The application of social cognitive theory to web-based learning through NetPorts

Shu-Ling Wang and Sunny S. J. Lin

Shu-Ling Wang is an assistant professor in the Center of Teacher Education at the National Taiwan University of Science and Technology. Sunny S. J. Lin is a professor in the Institute of Education at the National Chiao Tung University. Email: sunny@faculty.nctu.edu.tw. Address for correspondence: Shu-Ling Wang, Center of Teacher Education, National Taiwan University of Science and Technology, #43, Sec. 4, Keelung Rd. Taipei, Taiwan, R.O.C. Email: shuling@mail.ntust.edu.tw

Abstract

Although the Web allows for flexible learning, research has found that online students tend to lack focus, willingness to participate, confidence, and discipline. This study thus attempts to promote Web-based self-regulated learning from the social cognitive perspective, which emphasizes the interactions among personal, behavioral, and environmental influences.

This study has identified the most significant factors for personal, behavioral, and environmental influences in the social cognitive model of self-regulated learning, and also applied this model to the development of the NetPorts web-based learning system. NetPorts, in turn, allows us to empirically analyze the interactions between the aforementioned factors. Our Web-based findings support the social cognitive view of self-regulated learning: students who hold higher levels of motivation apply more effective strategies, and respond more appropriately to environmental demands, in the Web-based learning environment. These findings also further validate the application of the social cognitive model to Web-based learning through the NetPorts.

Introduction

Web-based learning tools provide students with greater access to information, as well as enhanced opportunities for working collaboratively with peers, all without constraints of time and distance (Palmieri, 1997). Research in education has increasingly focused on delineating the optimal methods for motivating e-learners while facilitating online learning behaviours. Many researchers draw on the social cognitive theory in order to explain and analyse the relationships between personal, behavioural and environmental influences, and to move towards the goal of helping students achieve high levels of self-regulated learning. Self-regulated learning, proposed by Zimmerman...
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(1989), describes students’ active involvement in self-motivation and the use of appropriate learning strategies to pursue self-established goals. Although the Web allows for flexible learning, many researchers have found that online students tend to lack focus (Boechler, 2001), willingness to participate, confidence (Hasan, 2003) and discipline (Castella, Abad, Alonso & Silla, 2000). Thus, there is a compelling need for self-regulated learning guidelines in web-based environments.

The social cognitive perspective holds that successful self-regulated learners possess higher levels of motivation (personal influences), apply more effective learning strategies (behavioural influences) and respond more appropriately to situational demands (environmental influences) (Pintrich & Schunk, 2002). In order to facilitate self-regulated learning, teachers must consider the interactions of environmental influences, student perceptions and learning behaviours. Unfortunately, researchers and engineers who construct web-based learning systems tend to overlook all but a few of the aforementioned factors and rarely examine influences and reciprocal interactions (Compeau & Higgins, 1995; Compeau, Higgins & Huff, 1999). This study thus introduces the important factors for personal, behavioural and environmental influences of the social cognitive model and analyses the interactions among these three influences.

The proposed social cognitive model further allows us to extrapolate guidelines for the development of the Networked Portfolio (hereafter referred to as NetPorts) web-based learning system, which was developed with simple functions in its early stages. Although some of our studies were conducted using the early version of the NetPorts system, the findings indicated a need to add more functions to enrich the system functionality. For a detailed description of the early development of the NetPorts system, see Liu, Lin and Yuan (2001).

Personal, behavioural and environmental influences on design considerations

Personal influences

Figure 1 delineates several important personal characteristics of online learners, including highly influential motivational factors: self-efficacy, task value, anxiety at the individual level and group efficacy at the group level. Three motivational components are believed to exert a significant influence on academic achievement: (1) an expectancy component (‘Can I do the task?’ eg, self-efficacy), (2) a value component (‘Why am I doing this task?’ eg, task value) and (3) an affective component (‘How do I feel about this task?’ eg, anxiety) (Pintrich & De Groot, 1990; Pintrich & Schunk, 2002).

According to Pintrich and Schunk (2002), the expectancy component may be conceptualized as the students’ belief that they are capable of performing the task. Particularly, self-efficacy, the students’ perceptions of their capability to execute an action required to achieve a particular outcome (Bandura, 1986), has been found to have strong influences on the choice of activity, the effort expended, the willingness to persist and task accomplishment (Bandura, Barbaranelli, Caprara & Pastorelli, 1996; Zimmerman, 1996). Research suggests that self-efficacy is more powerful in predicting academic

In addition to the expectancy component, the value component refers to students’ beliefs about the importance and interest of the task (Pintrich & De Groot, 1990). For example, task value is defined as individuals’ perceptions about the importance, utility or interest of a task (Eccles & Wigfield, 1995), which have been found to have strong effects on achievement behaviour (Eccles & Wigfield, 1995). Although it has been argued that task value is a better predictor for choice behaviours such as enrolment in courses and intentions to take future courses rather than actual achievement (Eccles, 1984), Pintrich and Schunk (1996), summarising most studies, suggested that task values positively relate to students’ actual achievement. However, although research shows that task value plays an important role in academic learning, research seldom examines its effects on web-based learning.
The affect component refers to students’ emotional reaction to the task. While test anxiety constitutes one of the most prevalent affective reactions in school learning contexts (Wigfield & Eccles, 1989), recent research indicates that computer anxiety, or negative emotional reactions to actual or imaginary interactions with computer-based technology (Bozionelos, 2004; Huang & Liaw, 2005), also has negative effects on performance levels (Brosnan, 1998; Desai, 2001; Desai & Richards, 1998; Eysenck, 1992). In a study of computer-based searching tasks, computer anxiety was found to affect the number of correct responses (Brosnan, 1998).

Group motivation has significant effects on group performance (Bandura, 2000; Gibson, 1999). Particularly, collective efficacy or the team members’ belief in the team’s ability to achieve learning goals has been proven to be positively correlated to group performance in a number of studies on fields such as schools, organisations and sports (Bandura, 1997; Goddard, 2001; Greenlees, Nunn, Graydon & Maynard, 1999; Hodges & Carron, 1992; Peterson, Mitchell, Thompson & Burr, 2000). According to Bandura (1997), collective efficacy is concerned with the group’s performance capability as a whole. Research shows that collective efficacy has a significant effect on group functioning, especially on the level of effort, persistence and achievement (Bandura, 1997, 2000; Durham, Knight & Locke, 1997). Our research in computer-supported learning shows that students with higher collective efficacy use more high-level of cognitive skills during their group discussion (Wang & Lin, in press), and demonstrate better group performance (Wang & Shiu, 2005).

**Behavioural influences**

In terms of behavioural influences, we focused primarily on learning strategies, feedbacks and group discussions. The inclusion of these factors is based on research that suggests that: (1) the use of proper cognitive (and metacognitive) strategies enhances students’ academic performance (Pintrich & Schrauben, 1992), (2) a higher quality feedback is an indication of advanced critical thinking skills among learners (Wang & Wu, 2002) and (3) a better quality of online group discussion and interaction is pivotal to successful web-based learning (Wang & Lin, in press; Wang & Shiu, 2005).

The students’ use of cognitive strategies has been found to have important effects on self-regulated learning processes (Pintrich, 2000). Weinstein and Mayer (1986) identify rehearsal, elaboration and organisational strategies as important cognitive strategies affecting academic achievement (Pintrich & De Groot, 1990; Pintrich & Schrauben, 1992). Research has shown that the selection of appropriate cognitive strategies can have very positive effects on learning and performance (Pintrich, 2000). For example, research on strategy use and information processing suggests that the use of elaboration and organisational strategies can help students to develop a deeper level of comprehension as compared to simple rehearsal strategies (Marton, Hounsell & Entwistle, 1984). Elliot, McGregor and Gable (1999) also identify that deeper level cognitive strategies involve elaboration and critical thinking, whereas surface level strategies involve memorisation and rehearsal. A study of computer-supported collaborative learning (CSCL) indicates that deeper level and
metacognitive strategies are critical in inquiry-based knowledge constructions (Salovaara & Jarvela, 2003).

In addition to cognitive strategies, metacognitive strategies consist of three general types of strategies: planning, monitoring, and regulating (Pintrich & Schrauben, 1992). Research has shown that the use of metacognitive strategies has positive effects on students’ academic performance (Pintrich & Schrauben, 1992; Pressley, 1986; Schraw & Nietfeld, 1998). For example, Schraw and Nietfeld (1998) indicate the positive relationships between self-monitoring and academic achievement. In addition, research on computer-supported collaborative learning suggests that metacognitive strategies are important for inquiry-based knowledge construction (Salovaara & Jarvela, 2003). A recent study conducted in the web-based environment also shows that students who are prompted to monitor their progress demonstrate better achievement than those who are not (Kauffman, 2004).

In addition to the use of cognitive or metacognitive strategies, research generally supports that learning is more effective when learners provide feedback (Bangert-Drowns, Kulick, Kulick & Morgan, 1991; Butler & Winne, 1995; Meyer, 1986). Particularly, research suggests that students who provide high-quality feedback to their peers are also critical thinkers (Wang & Wu, 2002). For example, a study indicates that students who apply more critical-thinking strategies tend to give high-quality feedback (eg, elaborated feedback) while those who use rehearsal strategies only provide a lower quality feedback (eg, knowledge of results) in the web-based environment (Wang & Wu, 2002). Indeed, from the social cognitive perspective, students who are more actively involved in their learning, such as providing high-quality feedback, are more likely to demonstrate better learning behaviours and academic performance.

In addition to individual learning, educational research has increasingly focused on the importance of collaborative learning (Garrison, Anderson & Archer, 2001; Johnson & Johnson, 1999; Kreijns, Kirschner & Jochems, 2003; Veerman, Andriessen & Kanselaar, 2000) and attempted to explore effective collaborative learning behaviours that promote learning and achievement (Wang & Lin, in press; Wang & Shiu, 2005). Although research tends to suggest that web-based collaborative learning can promote learning better than traditional collaborative environments can (Cohen & Scardamalia, 1998), research also declares that there are some potential losses such as free riding, social loafing and diffusion of responsibility (Benbunan-Fich & Hiltz, 1999), particularly when the teachers’ monitoring is not as direct in web-based learning situations as it is in the classroom. Thus, collaborative learning behaviours or processes may determine the success of web-based collaborative learning. Our previous research shows that group members who are highly cognitively involved in web-based group discussion tend to have a better academic performance (Wang & Shiu, 2005). In addition, research also suggests that the quality of communication during group interaction is positively related to group performance (Hooper, 2003; Tschan, 2002). Moreover, research suggests that groups that are more involved in the process stage perform better than those only involved in the input or output stages in the web-based learning environment (Wang &
Shiu, 2005). These studies support that group-based behaviours such as group discussion or interaction play a very important role in web-based collaborative learning.

**Environmental influences**

Environmental influences include factors such as feedback and assessment from peers and teachers as well as review of others’ efforts to improve performance. Feedback has been acknowledged as an effective social learning mechanism (Butler & Winne, 1995) that helps students correct misconceptions, improve academic achievement and enhance motivation (Wang & Wu, 2002; Zimmerman & Martinez-Pons, 1992). Previous studies indicate that receiving feedback correlates to effective learning (Bangert-Drowns et al., 1991; Crooks, 1988; Kulik & Kulik, 1988). In particular, receiving immediate and plentiful feedback can prevent some errors and provide clues for making progress. Our previous findings in web-based assessment indicate that specific feedback is much more beneficial than global feedback (Lin, Liu & Yuan, 2001); this serves as a compelling justification for the inclusion of a peer-assessment module.

Following along the lines of Pintrich and Schunk (2002), we treated the evaluation of academic performance by peers or teachers as a source of environmental influences. Research has suggested that peer assessment is an influential assessment strategy, enabling students to become more involved in the class activities (Sluijsmans, Dochy & Moerkerke, 1999). Research also shows a fairly high level of agreement between peer and teacher assessments (Falchikov, 1993; Freeman, 1995). Our own previous research developed procedures for networked peer assessment, which have proven both reliable and valid and indicate that peer assessment is more strongly related to teacher assessment than self-assessment (Liu, Lin & Yuan, 2002).

Since Pintrich and Schunk (2002) also found that students are capable of learning complex skills through observing modelled performances, modelling effects were thus considered as an important source of environmental influences in our model. Observing similar peers complete a task successfully may convey a sense of self-efficacy so as to improve performance. A study of computer skill training indicates that behavioural modelling has impacts on students’ efficacy beliefs and computer performance (Compeau & Higgins, 1995). Our previous study of the effect of peer review through the web-based system indicates that students with high assignment scores are those who can strategically adopt peers’ critiques for self-improvements (Liu, Lin, Chiu & Yuan, 2001). When we compared the students’ assignment scores (with peer review) with their final scores (without peer review), we found that students perform better with peer review.

In summary, while a number of significant personal, behavioural and environmental factors have been identified, to date, only a few studies have explored their effects and interactions in web-based environments. These latter considerations, however, are vital to the social cognitive perspective of self-regulated learning. The next section describes interactions among influences, which in turn help us to understand their effects in learning.
Interactions among the three dimensions
A brief sketch of the theory and research in interactions between personal, behavioural and environmental influences affords a better understanding of the social cognitive view of self-regulated learning. Motivational beliefs exert a significant influence on students’ learning behaviours and vice versa. Students with higher levels of motivation are generally more willing to use sophisticated learning strategies (Pintrich & Schrauben, 1992). Regarding the influence of behavioural factors on personal factors (Figure 1, Arrow 1), research suggests that group interaction behaviours influence both group motivation and group efficacy (Bandura, 1997).

Regarding the reciprocal interactions between personal and environmental factors (Figure 1, Arrow 2), Pintrich and Schunk (2002) reported that motivational beliefs exert a strong influence on academic achievement. The reverse is also true. Schunk (1991) found that feedback and modelling significantly influence students’ motivational beliefs. Research on reciprocal interactions between behavioural and environmental influences (Figure 1, Arrow 3) indicates that learning strategies, group discussion and social interactions facilitate students’ academic achievement (behavioural → environmental) and that feedback and modelling influence students’ learning strategy choices (environmental → behavioural) (Pintrich & Schunk, 2002).

The social cognitive view of self-regulation is very important in academic learning. If teachers realize the reciprocal formulation of these influences, they are more likely to be capable of facilitating student learning through the alternation of environmental influences, student perception and learning behaviours. One typical example of interactions among these influences for self-regulated learning is that students possess high levels of motivation and apply appropriate strategies, resulting in better performance, which in turn enhances their motivation. Inevitably, however, there will be times that students will encounter learning difficulties. For example, students may have knowledge of cognitive or metacognitive strategies but lack the motivation to put them to use. Therefore, if teachers understand the reciprocal interactions among these influences, they can place more emphasis on raising students’ motivational beliefs in order to promote their learning and achievement.

The application of the social cognitive model to web-based learning
Personal influence
In order to collect data on personal influences such as self-efficacy, group efficacy, task value and anxiety, we added an online questionnaire module to the NetPorts system. Using input from this module, a group member recommendation module uses an algorithm to assign students into heterogeneous teams. Since our experimental results indicate that groups consisting of a mix of high, middle and low self-efficacy members generate more meaningful interactions than groups whose members are all at the same efficacy level, it is crucial that teachers take self-efficacy into consideration when forming online learning teams. At the end of a cooperative task, teachers can compare group-
efficacy and self-efficacy levels as reported by each team member and then use this information to monitor student performance, motivation and assistance requirements.

**Behavioural influence**

For the purpose of this study, learning behaviours such as learning strategies, feedback and group discussion are all considered to be behavioural influences. In order to investigate the effects of these behavioural influences, the system provides some features to apply these behaviours. The NetPorts system thus includes: (1) a bulletin board function, allowing students to post messages, questions, arguments, responses and requests for help from teachers or classmates and (2) a chat room, allowing for structured group discussions among cooperative learning teams. With regards to the latter, teachers are able to create additional chat rooms for the exclusive use of a specific group of students.

In addition, the NetPorts system allows teachers to either present learning materials in HTML format or design their own scaffolding activities to aid students in making use of the appropriate cognitive strategies. Moreover, the system enables teachers to assign students or groups to create web-based portfolios. During our examination of system functionality, students were found to successfully plan, monitor, sort and store information in their web-based portfolios. Furthermore, students regularly reviewed their online portfolios, exhibiting the metacognition necessary for the self-assessment of their learning processes.

Finally, we added a peer-assessment module in order to overcome one of the major stumbling blocks to a successful execution of portfolio-centred learning: the teachers’ inability to spend sufficient time evaluating and providing quality feedback. Peer feedback is a far easier and far less time-consuming practice than a rigorous teacher-centred feedback. In a previous study (Lin, Yang, Liu & Yuan, 2001), we found that high school-level computer programming students were capable of offering quality feedback supported by high-level cognitive strategies.

**Environmental influences**

Environmental influences include feedback and assessment from peers or teachers as well as modelling effects. Researchers of web-based environments must keep in mind the fact that the system itself, including its applicability and functionality, constitutes a significant environmental influence on the facilitation and application of learning behaviours. In order to facilitate students’ learning behaviours in the web-based environment and investigate the effects of environmental influences such as peers’ and teachers’ feedback as well as modelling effects, the NetPorts system includes the following functions: (1) a management centre for teachers or assistants to announce assignments and requirements, (2) an information channel for students to hand in and revise assignments or review each other’s work and (3) a Bulletin Board Service for teachers and students to post information and express their opinions about the course and the system.
Through the course administration home page, teachers and assistants can effectively arrange and manage the learning process such as announcing homework assignments, asking for peer review and feedback, posting review and feedback schedules and maintaining students’ record files.

Through the course information centre, students submit their assignments, review others’ works and revise their assignments based on their received feedback. For the peer-reviewing process, the system randomly assigns one reviewer to each student. The designated reviewer rates and comments on the student’s assignment in the system. Students receive feedback from their peers and revise their assignment according to the received feedback. Teachers are also able to grade and provide feedbacks to students’ works through the system.

During our study of the effectiveness of peer review in the web-based system, we found that students displayed a higher level of thinking such as planning, monitoring and regulating. Students also reported that they benefited from reviewing other works, for example obtaining critical insight from other peers’ work and thus improving their own performance during the review process (Liu, Lin, Chiu & Yuan, 2001). Our empirical findings support that environmental influences such as receiving feedback or assessments as well as modelling effects significantly have an impact on students’ academic performance (Liu, Lin, Chiu & Yuan, 2001; Wang & Wu, 2002), which in turn prove the viability, functionality and applicability of the NetPorts system.

**Current findings and conclusion**

This study not only identifies the most significant personal, behavioural and environmental factors in the social cognitive model of self-regulated learning but also applies the model to the development of the NetPorts web-based learning system. NetPorts, in turn, allows us to empirically analyse the interactions between the aforementioned factors. During our research on the early version of NetPorts, we found the system in need of further functional development; nevertheless, our findings show that the recent version of NetPorts makes it possible to analyse the interactions between personal, behavioural and environmental influences. For example, our research on NetPorts suggests that self-efficacy and collective efficacy have positive effects on students’ learning behaviours, including better quality of feedback and learning strategies (personal → behavioural) (Wang & Shiu, 2005; Wang & Wu, 2002). Our results also demonstrate that receiving a better quality of feedback has positive effects on students’ self-efficacy (environmental → personal) (Wang & Wu, 2002). Moreover, learning strategies, group discussion and group interactions facilitate students’ academic performance (behavioural → environmental) (Wang & Lin, in press; Wang & Wu, 2002). Our findings corroborate the social cognitive view of self-regulated learning: students who hold high levels of motivation apply better learning strategies and respond appropriately to environmental influences such as using feedback to improve performance in the web-based learning environment. Our findings further validate the application of the social cognitive model to web-based learning through NetPorts.
In addition, consistent with other studies, our studies of NetPorts support the notion that a web-based learning environment provides students with more opportunity and flexibility to work with peers and thus promote students’ learning. In particular, students can learn from an interactive environment with a range of learning scaffolds and supports (Krantz & Eagley, 1996). In addition, our studies of NetPorts also show that a web-based learning environment allows students’ greater anonymity as well as more opportunities to practise a range of self-regulated learning skills such as management of self, others, information and task (Liu, Lin, Chiu & Yuan, 2001; Liu, Lin & Yuan, 2001; Oliver & McLoughlin, 2001). For example, our portfolio features help students to continue monitoring the progress of their work and regulate their learning (Liu, Lin & Yuan, 2001). These pieces of evidence show that a web-based learning environment promotes students’ practices of self-regulated learning and academic performance. In other words, while the social cognitive model of self-regulated learning helps to promote students’ web-based learning, the web-based learning environment provides students with further opportunities to practise self-regulated learning skills. Finally, future research may well be conducted on more personal, behavioural and environmental factors in order to further elucidate the social cognitive model of self-regulated learning in web-based environments.

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