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High and Low Computer Self-Efficacy Groups and Their Learning Behavior from Self-Regulated Learning Perspective While Engaged in Interactive Learning Modules

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This study utilized a SRL framework that covered self-efficacy, cognitive actions, and metacognitive components. While self-efficacy was represented by CSE, metacognitive component was represented by planning, monitoring, and regulating strategies. Cognitive actions represent contextual activities while using interactive learning modules. One hundred students from two high schools, InTech Collegiate and Logan High Schools, completed activities in this study. Each student worked on three modules, namely Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs. Three different forms of data were gathered for analysis. These data included questionnaires, screen captured videos, and audio recordings of interviews.

The findings of this study revealed that the students achieved the highest average score on beginning skills compared to advanced skills and file and software skills for their CSE. Furthermore, screen-captured video analysis showed that there were different profiles of cognitive actions and metacognitive strategies between high and low CSE groups in terms of the strategy changes and duration of their strategies. Issues gathered from interview analysis between these two groups were also elaborated.

Keywords

computer self-efficacy, cognitive actions, metacognitive strategies, interactive learning modules

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Introduction

Along with the rapid development of computer and Internet technologies, efforts have been made to include the design, development, and evaluation of computer applications for learning activities. For example, the National Science Foundation (NSF) is promoting research on computer-based learning through its Cyberlearning: Transforming Education program. One of the objectives of the program is to “better understand how people learn with technology and how technology can be used

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productively to help people learn, through individual use and/or through collaborations mediated by technology” (NSF, 2011, p. 1). Moreover, the Committee on Learning Research and Educational Practice of the National Research Council recommends that research on computer-based learning needs to consider learning theories to improve students’ learning experience (Donovan, Bransford, & Pellegrino, 2008).

Numerous definitions relate to the computer-based learning environment (CBLE). The focus investigation of this study is a type of CBLE called the *interactive learning module* (ILM). Previous research suggests that the module may be used to provide learning instruction in an interesting way (e.g., Millard, 2000; Teoh & Neo, 2007). Although extensive research has defined the use of computer applications in various disciplines, no study has systematically investigated students’ self-regulated learning (SRL) skills while learning with an ILM specifically in high school level. When explaining current trends in educational technology research, Winn (2002) challenged researchers to study the characteristics of environments that support learning and the interaction between students and their environments. Mayer (2003), in responding to Winn’s article, emphasized the need for evidence-based research on the CBLE. In 1999, he also stated, “To understand how to improve education, we will continue to need credible evidence based on scientific research methods” (Mayer, 1999, p. 259).

Zimmerman (2002) characterized self-regulated learners as they who are active in terms of their metacognitive, motivational, and behavioral aspects in learning. Exploring students’ SRL is paramount to understanding how they learn with the ILM. The information gathered can be used to suggest what types of efforts must be made to improve design and use of the ILM in the classroom. Compared to a classroom setting, learning in a CBLE requires a higher level of SRL skills. In this environment, students must be active, rather than waiting for instruction from a teacher. Azevedo (2008) emphasized the importance of SRL skills to learn effectively in a CBLE to avoid cognitive overload and navigation problems. Learning in the environment requires students’ motivation to identify what learning goals need to be achieved and what information needs to be processed. Students are also expected to bring into play their cognitive and metacognitive skills to not only interact with the features in the CBLE, but also to monitor the status of their learning process.

This study focuses on computer self-efficacy (CSE) and how it is reflected on cognitive actions and metacognitive strategies while students learn with the ILM developed by the Department of Computer Science at Utah State University (Neema, 2010). The researcher used CSE to understand students’ background knowledge and perception of computer usage. According to Compeau & Higgins (1995), CSE is “a judgment of one’s capability to use a computer” (p. 192). While cognitive strategies represent specific actions related to “internal processes by which

learners select and modify their ways of attending, learning, remembering, and thinking” (Gagne, Briggs, & Wagner, 1992, p. 67), metacognitive strategies specifically represent planning, monitoring, and regulating strategies of any cognitive actions.

Extensive research has evaluated the efficacy of metacognition in learning, especially in problem solving (e.g., Georgiades, 2000; Pintrich, 2002; Schraw, Brooks, & Crippen, 2005; Veenman, Elshout, & Meijer, 1997). It plays a significant role in a student’s control of cognition. Flavell (1979), who coined the term metacognition, described it as “knowledge and cognition about cognitive phenomena” (p. 906). Although the cognitive strategies component is not explicitly mentioned in the previous references (i.e., Zeidner, Boekaerts, & Pintrich, 2000; Zimmerman, 1989), it is highly connected with metacognitive strategies. Butler and Cartier include cognitive strategies as part of the SRL component in their SRL model (Butler & Cartier, 2004, 2005; Cartier & Butler, 2004).

The purposes of this study are to investigate (a) students’ CSE while engaged in interactive learning modules; and (b) students’ cognitive actions and metacognitive strategies based on their CSE level. Quantitative and qualitative data were gathered and analyzed in this study. The results of this study identify students’ cognitive actions and metacognitive strategies based on their CSE level while using the ILM. The outcomes can be used to inform educators, researchers, and developers of the importance of a SRL perspective when designing instruction using an ILM.

Relevant Literature Review

Insights Into Computer Self-Efficacy

According to social cognitive theory (Bandura, 1986; Wood & Bandura, 1989), individuals’ behaviors are influenced by certain factors including personal and environmental factors. Social cognitive theory provides the theoretical foundation of a motivational construct called self-efficacy. Bandura (1986) explained self-efficacy as: “Perceived self-efficacy is defined as people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances” (p. 391). In the context of computer use, Compeau & Higgins (1995) defined computer self-efficacy as “a judgment of one’s capability to use a computer” (p. 192).

Previous studies found that self-efficacy has a positive correlation with academic achievement. A study conducted by Pintrich and DeGroot (1990) revealed a positive relationship among students’ self-efficacy, SRL, and academic performance. Individuals with higher self-efficacy tend to show greater changes in behavior (Bandura, 1977) and spend more time while engaged in tasks (Brosnan, 1998) than those with lower self-efficacy. Moreover, Lent, Brown, and Larkin (1984) reported that

technical-major students with high self-efficacy for educational requirements achieved higher grades than their peers with low self-efficacy.

Numerous studies on CSE have been conducted to investigate how individuals' belief in their capability influences their performance while using a computer (e.g., Karsten & Roth, 1998; Khorrami-Arani, 2001). Furthermore, the research finding suggested that CSE can be trained. A study conducted by Karsten and Roth (1998) found that computer training in the introductory information system course significantly increased students' CSE.

Cognition and Self-Regulated Learning

Learning is a dynamic process rather than a static one. The process is represented by a change in behavior or knowledge, which can be measured through norms, values, or other types of measurement parameters. Davis (2004) described learning as "a recursively elaborative process rather than an accumulative process" (p. 23). Moreover, knowledge as a product of learning could be clustered into two different types: tacit and explicit; see Smith (2001) for examples of their use. We could measure a change in learning if someone explicitly describes their knowledge. However, it does not mean that if someone cannot perform on any task behaviorally, there is no change in their tacit knowledge.

Cognitive psychology views the human mind as a "white box" that can be observed. The information theory proposed by Shannon (1948) through a publication entitled "A mathematical theory of communication" influenced the field of psychology to better understand human cognition and learning. At the same time, the computer revolution in the 1950s helped the development of research on the human mind with Goodwin (2005) stating that the computer "added further legitimacy to the scientific study of the mind" (p. 411). Humans' cognitive processes are categorized into three main components: sensory register, short-term memory, and long-term memory (Atkinson & Shiffrin, 1968). These components are very similar to the components in computer system. Although the use of computer metaphor helps people in "understanding" the idea of the human mind, Guenther (1998) argued that there are problems in it. Guenther's argument was based on the difference characteristics between humans and computers, especially on how both of them increase the memory. While the computer relies on the hardware capacity, humans increase their memory (i.e., amount of information) by practicing or learning.

Through rigorous research, the field of cognitive psychology successfully examines aspects of the human mind in various contexts. Wiley and Jee (2010) highlighted research areas in cognition such as perception and attention, language acquisition and reading, memory, comprehension and conceptual understanding, problem

solving and reasoning, and metacognition. Specifically for metacognition, they defined it as "the act of monitoring cognitive performance, which serves as input to self-regulation of cognitive behaviors such as studying" (p. 248).

Components of Self-Regulated Learning

SRL has three main components: motivation, cognition, and metacognition (Kauffman, 2001). According to Zimmerman (1989), self-regulated learners are "metacognitively, motivationally, and behaviorally active participants in their own learning process" (p. 239). Several prominent researchers have proposed a different model or framework of SRL (e.g., Butler & Cartier, 2005; Pintrich, 2000; Winne & Hadwin, 1998; Zimmerman, Bonner, & Kovach, 1996).

The SRL models shared commonalities of their features in: planning, cognitive, monitoring, and regulating strategies. According to Schraw and Moshman (1995), planning refers to "the selection of appropriate strategies and the allocation of resources that affect one's learning performance" (p. 354). Understanding of the task will influence the way students set their planning strategies. Learners execute plans by conducting specific cognitive strategies or actions to accomplish the learning objectives. While metacognitive strategies can be applied across domains, cognitive strategies depend strongly on context. For example, cognitive strategies of reading texts are different from those of solving math problems. Another essential component of metacognition besides planning strategies is monitoring strategies. Learners must be able to monitor their learning progress to ensure that cognitive actions result in learning. Furthermore, regulating strategies refer to the actions taken by students as a consequence of what they have achieved during learning or problem solving. Regulating and monitoring strategies are highly correlated.

Compared to Pintrich's, Winne and Hadwin's, and Zimmerman's idea of SRL, Butler and Cartier's model is a relatively new one. Butler and Cartier developed their model by considering the previous SRL models such as those of Butler and Winne (1995), Pintrich (2000), and Zimmerman and Schunk (1994, 2001). Previous studies had used Butler and Cartier's SRL model as a framework in reading, biology, and engineering design activities (e.g., Butler & Cartier, 2005; Butler, Cartier, Schnellert, Gagnon, & Giammarino, 2011; Lawanto, 2011; Lawanto et al., 2013; Lawanto, Butler, Cartier, Santoso, & Goodridge, 2013; Lawanto, Goodridge, & Santoso, 2011). It can be used to investigate students' SRL in other contexts such as computer-based learning because this SRL model recognizes SRL as "a complex, dynamic, and situated learning process" (Butler & Cartier, 2005, p. 1) and emphasizes the context of learning activity. Other components of Butler and Cartier's SRL model that differ from other models

include layers of context, what individuals bring to context, mediating variables, task interpretation, and personal objectives.

Interactive Learning Modules for High School Students

ILMs are web-based tools to support the instruction of computer science concepts in the classroom. The use of ILMs is quite different with CBLEs used for distance learning or independent learning. The modules are used to support learning activity in a classroom. The teacher is still present and actively interacting with students. The teacher explains a particular concept before asking the students to work on the module. Students work individually on their computer, but quite often they ask the teacher and their classmates to clarify to issues.

The developers of the ILMs have successfully developed a variety of modules for high schools. Each module consists of reading and exercise sections. Students are expected to read the introduction and reading materials before doing some experiments in the exercise section. An exploratory approach is the nature of ILM usage. Students can explore whatever they want using the module after listening to the explanation from the teacher regarding a particular concept.

The Study

Our goal in this study was to investigate high school students' CSE, cognitive action, and metacognitive strategies in a SRL framework while utilizing an ILM. Two research questions guided this research: (1) how is students' CSE while engaged in interactive learning modules? and (2) how do high and low CSE groups plan and monitor their cognitive action, and regulate their monitoring strategies based on their CSE level?

Participants and Courses

Students at two high schools in Utah were the target research population. They enrolled in programming and math classes offered by Logan High School and physics classes offered by InTech Collegiate High School during spring 2013 semester. One hundred students completed activities in this study. Analysis of demographic questionnaires provided a description about study participant characteristics including gender, age, ethnicity, class, GPA, the highest math class already taken, and whether they were considering majoring in a field of engineering, technology, or computer science in college. The participants in this study were 77 males and 23 females. The majority of the participants were in the 17 or less age group (93%), with a few in the 18–19 age group (7%). About 62% of the participants have GPA of 3.00 or higher. According to the findings, about 66% of participants consider majoring in a field of engineering, technology, or computer

science in college. Among the participants, 34% of them have taken Algebra 2 and 27% have completed Geometry. The remaining students have taken Trigonometry/Pre-Calculus, AP Calculus, and Algebra 1. In addition, Figure 1 summarizes participants' information regarding ethnicity.

Student participants were informed of the purpose and methods of the project in which they participated. The participating students in this study received a \$5 honorarium. An additional \$5 was given to students who were selected for interview session.

Interactive Learning Modules

This study focuses on three ILMs that represent some fundamental concepts in computer science: Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs (Table 1 shows features of these modules). Boolean Logic module focuses on teaching the function of Boolean operators. The module helps students learn Boolean logic concepts by comparing a written Boolean expression and selected objects. In the Minimum Spanning Tree module, students were required to develop a sequence of steps to follow to find the cheapest network. The module aims to familiarize students with an algorithm concept. In addition, the goal of providing students with Modeling Using Graphs is to understand how to model a problem using a graph. Graphs are diagrams with nodes and edges. The current study uses these modules because the content and graphic representations are appropriate for secondary-level students and also relevant to programming, math, and physics classes. A 5-minute (or more) introduction to the problem in each ILM was provided at the beginning of activity. Figure 2 shows an example of an ILM.

Instrumentation

This study involved data collected from three sources: (1) survey questionnaires; (2) screen-captured videos; and (3) interview.

Demographic questionnaire

The questionnaire includes: gender, age, ethnicity, class, GPA, the highest math class already taken, and whether the

Figure 1. Participants' information regarding ethnicity.

Table 1
The features of interactive learning modules.

Features	Boolean logic	Minimum spanning tree	Modeling using graphs
Reading materials	✓	✓	✓
Instructions	✓	✓	✓
Exercise/task	✓	✓	✓
Different level of difficulty	✓	✓	✓

respondent is considering majoring in a field of engineering, technology, or computer science in college.

Computer self-efficacy questionnaire

The researcher assessed students' CSE by modifying the work of Durndell, Haag, and Laithwaite (2000); the work was based on Torkzadeh and Koufteros (1994) and Murphy, Coover, and Owen (1989). The CSE questionnaire has very high internal reliability scores. The Cronbach's Alpha scores of Beginning Skills (9 items), Advanced Skills (10 items), File and Software Skills (6 items), and Mainframe Computer Skills (3 items) are .93, .88, .90, and .95, respectively. The questionnaire responses range from 1 to 5 (1, "not at all true of me," to 5, "very true of me").

The researcher used a modified instrument due to some irrelevant items based on the latest work conducted by Durndell et al. (2000). This instrument has a very high internal consistency coefficient: .95. The rapid development of computer technology has rendered the original items outdated for today's students. For example, the original questionnaire consists of statements about mainframe computers (e.g., "logging onto a mainframe computer system," "working on a mainframe computer").

Currently, secondary-level students do not understand this terminology, and the researcher does not use such terms in the modified instrument. A face-validity by involving high school students learning with the ILM has been conducted in a pilot study to select relevant items for secondary-level students.

Screen-captured videos: Interactive learning module sequence of events

Previous studies have used screen-captured video (i.e., using a digital device to record activities) because of its capability to capture detailed events and unobtrusive characteristics. For example, the technique has been used in digital writing research by Geisler (2001) and Slattery (2005). Hadwin, Nesbit, Jamieson-Noel, Code, and Winne (2007) traced sequences of events and their time stamp to capture student SRL activity while using gStudy software. They suggested that trace data reflect the actual learning activity and "add depth to our understanding of student self-regulated learning" (Hadwin et al., 2007, p. 108).

Interview

Interviews provide an opportunity to confirm data collected from other data collection techniques (Harris &

Figure 2. An example of interactive learning modules: Boolean Logic (csilm.usu.edu).

Brown, 2010). Retrospective interview sessions (Fraenkel & Wallen, 2009) were conducted to clarify or gather better information about the way students used the modules. In this type of interview, the researcher gave the students an opportunity to review what they did while they were using the modules. The questions asked the students how they used features of the modules, arrived at solutions in a learning exercise, problem-solved, and what strategies they used.

Data Collection Procedures

Because this study involved data collection from human subjects, the Institutional Review Board reviewed the research proposal to assess the issue of risk or legal harm and provided an approval for the study. Appropriate guidelines were applied to administer the questionnaires. The questionnaires were administered to participants with the same questions and in the same order to ensure validity. The researcher also obtained permission from school principals and signed informed consent from the participants/participants' guardians. All activities in this study were carried out individually by the students (see Figure 3). The participation was part of class activities, and the students were given a grade for their participation.

Data collection included quantitative and qualitative data. The researcher gathered quantitative data from online demographic and CSE questionnaires, and qualitative data were collected using screen-captured videos and interviews. Information about the links of the online questionnaires and instructions were posted on each school's website to capture the student activity while using the modules. Camstudio and RecordMyDesktop were used to capture students' activities while using the ILM. While Camstudio, a Windows-based screen-capture software, was installed on computers at InTech Collegiate High School, RecordMyDesktop, a Linux-based software, was installed on computers at Logan High School. There was no difference in terms of the quality of the screen-captured videos between the two programs. Furthermore, interview transcripts were collected, coded, analyzed, and compared to a list of issues posed to the students in the form of questions.

Figure 3. Pictures of data collection at two high schools.

A classroom equipped with computers or a computer lab that has Internet connection was used in the data collection process because the students needed to fill in the surveys online and learn with the web-based interactive learning modules. They were given an ID code to protect their privacy. The students were also given an orientation to the research protocol. Participants completed an online CSE questionnaire preceded by a short demographic survey on the first day of the data collection. After completing the questionnaires on the first day, participants were asked to use the learning modules. Purposive sampling (Patton, 1990) was used to select students for interview sessions; SRL awareness level among the participants by applying cluster analysis was used in the selection for screen-captured videos and interviews.

Data Analysis

A CSE questionnaire was used in this study. The mean values of CSE items were calculated using descriptive statistics. Moreover, cluster analysis was conducted to determine groups of students who reported high and low CSE. Cluster analysis approach of SRL strategies conducted by Butler and Cartier (2005) was adjusted for the purpose of this study. The object of cluster analysis is to find groups of students who have similar responses to the questionnaires. In this study, the researcher does not have the same dimensions of SRL strategies as Butler and Cartier used. Dimension is subset of each strategy. For example, in their study, planning strategies have inquiry, task management, and help as dimensions.

A hierarchical cluster analysis using Ward's method was used in the cluster analysis to find relatively homogeneous clusters based on measured parameters (Burns & Burns, 2008). Cluster analysis of this study was conducted by considering students' CSE. This analysis is essential to investigate in more detail how students' CSE reflected on cognitive actions and metacognitive strategies. By using this approach, the researcher expected to describe students' cognitive actions and metacognitive strategies based on their CSE.

Results of cluster analysis were used to determine which screen-captured videos needed to be analyzed and to select students to be interviewed. Results of screen-captured video analysis were used to investigate how cognitive actions were planned and monitored, and also how monitoring strategies were regulated. Navigations of ILM screen-captured video were first parsed into events. An event is every single movement of ILM navigation captured. Two graduate students who had already taken the cognition class agreed to participate in "transcribing" ILM navigation into events with time stamp. Interrater reliability test was conducted to assign an event to an appropriate code. The data were coded into four categories: cognitive actions, planning, monitoring, and regulating strategies (see Table 2).

Table 2
Coding scheme and description.

Code	Description of code
Cognitive actions	Work on exercise available in the modules
Planning strategies	Read learning materials, view instructional videos, read instructions
Monitoring strategies	Check answer related to exercise available in the modules
Regulating strategies	Adjust any strategy when difficulties encountered, respond to any feedback received in the modules

The qualitative analysis was laborious and required a significant investment of time. The 24 screen-captured videos were transcribed by assistants. Concerns encountered during the transcription process were discussed between the researcher and assistants. Corrections made the time stamp as precise as possible, and 7% of time stamps were corrected during the review process. Moreover, Cohen's kappa was calculated between two raters for the coding process of sequence of events that represent SRL strategies (see Table 3).

Findings

The findings will be organized under two major sections. Each section will address one of the research questions. In the first section, we will report descriptive statistics of students' CSE while using ILMs. In the second section, we will present the findings regarding how high and low CSE groups plan and monitor their cognitive actions, and regulate their monitoring strategies during learning with ILMs.

Students' Computer Self-Efficacy While Engaged in Interactive Learning Modules

This section addresses the first research question, "How is students' computer self-efficacy while engaged in interactive learning modules?" To answer the question the researcher analyzed CSE questionnaires.

Descriptive statistics of students' computer self-efficacy

The internal reliability of CSE questionnaires was examined using Cronbach's Alpha (Brown, 2002; Cronbach, 1951) to measure the reliability of a number of items under one category in a questionnaire. The CSE questionnaire had very high internal consistency coefficients. The Cronbach's Alpha score for all items of CSE questionnaires was .954. Table 4 shows detailed information regarding the internal consistency coefficients of the CSE questionnaire.

Table 3
Cohen's kappa for cognitive actions and metacognitive strategies.

SRL feature	Cohen's kappa
Cognitive actions	.93
Planning strategies	.95
Monitoring strategies	.92
Regulating strategies	.90

Table 5 presents students' CSE that consists of their beginning, advanced, and file and software skills. The findings suggested that the students reported highest average score on beginning skills ($M=4.539$; $SD=0.519$) compared to advanced skills ($M=4.121$; $SD=0.725$) and file and software skills ($M=4.343$; $SD=0.641$).

Cognitive Actions and Metacognitive Strategies During Learning With Interactive Learning Modules

This section addresses the second research question, "How do students plan and monitor their cognitive actions, and regulate their monitoring strategies during learning with interactive learning modules?" To answer this research question, several steps were involved: (1) conducting cluster analysis; (2) selecting eight cases that represent both high and low CSE groups; and (2) analyzing qualitative data from screen-captured videos and interviews by involving selected students.

Cluster analysis based on computer self-efficacy

The purpose of cluster analysis was to find groups of students who have similar responses to the questionnaires. Cluster analysis of this study was conducted by considering students' CSE. This analysis is essential to investigate in more detail how students' cognitive and metacognitive strategies differed based on their CSE. The cluster analysis revealed three groups based on closeness of students' CSE, named as high CSE ($n=47$), medium CSE ($n=37$), and low CSE ($n=16$). Attention will focus on high and low CSE groups as they represent extreme conditions (i.e., high and low).

Selected cases

High and low CSE groups were revealed from cluster analysis. The researcher purposely selected four cases each from InTech Collegiate and Logan High Schools (see Table 5). The amount of time that the students spent while using the ILM was considered when selecting the eight cases. On average, the eight selected cases spent more time than did the other students in each category (i.e., high and low). Hypothetical names were used to represent the selected cases. The four selected cases in the high CSE group were Andy, Bailey, Carlos, and David. In addition, the four selected cases in the low CSE group were Earl, Farid, George, and Harold. Before presenting the results, profiles of selected students were created to provide

Table 4
Internal consistency coefficients of CSE questionnaire ($n=100$).

Category	Cronbach's Alpha	No. of items
All items	.954	29
Beginning skills	.866	10
Advanced skills	.919	12
File and software skills	.813	7

background information to the analysis. A summary of the selected students' characteristics is presented in Table 6.

Similar to the differences that existed between high and low CSE, the analyses of screen-captured videos and interviews revealed important differences between the two groups. From the analyses the researcher found that students with high CSE spent significantly more time on regulating strategies than did their low CSE peers. High CSE students also made strategy changes more often. When comparing the statements from the group interviews, the researcher encountered certain similarities and differences. Similarities between the two groups showed that previous experience in using a computer helped in using

the modules, preparing a strategy to find solutions for the tasks, and fixing errors in solving a problem. Differences between high and low CSE groups were found on strategies to carry out plans while using the ILM, strategies used to detect any errors in solving the task or problem, success parameters of using the ILM, and aspects of ILM that students like and dislike the most. Detailed findings from the qualitative data analysis are presented in the sections below.

Screen-Captured Video Analysis

Duration of cognitive actions and metacognitive strategies while using the modules between high and low CSE groups

An analysis of the duration of SRL strategies used by the students while using the modules revealed that, in general, the high CSE group spent a majority of their time on cognitive actions (50.45%) compared to monitoring (20.80%), regulating (17.47%), and planning (11.28%). The low CSE group spent the majority of their time on cognitive actions (54.01%) compared to monitoring

Table 5
Descriptive statistics of students' CSE ($n=100$).

Statement	<i>M</i>	<i>SD</i>
All items ($n\ item=29$)	4.319	0.602
Beginning skills ($n\ item=10$)	4.539	0.519
I feel confident working on a personal computer.	4.570	0.756
I feel confident entering and saving data (numbers or words) into a file.	4.550	0.757
I feel confident escaping (exiting) from the program (software).	4.610	0.827
I feel confident calling up a data file to view on the monitor screen.	4.250	0.925
I feel confident handling a flash drive correctly.	4.550	0.796
I feel confident making selections from an on-screen menu.	4.510	0.835
I feel confident using a printer to make a "hardcopy" of my work.	4.570	0.795
I feel confident moving the cursor around the monitor screen.	4.850	0.435
I feel confident using the computer to write a letter or essay.	4.730	0.566
I feel confident storing software correctly.	4.200	0.899
Advanced skills ($n\ item=12$)	4.121	0.725
I feel confident using the user's guide when help is needed.	3.960	0.942
I feel confident understanding terms/words relating to computer hardware, for example computer processing unit, hard-drive, memory.	3.910	1.055
I feel confident understanding terms/words relating to computer software, for example Microsoft Excel, Notepad, Adobe Photoshop.	4.290	0.902
I feel confident learning to use a variety of programs (software).	4.400	0.829
I feel confident learning advanced skills within a specific program (software).	4.100	1.040
I feel confident using the computer to analyze number data.	4.120	0.924
I feel confident writing simple programs for the computer.	3.850	1.258
I feel confident describing the function of computer hardware (e.g., keyboard, monitor, disc drives, computer processing unit).	4.290	0.868
I feel confident understanding the three stages of data processing: input, processing, output.	4.030	1.096
I feel confident getting help for problems in the computer system.	4.360	0.811
I feel confident using the computer to organize information.	4.340	0.956
I feel confident troubleshooting computer problems.	3.810	1.178
File and software skills ($n\ item=7$)	4.343	0.641
I feel confident getting the software up and running.	4.280	0.996
I feel confident copying a flash drive.	4.300	1.096
I feel confident copying an individual file.	4.600	0.711
I feel confident adding and deleting information from a data file.	4.530	0.731
I feel confident explaining why a program (software) will or will not run on a given computer.	3.710	1.157
I feel confident getting rid of files when they are no longer needed.	4.520	0.838
I feel confident organizing and managing files.	4.460	0.892

Table 6
Characteristics of selected eight cases.

Student	Gender	Ethnicity	Age	GPA	Class	Math level	Considering majoring in a technology field
Andy	Male	White	<17	3.50–3.74	Sophomore	Algebra 2	Yes
Bailey	Female	Mixed racial	<17	2.50–2.74	Sophomore	Algebra 2	Yes
Carlos	Male	White	<17	3.25–3.49	Sophomore	Algebra 2	Yes
David	Male	Asian American	<17	3.75–4.00	Sophomore	Geometry	Yes
Earl	Male	Asian American	<17	3.50–3.74	Sophomore	Algebra 2	No
Farid	Male	White	<17	<2.00	Sophomore	Geometry	No
George	Male	White	<17	3.50–3.74	Sophomore	Geometry	Yes
Harold	Male	Hispanic	<17	3.00–3.24	Freshman	Algebra 2	Yes

(21.15%), planning (15.76%), and regulating (9.08%). Table 7 shows the duration of SRL strategies for each group.

Selected cases from the high CSE group spent more time than their peers in the low CSE group. The researcher found from Chi-square tests that the differences in the duration were significant ($\chi^2=4.870$, $df=1$, $p<.05$). Specifically, the differences were significant in regulating strategies ($\chi^2=10.881$, $df=1$, $p<.01$).

Frequency of strategy changes while using the modules between high and low CSE groups

Furthermore, an analysis of the frequency of strategy changes while using the modules revealed that the high CSE group changed their strategies more often than did the low CSE group on all modules. On average, each high CSE student changed strategy 77.25, 58.5, and 17 times on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively. Each low CSE student changed strategy fewer times than did the high CSE group, on average, 43.75, 42.75, and 11.5 times on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

Moreover, the analysis of strategy changes revealed important differences across the two groups. The cases from the high CSE group made strategy changes more often than their peers from the low CSE group. The researcher found from Chi-square tests that the differences in the total frequency of SRL strategy changes were significant ($\chi^2=47.818$, $df=1$, $p<.001$). Specifically, the differences were significant in Boolean Logic ($\chi^2=37.099$, $df=1$, $p<.001$), Minimum Spanning Tree ($\chi^2=9.800$, $df=1$, $p<.01$), and Modeling Using Graphs ($\chi^2=4.246$, $df=1$, $p<.05$). Visualization examples of screen-captured

videos describing differences between the two groups are represented by Andy's and Earl's cognitive actions and metacognitive strategies while working on the Boolean Logic ILM (Figures 4–7). The figures show that Andy changed his strategies more often than did Earl.

The findings were also enriched by a summary of selected students' cognitive actions, metacognitive strategies, and task completion and students' answers to a few questions regarding their navigation on the modules.

Summary of Andy's cognitive actions and metacognitive strategies

An analysis of screen-captured videos revealed that Andy spent 36 minutes, 54 seconds on Boolean Logic; 19 minutes, 39 seconds on Minimum Spanning Tree; and 20 minutes, 14 seconds on Modeling Using Graphs. In terms of the strategies used, he spent 27 minutes, 40 seconds on cognitive actions; 8 minutes, 1 second on planning; 18 minutes, 20 seconds on monitoring; and 22 minutes, 46 seconds on regulating strategies on the three modules. Furthermore, it was revealed that he made 115, 29, and 16 strategy transitions on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

The researcher asked some questions related to Andy's strategies while using the modules. When asked about the strategy of getting prepared to find solutions for the task, he responded, "The first thing I did was... I saw all tools available. Saw what I could do." Andy also explained his strategies to carry out plans: "Well, what I originally trying to do is I'm trying to solve it as the program wants to solve it. Then I went to and I try to see whether I can do better than the program." Furthermore, he elaborated the strategies used to detect any errors in solving the task:

Table 7
Duration of cognitive actions and metacognitive strategies.

Groups	Cognitive actions	Planning strategies	Monitoring strategies	Regulating strategies	Total %
High CSE group	137 minutes and 3 seconds, 50.45%	30 minutes and 38 seconds, 11.28%	56 minutes and 31 seconds, 20.80%	47 minutes and 28 seconds, 17.47%	100
Low CSE group	120 minutes and 13 seconds, 54.01%	35 minutes and 5 seconds, 15.76%	47 minutes and 4 seconds, 21.15%	20 minutes and 19 seconds, 9.08%	100

Figure 4. An illustration of Andy's SRL strategies on the Boolean Logic module across time (part 1).

A lot of them...such as in the Minimum Spanning Tree, it wouldn't say what the solution was. But it would say the optimal answer would be. So that was definitely one way to check. And for the Boolean Logic just say, didn't work!

When the researcher asked him about strategies to fix any errors in solving the task, he answered:

I find if I keep getting an incorrect answer I am just not going back far enough. So, if I am only redoing my last step but I keep getting wrong answers, I just go back two steps, three steps, until I do find the error. Because as long as you did not make your mistake right at the beginning, that's more efficient than erase the whole thing.

Summary of Bailey's cognitive actions and metacognitive strategies

Analysis of screen-captured videos revealed that Bailey spent 38 minutes and 20 seconds on Boolean Logic, 9

minutes and 2 seconds on Minimum Spanning Tree, and 19 minutes and 39 seconds on Modeling Using Graphs. In terms of the strategies used, she spent 41 minutes and 58 seconds for cognitive actions, 13 minutes and 45 seconds for planning, 8 minutes and 1 second for monitoring, and 3 minutes and 57 seconds for regulating strategies on the three modules. Furthermore, it was revealed that she made 43, 37, and 28 strategy transitions on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

The researcher asked some questions related to Bailey's strategies while using the modules. When she was asked about the strategy of getting prepared to find solutions for the task, she responded, "Hmm, to read the instructions and explore what I can do. I think the predictability helps a lot. I try to make connections that may help to solve problems." Bailey explained her strategies to carry out plans while using the modules: "I guess, reviewing what you know. But it was easy because it's consistent and predictable." Moreover, she elaborated the strategies used to detect any errors in solving the task: "Like the option that told you

Figure 5. An illustration of Andy's SRL strategies on the Boolean Logic module across time (part 2).

Figure 6. An illustration of Earl's SRL strategies on the Boolean Logic module across time (part 1).

whether you're doing right or not, I guess if we just go back and check everything. Make sure we check the work." When asked about her strategies to fix any errors in solving the task, she answered, "You can ask for help. Read the instruction and materials again."

Summary of David's cognitive actions and metacognitive strategies

An analysis of screen-captured videos revealed that David spent 19 minutes, 31 seconds on Boolean Logic; 34 minutes, 28 seconds on Minimum Spanning Tree; and 18 minutes, 2 seconds on Modeling Using Graphs. In terms of the strategies used, he spent 33 minutes, 53 seconds on cognitive actions; 6 minutes, 20 seconds on planning; 17 minutes, 48 seconds on monitoring; and 14 minutes on regulating strategies on the three modules. Furthermore, it

was revealed that he made 41, 107, and 13 strategy transitions on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

The researcher asked some questions related to David's strategies while using the modules. When David was asked about the strategy of getting prepared to find solutions for the task, he responded, "Well, I read on the side (the instructions) and plan in my head what to do next. I read all through of the learning material." David also explained his strategies to carry out plans while using the modules, "Umm, just try to mess around..." When asked about his strategies used to detect any errors in solving the task, he stated, "I would click submit and see whether it is correct or not." David is an example of a student who reported high confidence in his skills related to using a computer, but did not show those skills while using the modules.

Figure 7. An illustration of Earl's SRL strategies on the Boolean Logic module across time (part 2).

Summary of Earl's cognitive actions and metacognitive strategies

An analysis of screen-captured videos revealed that Earl spent 30 minutes, 29 seconds on Boolean Logic; 17 minutes, 6 seconds on Minimum Spanning Tree; and 22 minutes, 8 seconds on Modeling Using Graphs. In terms of the strategies used, he spent 43 minutes, 58 seconds on cognitive actions; 12 minutes, 42 seconds on planning; 11 minutes, 4 seconds on monitoring; and 3 minutes, 39 seconds on regulating strategies on the three modules. Furthermore, it was revealed that he made 27, 22, and 17 strategy transitions on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

The researcher asked some questions related to Earl's strategies while using the modules. When Earl was asked about the strategy of getting prepared to find solutions for the task, he responded, "Play around with the functions or features of the module, read the instruction, and view the demo video." Earl also explained his strategies to carry out plans while using the modules: "Just try to complete the problems available on the ILM." Moreover, Earl elaborated his strategies used to detect any errors and fix them in solving the task: "If I find any errors in solving the problem, I just try it again."

Summary of Farid's cognitive actions and metacognitive strategies

An analysis of screen-captured videos revealed that Farid spent 33 minutes, 51 seconds on Boolean Logic; 19 minutes, 55 seconds on Minimum Spanning Tree; and 19 minutes, 12 seconds on Modeling Using Graphs. In terms of the strategies used, he spent 34 minutes, 20 seconds on cognitive actions; 13 minutes, 29 seconds on planning; 16 minutes, 32 seconds on monitoring; and 8 minutes, 23 seconds on regulating strategies on the three modules. Furthermore, it was revealed that he made 33, 52, and 15 strategy transitions on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

The researcher asked some questions related to Farid's strategies while using the modules. When Farid was asked about the strategy of getting prepared to find solutions for the task, he responded, "No. I'm not a specific person. I just play around with it." Farid also explained there were no specific plans he carried out while using the modules: "No. No plan." Furthermore, Farid elaborated his strategies used to detect any errors in solving the task, saying, "Hmm, I guess the closest thing is when it said that it was wrong." When asked about strategies to fix any errors in solving the task, he answered, "Try something different. Something that makes sense but different..."

Summary of George's cognitive actions and metacognitive strategies

An analysis of screen-captured videos revealed that George spent 10 minutes, 52 seconds on Boolean Logic; 13 minutes, 57 seconds on Minimum Spanning Tree; and 4

minutes, 28 seconds on Modeling Using Graphs. In terms of the strategies used, he spent 16 minutes, 18 seconds on cognitive actions; 2 minutes, 45 seconds on planning; 8 minutes, 36 seconds on monitoring; and 1 minute, 38 seconds on regulating strategies on the three modules. Furthermore, it was revealed that he made 25, 51, and 1 strategy transitions on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

The researcher asked some questions related to George's strategies while using the modules. When asked about the strategy of preparing to find solutions for the task, he responded, "I just see how it works. Review the instruction and just take it step by step." George also explained his strategies to carry out plans: "Just trial and error. Might get it wrong a couple times... You always get it right eventually I guess." Moreover, George elaborated his strategies used to detect any errors and fix them in solving the task: "Read through it and deep think about it. See if there is anything to be solved."

Summary of Harold's cognitive actions and metacognitive strategies

An analysis of screen-captured videos revealed that Harold spent 20 minutes, 52 seconds on Boolean Logic; 14 minutes, 47 seconds on Minimum Spanning Tree; and 13 minutes, 36 seconds on Modeling Using Graphs. In terms of the strategies used, he spent 25 minutes, 37 seconds on cognitive actions; 6 minutes, 9 seconds on planning; 10 minutes, 52 seconds on monitoring; and 6 minutes, 39 seconds on regulating strategies on the three modules. Furthermore, it was revealed that he made 90, 46, and 13 strategy transitions on Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs, respectively.

The researcher asked some questions related to Harold's strategies while using the modules. When asked about the strategy of preparing to find solutions for the task, he responded, "Umm, just try to mess around..." Harold also explained his strategies to carry out plans: "First, I tested it to see if it works and do some enhancements and take something out, and re-tested again." He elaborated the strategies used to detect any errors in solving the task: "I read the objective, if it is similar to it or on the spot then I think I did what I am supposed to do." When asked about strategies to fix any errors in solving the task, he answered, "First, look at my program. Review the answer if I missed. Just make some enhancement to it."

Issues Gathered From Interview

Differences and similarities between the high and low CSE groups were found in the data gathered from interview. An analysis of interview data revealed seven issues: five related to CSE, cognitive actions, and metacognitive strategies; and two related to students' perception regarding the features of the ILM. The five

issues were: (1) CSE, (2) planning strategies, (3) cognitive actions, (4) monitoring strategies, and (5) regulating strategies. In addition, the other issues were: (1) success parameters of using the ILM and (2) aspects that students liked and disliked about the ILM.

Issue 1: Previous experience in using a computer helps students to use the interactive learning module

Most of the students revealed that their previous experience helped them to navigate the ILM and use its features. Andy, who was one of the selected cases with high CSE, commented:

Hmm, alright, I have worked on programming before. I worked with other systems and I did have trouble with Boolean Logic originally. As for using the ILM, umm, my previous computer experience did help especially, the Boolean Logic, Minimum Spanning Tree, and Modeling Using Graphs. I think Modeling Using Graphs is probably the most complicated for me. Just general computer experience helps. I definitely try to use all resources available, umm, to help using the program. I said if I didn't know how to use the computer at all, definitely will be a lot harder. But, my previous computer experience just helps me make sure that I use all the tools available and hope to interact better with design, I suppose.

Similar to the comment reported by Andy, Harold said, "In some ways yes. It helps me to navigate. What can be done first, and what can be done later." However, Farid, one student who reported low CSE, said that, "I feel that my previous experience is not enough to use the ILM."

Issue 2: Strategy of preparing to find solutions for the task

When the interview participants were asked how they prepared themselves to find a solution to a task involving the interactive learning modules, almost all of them mentioned that they read the instructions first before working on the modules, except for Farid who said, "No. I'm not a specific person. I just play around with it." Among the respondents' comments, probably the most comprehensive response came from Carlos:

Looked at the button... See what they all do. I read the instruction to see what the objective is. And then I looked at different options and different difficulties to see how they range... And then I picked the easiest one at first... Make sure I am doing correctly and then I just progressively bump up it.

I just look over at the side objective again, reread them. Make sure they're solid in my mind. Look over the instructions for the module that currently I am doing and then I go into the module and I look at all the low buttons and hold my mouse because it tells you what

they do. And with that I know what the buttons do, so I can better use them.

Issue 3: Strategies to carry out plans while using the interactive learning module

The selected participants were also asked to share strategies they used to carry out their plans while using the ILMs. While most of the high CSE students executed their movements or steps somewhat carefully, the low CSE students tended to use a trial-and-error approach. For example, Andy tried to solve the problem by seeking the optimum solution, stating:

Well, what I originally tried to do is... I'm trying to solve it as the program wants to solve it. Then I went to and I try to see whether I can do better than the program.

Minimum Spanning Tree... I created minimum spanning tree, umm...check the answer. I continually revised my answers. When formulating my answers, I just go visually with what appears to be the best solutions.

On the other hand, most of the students with a low CSE reported that they just played around with the modules and hoped to be able to figure out and solve the problems, as mentioned by George: "Just trial and error... Might get it wrong a couple times. You always get it right eventually, I guess." One student, Farid, even said that, "No. No plan."

Issue 4: Strategies used to detect any errors in solving the task or problem

Detecting any errors or incorrect answers is critical in using the ILM. Participants' responses related to the strategies they used to make sure they were on the right track in solving the problem effectively. They reported that the feedback comments from their work on the modules were quite helpful. Interestingly, the high CSE students commented in more detail than did their low CSE peers. To investigate students' monitoring strategies more comprehensively, the researcher asked additional questions about the strategies used when dealing with the Modeling Using Graphs module that does not have a feedback mechanism. Andy knew exactly the available features on the interactive learning modules:

A lot of them... Such as in the Minimum Spanning Tree, it wouldn't say what the solution was. But it would say what the optimal answer would be. So that was definitely one way to check. And for the Boolean Logic just say, didn't work!

When asked about the Modeling Using Graphs, Andy responded:

You have much less constraints. But the way the graph generally taught...I think for a lot of students and I have

problem as well, it was quite difficult to go from our current conception of graph we have...and maybe a little bit more introductory phase would be good on that section. Maybe do a walkthrough example of one and then once they have one then you can give them a problem, build it with some constraints and then you want this. They can make it and then you can show them the example of another one. They can compare with their own.

Low CSE students responded with less details compared to their high CSE peers. For example, Farid stated, "Hmm, I guess the closest thing is when it said that it was wrong." Regarding their responses to Modeling Using Graphs questions, they felt frustrated. The same student, Farid, made a comment, "I think that...maybe just me...I was always slow. I don't understand it." In addition, George expressed his experience: "That is a little bit harder to work. But I think it wasn't too hard. But it was still quite challenging."

Issue 5: Strategies to fix any errors in solving a task or problem

The ability to fix any errors will help students to move forward and solve problems in the ILM. In general, students' responses were similar. They tried to figure out what was wrong and fix it. Based upon the review, only Andy and Bailey reported clear and specific approaches to deal with errors. Bailey was straightforward in making a comment: "You can ask for help. Read the instruction and materials again." Andy mentioned his strategy:

I find if I keep getting an incorrect answer I am just not going back far enough. So, if I am only redoing my last step but I keep getting wrong answers, I just go back two steps, three steps, until I do find the error. As long as you were not making a mistake right at the beginning, that is more efficient than erasing the whole thing.

Issue 6: Success parameters of using the interactive learning module according to the students

An issue regarding success parameters while using the ILM is a very important point to emphasize. Since every interviewed participant has a different or unique perspective, the researcher outlined all of their comments:

Andy: "You have to use computer before. But even without any experience in Boolean Logic, or Minimum Spanning Tree, I think you can still use the program (ILM) successfully and learn from it. You might...umm, some motivation. I'd say a person doing it with peers around them would do it a lot more energetically than just them alone. Doing it in a group setting, I'd say it is more beneficial."

Bailey: "Whether they have previous knowledge or not might be the constraint. I guess you have to pay attention. I thought it was easy."

Carlos: "I think they just need to use the steps I specified earlier. You know, just first look at the objectives, remind yourself what you're trying learn, look at the instructions so you can do it correct the first time, not how to try it several times. And then going to the module, make sure you know what the buttons do. Then do what it asks you to do. Then just go through and do it and check your answer and if they're incorrect hasn't it an option that shows you what you did incorrectly? Use it because it will tell you. Opinions on how you're doing are great. It helps you to improve yourself even if it's a negative feedback. Okay, I can improve myself in this area. But if it is a positive feedback I'm good in this area, then I should focus more on this area where I am not doing so great. And that's where this module comes in."

David: "Hmm, I would say read the instructions first. Make sure you understand what to do."

Earl: "Keep trying... ILM should be created by considering a real-life situation. For example, I really like the Minimum Spanning Tree and Boolean Logic part that show real-life objects (e.g., cars, people)."

Farid: "Bring headphones so he can listen to the instruction audio."

George: "Just kind of trial and error. Check often, make sure you do it right."

Harold: "Reread the objectives twice. If you don't get it, follow the objectives. Be on task."

Issue 7: Aspects of interactive learning module that students like and dislike the most

Students in the high CSE group explained specifically the aspects of the ILMs that they liked the most. Andy liked the feedback mechanism of the modules:

Hmm, I would say what I really like about it was the fact that you could do something and then it would tell you, oh you did this wrong. And it wouldn't just say you did it wrong. It would say, you did it wrong, here is a hint to help you and then you can go back and fix it. And then you can do another different problem and then see if you can do right at that time. Instead of just saying you did it wrong, but never actually telling you why you're wrong.

Similar to Andy's comments, David stated, "I like all of it. It's really interesting. The features are really cool. Also the feedback feature is good. When it says I don't get it right. You know...I try to get it right." Another interesting point came from Carlos:

Hmm, the fact that they were pretty challenging ones... I couldn't just have all really easy ones. All really challenging ones... It did build up and it's like progressive order. You can like do some easy ones. Learn how... What the goal of the module is you can bump it up harder where you can challenge yourself a little bit.

On the other hand, the low CSE group focused more on the picture and navigation of the ILMs as the aspects they liked the most. Earl commented, “I like the module that has cartoons. I like it because it is not boring. It looks cool.” Another student, Farid, pointed out, “I like the pictures. It does make the thing easier.”

Moreover, students also disliked some aspects of the ILMs such as the design which they reported as looking “amateurish” and navigations that were confusing in parts. For example, Bailey commented, “I think the interface is just like amateur.” Also, Farid stated, “Structure on the side. I think they’re pretty confusing. I didn’t understand. I just do it, I think that’s right, and move on.”

Conclusions and Discussion

Descriptive statistics analysis of the CSE questionnaire found that the students achieved the highest average score on beginning skills compared to advanced skills and file and software skills. Overall, the students reported high confidence on their abilities dealing with computer for all CSE scales. Cluster analysis found two extreme conditions regarding student CSE: high and low CSE groups. Analyses of screen-captured videos revealed the duration of SRL strategies used by the students while using the modules and showed that, in general, the high CSE group spent a majority of their time on cognitive actions compared to monitoring, regulating, and planning. The low CSE group spent the majority of their time on cognitive actions compared to monitoring, planning, and regulating strategies. Furthermore, an analysis of the frequency of strategy changes while using the modules revealed that the high CSE group changed their strategies more often than did the low CSE group on all modules. These findings suggested that the high CSE group felt more flexible in changing their strategies than the low CSE group. Moreover, the high CSE group might feel more comfortable than the low CSE group by spending more time working with the modules. The findings are similar to the work of Bandura (1977) and Brosnan (1998), whose studies suggested that individuals with higher self-efficacy tend to achieve greater changes in behavior and spend more time while engaged in tasks than their peers with lower self-efficacy.

The interview data analysis revealed differences and similarities between high and low CSE groups. The analysis found seven issues: five related to CSE, cognitive, and metacognitive strategies; and two related to the students’ perception regarding the features of the ILM. *First*, most of the students participating in the interview reported that their previous experience helped them to navigate the ILM and use its features. The findings suggested that students need to have experience in using a computer before learning using ILMs. *Second*, when the interview participants were asked how they prepared themselves to find a solution to a task involving the

ILMs, almost all of them mentioned that they read the instructions first before working on the modules, except one student from the low CSE group who reported that he just played around with the modules. *Third*, the participants were also asked to share strategies they used to carry out their plans while using the ILMs. While most of the high CSE students executed their movements or steps somewhat carefully, the low CSE students tended to use a trial-and-error approach. *Fourth*, participants’ responses related to the strategies they used to make sure they were on the right track in solving the problem effectively. They reported that the feedback comments from their work on the modules were quite helpful. Interestingly, the high CSE students commented in more detail than did their low CSE peers. *Fifth*, the ability to fix any errors will help students to move forward and solve problems in the ILM. In general, students’ responses were similar. They tried to figure out what was wrong and fix it. Based upon the review, only students from the high CSE group reported clear and specific approaches to deal with errors. *Sixth*, an issue regarding success parameters while using the ILM is a very important point to emphasize. Every interviewed participant has a different or unique perspective regarding the success parameters, such as the importance of previous experience; working in a group is more beneficial; the importance of reading the objectives of the activities; keep trying; or using a trial-and-error approach. *Seventh*, while the students from the high CSE group liked the feedback mechanism of the modules the most, the low CSE group focused more on the picture and navigation of the ILMs as the aspects they liked the most.

Implications

This research has implications for SRL researchers and teachers, and ILM developers. Analysis between high and low CSE groups revealed that students who reported high CSE tended to have high strategy changes and spent more time on the modules than low CSE students. Informed by these findings, in particular, SRL researchers may consider CSE as a factor that may influence students’ cognitive actions and metacognitive strategies in an ILMs context.

Furthermore, the findings of this research may also inform any teacher who uses ILMs or any CBLE to design appropriate instructional strategies while using electronic modules in their classrooms. Working with around 20 high-school students or more in a classroom is not an easy task. When students work on the module, they often asked what they should do or asked about the features of the module. The teacher may need to have assistants when she or he asks the students to learn computer science-related concepts using the modules.

The findings also have implications for the developers of ILMs. Improvements of these modules can have two aspects: feature and usage. Based upon the comments from

interviewed participants, some features that need to be improved include: the graphics, instructions, and feedback mechanism. An ILM can also be improved in terms of its usage. The researcher's observation while collecting the data in classroom and computer lab found that the students sometimes got confused with the modules and asked their friends or their teacher. This finding suggests that it may be helpful for the students to work in groups, instead of working individually. However, the consequence of this option is the arrangement of the chairs needs to be adjusted to enhance learning convenience.

Recommendations for Future Studies

There were three recommendations made associated with the sample of this study, research design, and context of the study. *First*, students who participated in this study enrolled in different classes such as programming, math, and physics. Depending of the objective of future studies, a sample can be limited to only students who enroll in a programming class. This sample can be used if we want to focus more on pedagogical improvement in a computer science education context. However, a more diverse sample can also be used if the focus of study is more on the evaluation of ILMs.

Another recommendation related to the sample of the study was connected to the characteristics of the students. The way that high-school students work may influence the results. According to the researcher's observation during the pilot and main study, students got distracted easily. Although the majority of the participants focused on the modules, a few students might distract the entire class because of the noise they made. The researcher also noticed that students accessed irrelevant web pages while using the modules. The appearance of the teacher during the data collection process could help the students to focus on working on the modules.

Second, the nature of this study is a descriptive one. This study investigates students' CSE, cognitive, and metacognitive strategies while using ILMs. In other words, this study captures students' strategies when using an example of a CBLE. Informed by the findings of this study regarding the differences of students' cognitive and metacognitive strategies based on their CSE, researchers can create any intervention to improve cognitive and metacognitive strategies of students with low CSE. Research suggests that CSE and self-regulation skills can be trained (Coutinho, 2008; Kher, Downey, & Monk, 2013). Experimental study can be conducted to see whether modified ILMs can improve either CSE or cognitive and metacognitive strategies.

Third, regarding the context of this study, further research can use a similar approach to that used in this study to be applied to other CBLEs such as modules developed by Khan Academy or modules presented by

Massive Open Online Courses (MOOC) providers such as Coursera and Udacity. Ideas of educational research on MOOC have been proposed recently to analyze student learning while using the MOOC application (e.g., Breslow et al., 2013; Daly, 2013; Simonite, 2013). However, it is not clear yet what framework is used in the analysis.

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