet, such as playing a video clip										
Put a website on "Favorites" list or "Bookmark" it.										
Correctly solve a problem which prevents me from using the internet that I have not encountered before										
Keep trying to solve a problem I have not encountered before, even if I was not successful the first few times										
Find information which might be on another medium such as TV, newspaper or books										
Turning the volume on the computer up and down on a computer that is familiar to you										
Turning the volume on the computer up and down on a computer that is NOT familiar to you										

Installing a program on the computer										
Identify the basic components of an unfamiliar computer (such as keyboard, mouse, screen, power button, etc)										
Attaching external devices (flash drives, external hard drives, etc) to a computer										
Using an unfamiliar program										
Using the "Help" or online "Help" section of a program										
Using a word processor or calculator instead of paper or external calculator										
Following instructions for an unfamiliar online tutorial										
Using an online instructional tool for studying vocabulary										
Using an online instructional tool for studying processes										
Using an online instructional tool for studying concepts										
Navigating an online instructional tool that is new to me										
Troubleshoot if the instructional tool does not work properly										
Determine what I should "click" on to operate the tutorial										