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Optimization of a Cooperative Programming Learning System by Using a Constructivist Approach

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Abstract: This work describes a cooperative programming learning system (CPLS) based on a novel constructivist approach. This system embeds various constructivist elements within functions to support each phase of the information process that allows students to construct programming skills through knowledge, tasks, and assessment domains. The CPLS comprises a discussion forum, programming editing forum, design forum with structure charts, project management, project guidance, performance demonstration, and peer assessment models. Effectiveness of the proposed system is demonstrated based on an experiment involving 54 undergraduate students in a private university in Taiwan. Learning effectiveness is analyzed using Pearson correlation coefficients. Analytical results indicate that students using this CPLS more frequently could learn programming skills more easily. Efforts are underway to incorporate more pedagogical models in the proposed system, as well as improve the system interface and functions.

Keywords: Cooperative programming learning system, programming learning, project-based

Introduction

Computer education highly prioritizes programming skills, which are challenging to teach owing to their complexity and hesitancy among students to learn them. Applying program -ming concepts to real world problems is the primary learning objective. Whereas syntax and semantics are insufficient alone in learning a programming language, problem solving must be incorporated [4]. However conventional tutoring strategies for programming courses have difficulty in fostering the problem solving skills of students [1]. Conversely, project-based teaching strategies have been developed as a viable alternative [12]. While representing the best accomplishment for a project, collaborative learning can coordinate project activities into academic and social learning experiences. Technology advances have made it feasible to incorporate more constructivist motion in the design of cooperative learning in programming [5]. Cooperative learning systems have proven beneficial in providing marvelous opportunities for communication during programming learning [3].
This work presents a cooperative programming learning system (CPLS) by applying constructivist pedagogical approaches. An overview of the constructivist approach is provided, followed by a discussion of the transformative role of constructivist education in programming learning. The proposed CPLS consists of knowledge based domain, task based domain, and assessment based domain to construct a cooperative programming environment. A task involving real world scenarios is subsequently assigned to encourage learners to interpret programming knowledge actively, rather than receive it passively.
Students record their experiences on logs, followed by attitudinal questionnaire to understand their use of the system. Additionally, the learning outcome is evaluated based on

group-based tasks and an individual knowledge test. Moreover, the effectiveness of the proposed CPLS in enhancing programming learning is analyzed using the Pearson correlation coefficients.

Literature Review

1. Programming Learning

A conventional approach in programming education involves orienting students on programming language concepts and then guiding students to effective strategies for programming implementation. However many studies have cited the knowledge driven method as incapable of solving learner problems when teaching programming [6]. This inability may be owing to the lack of practical experience in becoming competent in programming, despite their previous knowledge of a program language. However, learners could nurture their programming skills if assisted by appropriate instructional tasks and educational technologies [9].

2. Learning Theory Approach

Exactly how constructivist learning theories comply with cooperative programming learning requirements is explained by discussing constructivist learning theories and their implications for the proposed CPLS.

2.1 Constructivist Learning and its Implications

Constructivism is based on the premise that our perceptions are constructed through individual experiences [2]. Learners interpret what they have received through their senses to create knowledge [11]. Constructivism heavily emphasizes cognitive constructivism and social constructivism.

2.2 Cognitive Constructivism

Based on the pioneering work of Jean Piaget as the foundation for teaching and learning, cognitive constructivism posits that individuals must construct knowledge through their experiences to create schemas [12]. Students learn better when information is introduced to support problem solving, in which learning functions as a tool rather than merely as facts.

2.3 Social Constructivism

The social constructivism theory of Vygotsky extends individual learning to collaborative learning by allowing individuals to share background knowledge and participate in a given task to create meaning by interacting with others [14]. Importantly, this theory emphasizes the impact of collaboration and views learning as occurring in social processes [13].

3. Collaborative Activities through CSCL

Collaborative learning motivates individuals to solve problems through individual learning in group work [8]. The task-related activities are performed through group members sharing and discussing task-related information, as well as verbalizing their ideas.

Computer-supported collaborative learning (CSCL) assists students in constructing knowledge through online collaboration [7]. CSCL also performs scaffold processes that are not achieved through face-to-face communication, such as having learners to record their communication through logs [10].

System Design

According to previous literature, this work develops a cooperative programming learning system (CPLS) for a task-construct-based cooperation programming environment. ASP.NET and MSSOL syntax are used as developing tools in the system. Figure 1 illustrates the architecture of the proposed system.

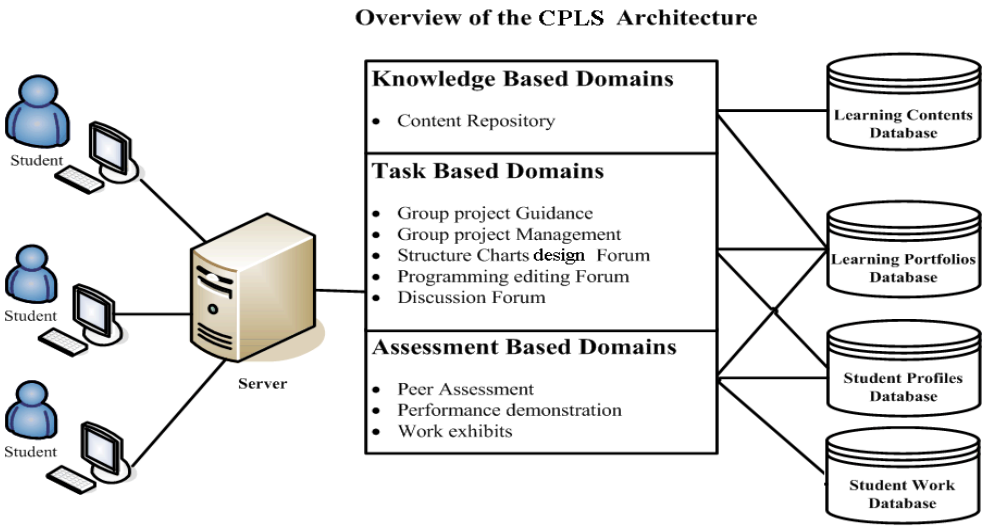

Figure 1： Architecture of the proposed CPLS

The CPLS incorporates various constructivist elements within functions, such as: discussion forum, programming editing forum, design forum with structure charts, project management, project guidance, performance demonstration, and peer assessment models to support pedagogical training as follows:

1. Compliance of the Proposed CPL System with Cognitive Constructivism

The proposed system provides a learning content repository in which students can download and read the teaching materials, followed by completion of real-world related tasks using ASP.NET. The proposed CPLS has the following features:

- The knowledge based domain with a content repository provides online information and resources to allow students to put their knowledge directly into practice.
- The system supports each phase of the information process in which students can construct programming skills through knowledge, task, and assessment domains to complete assigned projects.
- In addition to providing facts and examples, the proposed system is also presented as a medium to solve global problems.

2. Compliance of the CPLS with Social Constructivism

Among the visualized functions that the proposed CPLS provides include a discussion forum, programming editing forum, and design forum with structure charts (Figs. 2-a and 2-b). Group members collaborate with each other in completing all programming tasks.

Figure 2-a

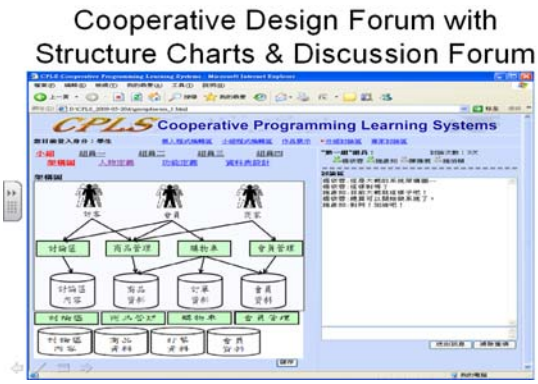

Figure 2-b

The proposed CPLS has the following features:

- The task based domain allows learners to construct knowledge based on their experiences in working group project rather than receiving that knowledge from teachers.
- In the cooperative forum, the leader has the authority for editing or passing the leadership onto another group member.
- The proposed CPLS provides a highly interactive environment that allows learners to complete their programming tasks through social constructivism.

3. Improved Human Knowledge Management Capabilities through the Proposed CPLS

In addition to providing teaching materials and a self-coding panel for individual learning, the proposed CPLS facilitates cooperative learning with the following features:

- A teaching assistant can model a lesson and handle student questions. Learners can serve as apprentices in terms of understanding problem complexity and acquiring knowledge skills.
- The proposed CPLS provides guidance and management tasks that require high levels of processing and facilitate student performance.

The proposed system supports all phases of the following tasks: design of structure chart, online coding, database design, presentation of learning achievement, and peer assessment.

Research Method

Fifty four undergraduate students from a private university in Taiwan participated in the study. The students were enrolled in a web-based programming course using ASP.NET. Basic concepts and knowledge were introduced during the first 9 weeks, followed by a 9-week experimental period. Each group comprised 4-5 students and was assigned a task through the proposed CPLS, aimed at designing an e-commerce website. Students logged their experiences to examine the effectiveness of system implementation. The projects were scored, followed by an individual knowledge test to evaluate the learning effectiveness.

Results

1. System Usage

User logs were corrected to understand the frequency of system use. System functions of "edit database", "save a file", "send a message", and "view the outcome" were used the most during collaborative learning.

2. Correlation between System Usage and Learning Effectiveness

Effectiveness of the proposed CPLS in enhancing programming learning was determined by evaluating the Pearson correlation coefficients to analyze the relation between the frequency of system use and knowledge test score, project score, as well as student attitudes. According to SPSS statistical results, system usage correlated well with the knowledge test score ($r = 0.45$, $p < 0.01$) and the group project ($r = 0.30$, $p < 0.05$) (Table 1). Students that used the proposed CPLS more frequently than others achieved a higher learning outcome, demonstrating the effectiveness of student learning of programming skills.

Table 1 Correlation coefficients between system usage and learning achievements

	System usage	Knowledge test	Project score	Attitude
System usage	1	.45**	.30*	-.04
Knowledge test	.45**	1	.02	-.02
Project	.30*	.02	1	.03
Attitude	-.04	-.02	.03	1

Asterisk (*) denotes the correlation coefficients that are statistically significant at the 0.05 level.
Double asterisks (**) denotes the correlation coefficients that are statistically significant at the 0.01 level.

Conclusion and Future Studies

This work presents a cooperative learning system for programming by providing a complementary discussion function to facilitate group interaction. The proposed CLPS facilitates guidance and management tasks in programming. Analysis results indicate that the proposed system improves learning, but not student attitudes. Future studies should incorporate additional pedagogical models in the proposed system to foster cooperative) learning. The system interface and functions should also be improved to meet user requirements.

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