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The impact of using virtual reality on student's motivation for operating systems course learning

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Abstract

This paper develops a virtual reality education system for mobile devices through mobile virtual reality technology with virtual reality glasses. The purpose of this study was to investigate the impact of mobile Virtual interactive e-Learning environment on 3D operating system course learning motivation. The paper aims to increase students' interest and enhance their learning motivation for understanding CPU process scheduling algorithms in an operating systems course. A total of 110 students from the department of computer sciences at Sadat Academy were invited to participate. A 5-point scale was adopted based on the ARCS model to stimulate learning to collect student data. A one-way analysis of variance (ANOVA) was performed to assess if the apparent difference was significant. Perform a data factor analysis to determine the appropriate factor ($p = 0.000 < 0.05$). The results show that mobile virtual reality game-based learning is an effective pedagogical tool for operating systems education, and it can promote students' motivation and interest in learning 3D animation.

KEYWORDS: e-Learning, Game-based Learning, Mobile Learning, Learning Motivation, ARCS

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1. Introduction

Learning does not mean repetition and retention; it means acquiring the abilities, skills and way of thinking required in a variety of situations (Jong 2012). The rapid development of the Internet has been attached with rapid evolution in e-services. E-Learning, one type of e-services, is one of the most important developments in both schools and universities (Violante, 2015). The advent of virtual reality, along with the adoption of games or play features, makes the learning process more motivating and dynamic (Braga, 2019).

Virtual reality (VR) is becoming increasingly important as an educational tool in schools as well as in universities because of its interactive and animated features (Abdelaziz, 2014). VR can be an effective way to educate and support complex concepts by enabling learners to interact with visualization tools. The approach that combines VR technology with e-Learning is a different teaching method that enhances students' ability to analyze and think through problems.

Unity3D is the most common 3D video game development engine, a flexible graphics engine that is currently available in the market and offers a wide range of resources. It is easy to learn and use and provides a free version compatible with VRs for project design both in 2D and 3D. By being common to platforms, it can export any project to both mobile devices (Android and IOS) and desktop operating

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systems (Windows, Linux, and Mac OS). Therefore, this engine - Unity3D - was used in this research (Vergara, 2017).

Therefore, to motivate the student's interest in both learning and entertainment, virtual reality game-based learning has been considered on mobile devices.

The educational game should not be more fun than just teaching. The learner must learn in a more motivating way (Braga, 2019). Motivation is an important concept in human behaviour and plays a key role in student learning and the way educators can help students learn better (Li, 2018). This research focuses on the motivational side of the learning process. Most teachers easily agree that motivating students is an important variable to consider when developing, monitoring, and evaluating educational effectiveness in educational games. It is generally recognized that there is a positive relationship between motivation and learning. The more motivated a student is, the more likely he is to study at this course.

One of the theories supporting this research is the attention, attention, trust and satisfaction model (ARCS) created by Keller (Bixler, 2006). It provides teachers with systematic guidance that motivates students to learn. The ARCS model has three advantages: it emphasizes motivation and emotional motivation; it can be coordinated with other theories and instructional designs; and promotes learning and learning effects (Wu, 2018). Thus, the ARCS model can effectively integrate the learning strategies of traditional operating systems and use a systematic design to enhance learners' learning motivation and combine theory and practice.

The study has developed a Mobile Virtual Reality Game-based Learning system (MVRGBL) through mobile virtual reality technology with VR Box (Virtual Reality glasses). The purpose of this research is to increase learners' interest and motivation to learn CPU scheduling algorithms of the operating systems course and achieve higher levels of performance.

In this paper, the authors decided to select the course of CPU scheduling as teachers often use text descriptions only, students sometimes find it difficult to understand the task of maximizing the use of CPU and how the processes that are in memory and ready to execute are selected and allocates the CPU to one of them. To solve this problem, mobile game graphics can be used.

2. Literature review

Many studies integrate virtual reality systems into mobile devices because they provide students with highly dynamic learning content according to their way of life.

A Pallavicini (2018) study describes mobile virtual reality and highlights the features that describe it. It discusses the enhancement of mobile virtual reality supported by concrete examples and research analysis studies. Christof Sternig (2018) developed a prototype math game at a school for students aged twelve to thirteen, through a range of mobile devices and virtual reality. The result of the game's evaluation was very positive, and students were motivated and excited to use virtual reality game-based learning in schools as a learning tool (Sternig, 2018). A study by Sonia Cruz (2017) taught Portuguese history to students through mobile games. The game was developed to motivate students and engage them in learning history through dialogues along with characters, adventure and challenging tasks. The results showed that playing games gives students a desire to understand what happened in the past and at the same time to achieve better scores in the game.

The previous studies mentioned above illustrate the gap in the current research; it has been observed that the games for operating systems course can fill an educational gap.

Marwa Abdelaziz (2019) developed a virtual reality game-based learning for memory management of operating system course but did not discuss increasing the interest of learners and motivating them to learn scheduling operations on the CPU for the operating systems course.

The selected experiment course of "CPU scheduling" is the core concept of operating systems. As lecturers often use text description only, students sometimes feel difficulty in understanding the different scheduling algorithms. There is a need for more practical activities for this course to represent the reality of the profession, and thus, the possibility of improving operating systems education is created. A mobile 3D CPU scheduling learning system, through mobile virtual reality technology, with VR Box is a new trend that is in line with the current environment that desires to improve learning motivation and achievements. The aim of this study is to see if the game of this study has any motivational effect on the students. In this article, the basic algorithms of CPU scheduling, including "first come first served" scheduling as well as shortest job first scheduling and priority scheduling, are incorporated into the game design.

3. Motivations

Most educational approaches are boring, causing a low motivation to learn. VR integration and mobile devices provide great potential for using digital gaming-based learning concepts to create an immersive learning environment.

Surveys on the combination of VR game-based learning and mobile learning are few, so this study combines these elements to develop an Android smartphone application. This research can help to enhance students learning motivation.

4. Problem statement

Students who enrol in the course of operating systems have low motivation because this course is considered a boring course. For this reason, there is a strong motivation to incorporate game-based learning into the teaching of this course. A little research has been done to explore virtual reality game-based learning as a way to learn operating systems course. Moreover, most completed studies do not conclusively compare the effects of mobile education technology with traditional methods.

There are different modules of the Operating Systems course including: computer system architecture, operating system architecture, processing unit, synchronization, CPU scheduling, deadlock, memory management, and file system management.

CPU scheduling while learning operating system course is one of the most critical and complex tasks. Most of the teaching methods for this part are boring, causing low learning motivation. Because of all these factors, students can be frustrated in their learning and often have less motivation, which leads to abandonment of the course. This complex part of operating systems can be enhanced by integrating technology into the learning process. In particular, digital games can be helpful to make this dull part of learning more enjoyable since they are motivating learning tools for the students. Mobile technologies represent a good platform for gaming applications.

No studies have implemented the use of mobile virtual reality game-based learning system in the CPU scheduling of operating systems course. So, developing this learning model will provide an interactive learning environment.

5. Objectives

This research proposes to introduce the content of the educational modules in the way of games to attract students. A mobile virtual reality game-based learning application was developed to be used in teaching CPU scheduling algorithms by aiming for the following:

- to create a game integrated with the course content of the Operating Systems course and utilize it in teaching;
- to promote and raise students' interest and motivation to learn the various techniques associated with memory management;
- to make students achieve higher levels of motivation;
- to learn in an informal way, so that the students do not feel bored;
- to contribute to the use of educational technologies to review the knowledge that the students have just acquired.

5.1 Study contribution

With the introduction of virtual reality viewer (VR Box/glasses), a combination of mobile devices and VR was created. This integration has opened up a wide range of possible and inexpensive virtual reality applications that everyone can take advantage of. This research applied the virtual reality game on mobile devices to assess the need for such educational games, and to support and motivate students for the course of operating systems. The results of this study were very positive and showed high motivational potential combining mobile devices and virtual reality game-based learning and its utilization in universities as educational tool.

5.2 Research questions

This study contains the following basic research questions:

- does the type of learning methodology used in course development affect student motivation?
- does the students' gender have a significant effect on how well the mobile virtual reality game-based learning will motivate him or her to learn about the operating system course?

5.3 Significance of the study

This study will be of interest to the instructor to provide another way to teach the operating system course using a variety of teaching methods, using virtual reality games to make students interact with the course and support the efficiency of the course.

6. Development of Virtual Interactive Game-based Learning System

For digital 3D content in VR Mobile, Autodesk 3D max was used to produce 3D object models. Photoshop was used for the interface. In addition, the produced models were introduced to Unity3D and connected with the hardware, VR box, through Google VR SDK (Linowes, 2016) as shown in Figure 1. The Google VR SDK for Unity allows developers to effortlessly adjust a current Unity 3D application for Virtual Reality or build the VR experience from scratch. Learners can therefore place the "VR Box" headset on a smartphone to use and operate the VR mobile learning system via Bluetooth controllers, such as the pause, play, loop and exit function.

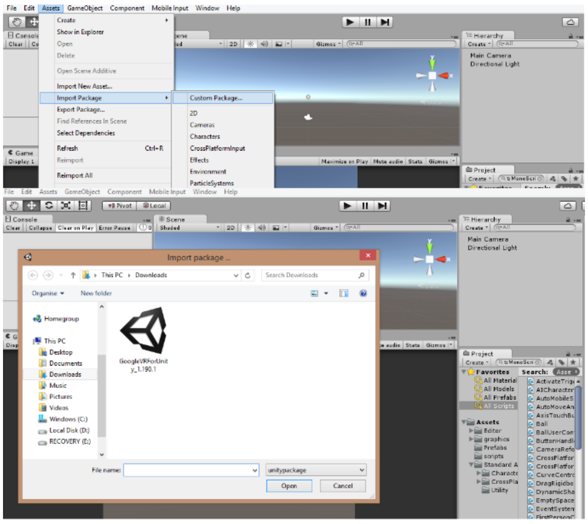

Figure 1- Google VR SDK import for Unity
Source: Abdelaziz et al.

As shown in Figure 2, the player will select any type of the CPU scheduling algorithms such as "first come first served" scheduling, shortest job first scheduling and priority scheduling. The player will draw the Gantt chart by assigning the processes in order according to the chosen type of scheduling algorithm and calculate the average waiting time. For example, if the chosen scheduling type was "first come first served", the player will allocate the CPU with the process which arrives first and calculate the average waiting time.

The scoring will depend on how many times he/she failed as shown in Figure 3 and 4 and it will be marked from a count of 100% with each mistake deducting 5% (assumption from the researcher).

In the shortest job first scheduling method, the player will allocate the waiting process with the smallest execution time to execute. In priority type, the player will assign the processes with their arrival time, burst time and priority. Then Sort the processes, according to arrival time if two process arrival time is same then sort according process priority if two process priority are same then sort according to process number.

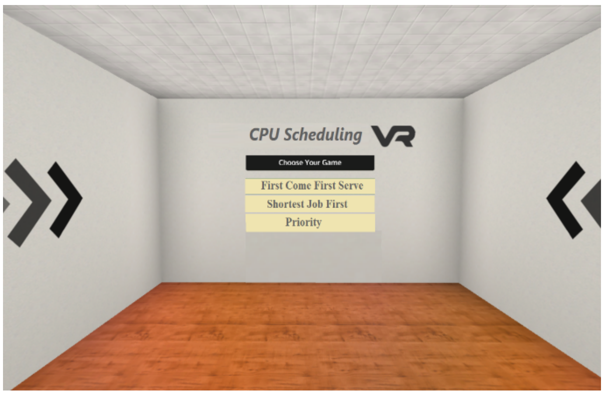

Figure 2- CPU Scheduling Algorithms.
Source: Abdelaziz et al.

Figure 3- The Scoring Result.
Source: Abdelaziz et al.

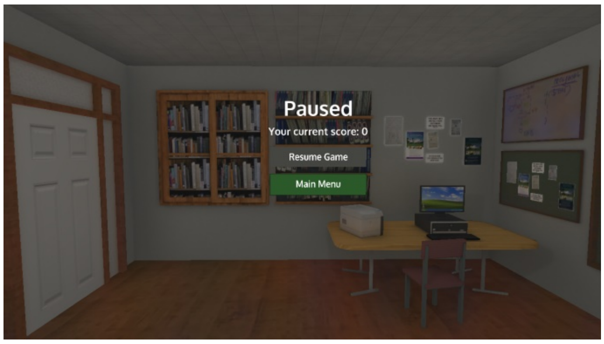

Figure 4- Resume Game.
Source: Abdelaziz et al.

7. Experimental Procedure

The execution of the experimental procedure continued for more than three weeks. The first phase (first week) included the different algorithms of CPU scheduling. In the second phase (second week) the students were asked to fill out the learning motivation questionnaire, which was used to collect pretest data. In the third phase (fourth and fifth week), the two learning conditions were implemented. The learning activity was performed in the CPU scheduling area. In the fourth phase (week 6), after the end of the experiment, the students completed a learning motivation questionnaire, which was used to collect posttest data. Finally, a one-way analysis of variance (ANOVA) was performed to show if the apparent difference is significant. Figure 5 shows the implementation stages of this study.

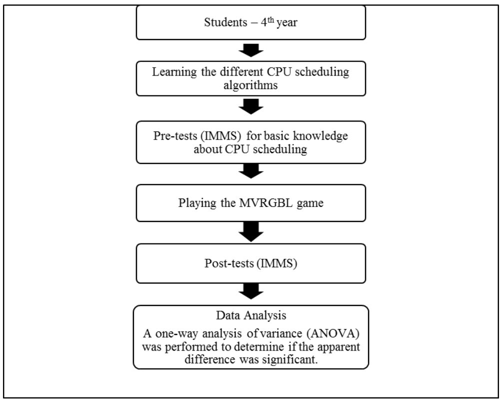

Figure 5- Stages of The Research Execution.
Source: Abdelaziz et al.

8. Experimental Participants

The language research's game is English. The students' level of English proficiency is fluent. It targets the fourth-year students of computer sciences department of Sadat Academy for Management Sciences. A group of these students was asked to fill out the learning motivation questionnaire, which was used to collect pre-test data. Then, the game operation was explained to the students, including instructions on how to play the game on PC or on mobile phone. Afterwards, the students began to play the game. After the experiment was over, the students filled out the learning motivation questionnaire, which was used to collect posttest data. These two questionnaires were a part of the Instructional Materials Motivation Survey (IMMS) (Appendix A). This survey measures the motivational effect of the mobile game-based on Keller's motivational model (Keller, 2010) that comprises of four factors, namely, Attention, Relevance, Confidence, and Satisfaction (ARCS). The questionnaires were used to gather data on learner motivation. Later, a one-way analysis of variance (ANOVA) was performed to determine if the apparent difference was significant.

9. Data Analysis

The course was taught through the main method of education. Once the course was taught, the phases of the research method started. The research method had three different phases: pre-test survey, playing the game, and posttest survey. The posttest survey had the same questions as the ones used in the pre-test except that they were prepared for the game. The same group of students with a pre-test as well as a posttest. The questionnaire format ranged from *Strongly Disagree* to *Strongly Agree* developed by Keller (2010). The results of the posttest survey were statistically analysed along with the results from the pretest to evaluate the motivation level of the game. The IMMS survey instrument is an essential part of ARCS model designed by Keller to measure students' motivation levels. The IMMS survey consists of 36 items and 4 factors. The 4 factors are attention (12 items), relevance (9 items), confidence (9 items), and satisfaction (6 items). It measures learners' motivation level by applying a 5-point symmetrical Likert scale (Huang, 2016).
Once the data was gathered, a statistical analysis was performed to determine the results of the research. The data that was analysed was the data collected from the revised IMMS sections of the pretest and posttest surveys. The independent variables were the type of educational material (traditional method of education and the mobile virtual reality game) and gender. The dependent variables were the motivational factors as described by the ARCS model (attention, relevance, confidence, and satisfaction) as well as total motivation. The answers to the Likert scale ranged from 1 to 5 in the ascending order: 1 denoted *Strongly Disagree*, 2 denoted *Disagree*, 3 denoted *Neither*, 4 denoted *Agree*, and 5 denoted *Strongly Agree*. The data were analysed independently as indicated by the ARCS factors utilizing one-way ANOVAs using the Statistical Analysis Software (SAS) package.

10. Results

<u>10.1 Mobile Virtual Reality Game-based Learning system</u>

The main research question was: Can the type of learning methodology used in course development affect student motivation? Each component of the ARCS model was analysed, and the results obtained before playing the game were compared with the results obtained thereafter.
It was found that the mean scores were higher after the game than they were before, as reported in Table 1 and Figure 6.
A one-way analysis of variance (ANOVA) was performed to show if the apparent difference is significant. Alpha is the value for determining significant or insignificant results. The value is usually 0.05. When p-value is less than 0.05, the result was significant. When p-value was more than 0.05, the result was not significant. The results showed that there is a statistically significant difference in the students' total motivation ($p=0.03$), as shown in Table 2 and Figure 7 before and after they played the game. Moreover, the confidence factor of ARCS ($p=0.02$) and satisfaction ($p=0.01$) showed a statistically significant difference, but attention ($p=0.15$) and relevance ($p=0.53$)

Factor	Survey	N	Mean	Std Deviation	Smallest	Largest
Attention	Before game	110	3.7	0.27	3.2	4.1
	After game	110	3.9	0.34	3.3	4.5
Relevance	Before game	110	3.6	0.35	3.1	4.4
	After game	110	3.7	0.36	3.1	4.4
Confidence	Before game	110	3.7	0.35	3.2	4.4
	After game	110	4.1	0.37	3.4	4.8
Satisfaction	Before game	110	3.3	0.22	2.8	3.6
	After game	110	3.3	0.28	2.6	3.7
Total	Before game	110	3.6	0.19	3.3	3.7
	After game	110	3.8	0.34	3.6	4.1

Table 1 - ARCS Data for Instructional Materials.

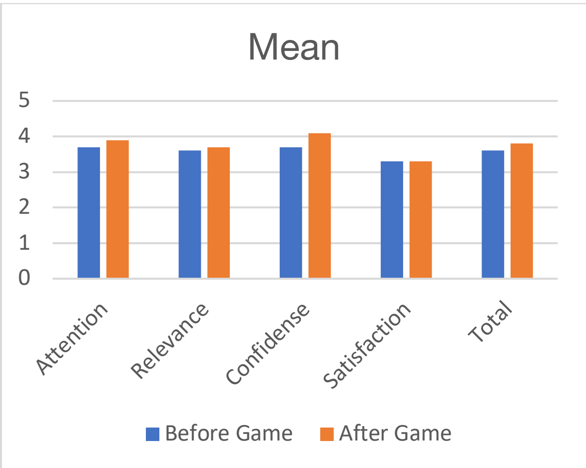

Figure 6- The Mean Scores for Pretest and Posttest.
Source: Abdelaziz et al.

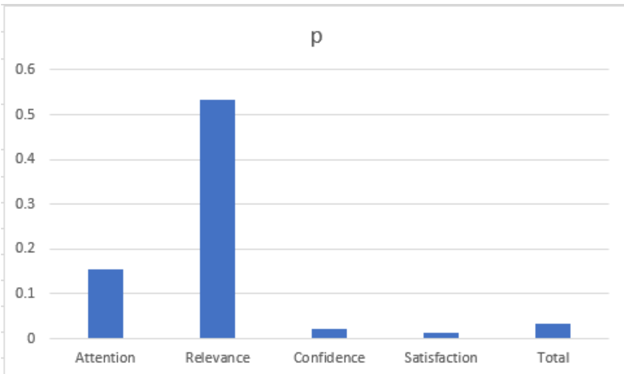

Figure 7- The P-value for Determining Significant or Insignificant Results (the Effect of the VR Game on ARCS).

Factor	*df*	*f*	*p*	*Cohen's d*
Attention	*1*	*2.190*	*0.154*	*0.631*
Relevance	*1*	*0.402*	*0.533*	*0.27*
Confidence	*1*	*6.257*	*0.021*	*1.067*
Satisfaction	*1*	*7.226*	*0.014*	*1.146*
Total	*1*	*5.207*	*0.034*	*0.973*

Table 2 - ANOVA and Effect size for Instructional Materials.

factors did not as shown in Figure 7. This proved that Confidence (d = 1.06), Satisfaction (d=1.14) and Total Motivation (d = 0.97) have a large effect, while Attention (d =0.63) and Relevance (d = 0.27) have a medium effect on student motivation.

10.2 Gender and Motivation

The second research question was: Does students' gender have a significant effect on how well the mobile virtual reality game-based learning will motivate them to learn about the operating systems course, such as the part of CPU scheduling algorithms? To answer this question the ARCS scores that were recorded after the game were compared between males and females.

The results of these ARCS scores can be seen in Table 3 and Figure 8, from which it is apparent that the mean scores were higher for males than for females.

A one-way analysis of variance (ANOVA) was performed to show if the apparent difference was significant. The results showed that the students' gender does not have a statistically significant effect on the total motivation (p = 0.24), as shown in Table 4 and Figure 9. However, it has a statistically significant effect on Confidence (p = 0.02). The effect size test shows that this effect for Confidence is large (d = 1.58).

Factor	Gender	N	Mean	Standard Deviation	Smallest	Largest
Attention	Female	40	3.7	0.29	3.3	4.0
	Male	70	3.9	0.36	3.5	4.5
Relevance	Female	40	3.5	0.35	3.1	3.9
	Male	70	3.7	0.38	3.4	4.4
Confidence	Female	400	3.8	0.37	3.4	4.2
	Male	70	4.3	0.25	4	4.8
Satisfaction	Female	40	3.1	0.10	3.1	3.3
	Male	70	3.3	0.37	2.6	3.7
Total	Female	40	3.5	0.31	3.1	3.8
	Male	70	3.8	0.42	3.3	4.3

Table 3- ARCS Data for Gender Groups.

Factor	*df*	*F*	*p*	*Cohen's d*
Attention	*1*	*3.883*	*0.080*	*0.612*
Relevance	*1*	*0.743*	*0.411*	*0.547*
Confidence	*1*	*7.289*	*0.024*	*1.584*
Satisfaction	*1*	*1.076*	*0.327*	*0.738*
Total	*1*	*1.531*	*0.247*	*0.813*

Table 4 - ANOVA and Effect Size for Gender Groups.

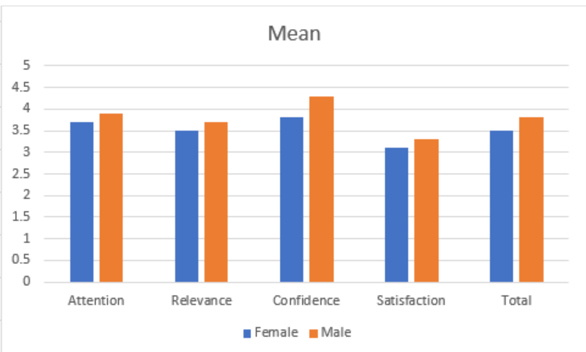

Figure 8- The Mean Scores for Male and Female Students
Source: Abdelaziz et al.

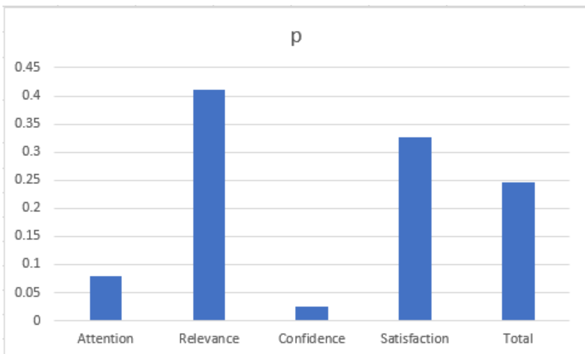

Figure 9- The P-value for Determining Significant or Insignificant Results (the Effect of Gender on ARCS).
Source: Abdelaziz et al.

11. Conclusion

This research paper has developed a mobile VR-enhanced operating systems education using a gaming approach to improve the learning process.
The game was developed using Unity3D's virtual reality environment, which was chosen for ease of use. The purpose of this study was to discover whether the created game had any motivational effect on students. The paper was quantitative following a classic quasi-experiment design, where one group of participants conducted a pretest and a posttest survey. The students' motivation was measured with the Instructional Materials Motivation Survey (IMMS) and the data analysis of the results showed that there is a statistically significant difference in the students' total motivation as well as the two factors of confidence and satisfaction. However, there was no statistically significant difference for the attention and relevance factors. Also, the results showed that the students' gender does not have a statistically significant effect on the total motivation. However, it has a statistically significant effect on confidence.

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Appendix A

Instructional Materials Motivation Survey (IMMS) (Keller, 2010)

There are thirty-six statements in this questionnaire. Please think about each statement in relation to the instructional materials you have just studied and indicate how true it is. Give the answer that truly applies to you, and not what you would like to be true.

Think about each statement by itself and indicate how true it is. Don't be influenced by your answers to other statements.
Record your responses on the answer sheet that is provided and follow any additional instructions that may be provided in regard to the answer sheet that is being used with this survey. Thank you.
Use the following values to indicate your response to each item:

1 (or A) = Not true
2 (or B) = Slightly True
3 (or C) = Moderately True
4 (or D) = Mostly True
5 (or E) = Very true

1. When I first looked at this lesson, I had the impression that it would be easy for me.
2. There was something interesting at the beginning of this lesson that got my attention.
3. This material was more difficult to understand than I would like for it to be.
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.
5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.
6. It is clear to me how the content of this material is related to things I already know.
7. Many of the pages had so much information that it was hard to pick out and remember the important points.
8. These materials are eye-catching.
9. There were stories, pictures, or examples that showed me how this material could be important to some people.
10. Completing this lesson successfully was important to me.
11. The quality of the writing helped to hold my attention.
12. This lesson is so abstract that it was hard to keep my attention on it.
13. As I worked on this lesson, I was confident that I could learn the content.
14. I enjoyed this lesson so much that I would like to know more about this topic.
15. The pages of this lesson look dry and unappealing.
16. The content of this material is relevant to my interests.
17. The way the information is arranged on the pages helped keeps my attention.
18. There are explanations or examples of how people use the knowledge in this lesson.
19. The exercises in this lesson were too difficult.
20. This lesson has things that stimulated my curiosity.
21. I really enjoyed studying this lesson.
22. The amount of repetition in this lesson caused me to get bored sometimes.
23. The content and style of writing in this lesson convey the impression that its content
24. I learned some things that were surprising or unexpected.
25. After working on this lesson for a while, I was confident I would be able to pass a test on it.
26. This lesson was not relevant to my needs because I already knew most of it.
27. The wording of feedback after the exercises, or of other comments in this lesson helped me feel rewarded for my effort.
28. The variety of reading passages, exercises, illustrations, etc. helped keep my attention on the lesson.
29. The style of writing is boring.
30. I could relate the content of this lesson to things I have seen, done, or thought about in my own life.
31. There are so many words on each page that it is irritating.
32. It felt good to successfully complete this lesson.
33. The content of this lesson will be useful to me.
34. I couldn't really understand quite a bit of the material in this lesson.
35. The good organization of the content helped me be confident that I would learn this material.
36. It was a pleasure to work on such a well-designed lesson.