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A preliminary study of the relationship between self-efficacy and cognitive load on solving ill-structured problem

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Students often need to face a complicated case when trying to make a decision in the class. Moreover, the related information that required solving the problem is usually insufficient; meanwhile, the solutions of the problems are either multiple or not at all. The study tries to explore the relationship between students' self-efficacy and cognitive load on solving ill-structured problems. A total of 90 questionnaires were sent to undergraduate students to understand their attitude toward the issue. The preliminary results indicated that there exists close relationship between students' self-efficacy and cognitive load when solving ill-structured problems**ABSTRACT**
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KEYWORDS: self-efficacy, cognitive load, solving ill-structured problem

Introduction

In the field of business education, students often need to face a complicated case when trying to make a decision in the class. They have to choose a best alternative among different situations. As researchers (Chi & Glaser, 1985) noted, ill-structured problems are usually ill defined, open ended and connected with the real life. Moreover, the related information that required solving the problem is usually insufficient; meanwhile, the solutions of the problems are either multiple or not at all. For the features stated above, students are all in a jumble and not knowing where or how to start when solving ill-structured problems. Numerous researchers and educators were trying hard to find out the way to help students on solving problems from the perspective of instructional design in the past many decades.

Prior research（Shih,2006）reported that if students are confident in their learning, they may perform as expected. In other words, if their self-efficacy is high, then their ability of problem-solving may be increased simultaneously. Self-efficacy was defined as:" People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performance. It (self-efficacy) is concerned not with the skills one has but with judgments of what one can do with whatever skills one possesses." (Bandura, 1986: p. 193) It is a motivational factor that plays a critical role on learning (McRobbie & Thomas, 2000; Roth & Tobin, 2001). Knowledge, skill, and prior attainments are regarded as poor predictors of students' subsequent achievements because the beliefs that they hold toward their own ability to solve the problem can powerfully influence their performance on problem-solving (Pajares, 1996) .Therefore, two students with the same ability and experiences , the one with higher self-efficacy may outperform the other one.

On the other hand, as the prosperity of technology in the recent decades, computing has become more and more prevalent in higher education, a lot of academic activities (such as electronic database of library, courses related to computer, or the accomplishments of assignments …, etc.)are facilitated through the device of computer. Whether a student is skilled on using computer has become one of the important criterions to evaluate his/her performance. According to Bandura's work (1995) , the concept of self-efficacy can be applied in different domains. Computer self-efficacy can be regarded as people's judgment of their own abilities on computer. For dealing with computer has become most of the students' daily life, the higher the student's computer self-efficacy, the better the performance they may present.

Imagine a student is facing a complex problem with insufficient information and the contents are highly interactive with other domain of knowledge, what kind of procedure would the student adopt to facilitate him/her to reach the best solution? Cognitive load theory provides a theoretical background for understanding the cognitive process and instructional design, which may be helpful to answer the questions. Cognitive load theory assumes that the processing ability of learner is limited; so it is important to properly allocate the cognitive resource to enhance learning ability otherwise too much mental burden may cause learning be hindered (Kalyuga, Chandler & Sweller, 2001). Based on the statements above, one may wonder that what kind of cognitive load does a student need to burden if s/he is with high self-efficacy when solving ill-structured problem? Therefore, the objective of the study is to explore the relationship between self-efficacy and cognitive load on solving ill-structured problems.

Self-efficacy

Self-efficacy means people's judgment toward their ability to solve the problem, it is an internal motivational factor that would have impacts on the problem-solving performance. The belief of self-efficacy influences our daily lives in various domains such as student's learning outcomes(Pajares, 1996; Meece, Wigfield, and Eccles, 1990), patient's control over pain(Manning & Wright, 1983), and sportsman's performance on the playground (Barling & Abel,1983) . It is a powerful factor to predict people's achievements because it can help to determine how much effort a man should spend on the task and how long he should persist in doing the mission（Pajares, 1996）. A man with low self-efficacy would think that things are more difficult and complicated than expected. In contrast, a man with high self-efficacy may usually perform than predicted.

In the past many years, self-efficacy has attached more and more attention on evaluating academic achievements. Prior research （Lent, Brown, & Larkin, 1987; Pintrich & De Groot, 1990）reported that self-efficacy is the most powerful factor in forecasting students' academic performance than any other internal motivation component. As noted, students with high self-efficacy will tend to engage more energy in a complicated case and hold on straight with it when they run into difficulties or obstacles. In other words, students' beliefs in efficacy can powerfully influence and regulate their learning, control their academic activities, guide their level of motivation and promote their academic accomplishments（Bandura, 1993）.

Likewise, students with low sense of efficacy would be vulnerable to face academic difficulties. Prior research （Meece, Wigfield, and Eccles, 1990） reported that past academic experiences（no matter successes or failures）may produce anxiety through their effects of self-efficacy. The unsatisfied achievements may decrease their sense of efficacy and make them perturbed about academy. Therefore, students' self-efficacy on academic program would effectively forecast their subsequent academic performance, while the degree of anxiety does not have impacts on it.

Cognitive load and learning

Cognitive load theory emphasizes on the topics of learning contents and instructional design on learner's influence. Human's working memory stores and processes information. However, the capacity of working memory is limited, one can process only two or three items of information at a time. Too much information may cause the overburden of working memory and decrease its processing ability (Kalyuga, Chandler & Sweller, 2001). Therefore, the design of instructional material should be within the capacity of working memory to ensure the understanding by students. In contrast, long-term memory, holds knowledge permanently and with unlimited capacity, can overcome the limitations of working memory (Kirschner, 2002). The major function of long-term memory is to store schemas, which can hold a vast amount of information. "Schemas are domain-specific knowledge structures that allow people to categorize multiple elements of information as a single element." (Kalyuga, Chandler & Sweller, 2001:p.6) In other words, schema has the function of storing and organizing the elements of information. The difference between expert and novice is that expert's long-term memory holds a great number of schemas that related with various domains of knowledge, whenever confronted with problems, expert can acquire solutions from schemas right away (Sweller, Mawer, & Ward, 1983) and find out the best alternative for solving the problem. Thus, the objective of instructional design is to build shema and automation, and how to reduce the difficulty of information in working memory to construct schemas is the critical issue of cognitive load theory.

From the perspective of instructional design, cognitive load theory provides substantial theoretical framework to interpret the instructional structure. Intrinsic cognitive load is one form of cognitive load and determined by the intrinsic character of the instructional material or learning task itself. A very difficult material may overburden learner's intrinsic cognitive load and result in an inferior learning outcome. Meanwhile, one cannot make changes in the degree of intrinsic cognitive load as "it is determined by the interaction between the nature of the materials being learned and the expertise of the learner" (Merrienboer and Sweller, 2005, p.150). If the material is hard to be understood depends on the amount of elements that need to be processed at the same time and the interactivity among elements of the material. A material with high element interactivity is difficult to understand and need to develop cognitive schemata to integrate the high interacting elements. As ill-structured problems possess the characteristics stated above, students usually have difficulties to deal with the processing of ill-structured problem solving; therefore, the presentation of instructional material would be a key factor to influence the students' performance.

Extraneous load is another category of cognitive load; the unrelated information or unnecessary load is the cause of extraneous load, which is alterable by the different design of material. Conventional instructional design often imposes unrelated mental load on students for it was not developed under the consideration of knowledge structure or cognitive architecture（Paas, Renkl & Sweller, 2003）. During the process of problem-solving, students need to search for solutions or related information, so the resources come from working memory have to be used. However, for the activity may not be relevant to schema acquisition or automation, it may be the cause to overburden of students' extraneous cognitive load. In other words, instructional design should be presented in a proper way to enhance learning but not add extra load on learners.

The other form of cognitive load is germane load or effective cognitive load. Similar to extraneous load, germane load will also be influenced by instructional design; it does not only increase learners' cognitive load but also their learning efficiency. That is, a designed instructional material will both increase student's extraneous cognitive load and germane load. However, extraneous cognitive load blocks students' learning while germane cognitive load facilitate learning（Paas, Renkl & Sweller, 2003）.

Method

Participants

90 undergraduate students, who were registered in the course of Service Marketing during a spring semester in last year at a university located in the south of Taiwan were invited to participate the study.

Material and procedure

The participants were requested to fill out a self-reported questionnaire to evaluate their self-efficacy and cognitive load toward the problem. The questionnaire mainly consisted of two parts: Part one, the demographic part, recorded the subject's gender, age, and level of education; Part two measured the participant's self-efficacy and cognitive load.

The questionnaire consisted of 45 items measuring the five different constructs, which are presented in Table 1. The items of the first two constructs utilized the ones developed by Durndell, Haag, & Laithwaite (2000) which was adapted from Torkzadeh and Koufteros's version of the Computer Self Efficacy scale（1994）. Data of the first two constructs were collected using a seven-point Likert-type scale, from 1 (not at all true of me) to 7 (very true of me). The third construct was developed based on the definition reported by Chi & Glaser (1985). The fourth construct was one of the constructs that developed by Pintrich, Smith, García, & McKeachi（1991,1993）. The fifth construct was developed based on the model presented by Paas and van Merrienboer（1994） to evaluate the participants' mental load, mental effort and performance. Data of the last three constructs were collected using a seven-point Likert-type scale, from 1 (strongly disagree) to 7 (strongly agree). Then the instrument was translated into Chinese by a bilingual professional to ensure its validity.

Table 1 Constructs of the scale

Constructs	Item	Reference
Hardware Self-efficacy	1-21	Durndell, Haag, & Laithwaite, (2000)
Software Self-efficacy	22-29	Durndell, Haag, & Laithwaite, (2000)
Problem-solving Self-efficacy	30-34	Chi& Glaser (1985)
Learning Self-Efficacy	35-42	Pintrich, Smith, García, & McKeachi（1991,1993）
Cognitive Load	43-45	Paas and van Merrienboer（1994）

Operation measure

Hardware Self-efficacy: The participants were requested to answer the judgment of their own abilities on computer hardware, such as how to initiate and operate computer device and its peripheral equipment, the utilization of computer related information and the understanding of computer language…etc. The higher the score, the higher the respondents' self-efficacy toward computer hardware.

Software Self-efficacy: The dimension measured the respondents' personal evaluation of their own capability on operating computer software, such as the organizing and managing files, the using of computer program and the handling of minor trouble…etc. The higher the score, the higher the respondents' self-efficacy toward computer software.

Problem-solving Self-efficacy: The participants were requested to express the judgment of their own abilities on problem-solving. For the given problem is ill-structured, the respondents were asked about their self-efficacy related to the understanding of the problem and the certainty of problem-solving. The higher the score, the higher the respondents' self-efficacy toward problem-solving.

Learning Self-Efficacy: The construct was devised to evaluate the respondents' self-evaluation toward the course. The higher the score, the higher the respondents' self-efficacy toward the course.

Cognitive Load: The section measured the participants' mental load, mental effort and performance. The higher the score, the higher the respondents' cognitive load toward the given problem.

Conclusion

The preliminary results indicated that self-efficacy and cognitive load on solving ill-structured problems are closely related. The higher the respondents' self-efficacy, the higher the cognitive load they hold. Future researchers may go further to explore and understand the gender difference about the issue.

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