

Integrating ARCS Model of Motivation and PBL in Flipped Classroom: a Case Study on a Programming Language

Yi-Hsing Chang ^{1*}, An-Ching Song ¹, Rong-Jyue Fang ¹

¹ Department of information management, Southern Taiwan University of Science and Technology, Tainan City, TAIWAN

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ABSTRACT

This study proposed a teaching model that integrates attention, relevance, confidence, and satisfaction (ARCS) model and problem-based learning (PBL) and applied the proposed model to a flipped classroom to improve learners' learning motivation and effectiveness. Proficiency in the C# program language was the learning objective in this study. For the experiment, students were assigned either to the control group that used the conventional teaching method or to the experimental group that used this study's flipped classroom method. The learning outcome levels of the two groups were assessed based on their pretest and posttest data. In addition, the students' learning motivation was discussed in terms of the four dimensions of ARCS. The results showed that regarding learning outcomes, the experimental group had a more significant improvement in their learning results than the control group did; the experimental group achieved significant results for every dimension in the questionnaire. Therefore, the learners gave a positive review of the flipped classroom model designed in this study.

Keywords: flipped classroom, ARCS model, Problem-based learning, programming language

INTRODUCTION

According to the 12-year basic education curriculum guidelines to be implemented by the Taiwanese government in August 2018, "information technology" will be added to the junior high and senior high school curriculum. The goal is to cultivate students' capabilities such as "computational thinking and problem-solving," "information technology and co-creation," and "information technology and communication" (National Academy for Educational Research, 2017); these guidelines indicate the crucial position occupied by programming today. Linn and Dalley (1985) noted that students who study programming can learn how to design programs and solve problems, and these students can apply these skills to other areas. Mayer, Dyck, and Vilberg (1986) also argued that students who studied programming displayed superior performance levels in problem transfer and understanding. Duke, et al. (2000) believed that learning programming can cultivate students' problem-solving and high-level thinking capabilities, which can bring about positive effects in future career planning.

However, numerous scholars have indicated various difficulties in the process of learning programming. For example, the overemphasis on syntax by conventional programming teaching methods often leads to students piecing together their programs through the wrong methods, causing them to be easily frustrated by mistakes and difficulties (Costelloe, 2004; Linn & Clancy, 1992). Conventional teaching also places excessive focus on knowledge transfer and is prone to neglect the processes whereby students absorb and internalize relevant knowledge (Mazur, 2011), thus novel approaches should be sought in the teaching of programming.

Even though the lecture method is commonly applied to teach large classes, its biggest problem is the compression of teacher-student interaction opportunities in class. Due to the recent advances in information technology, students' sources of knowledge are not merely limited to teachers. Students can also acquire knowledge through the Internet, thus producing various teaching methods (with the flipped classroom being one of the

Contribution of this paper to the literature

- This study firstly proposed a teaching model that integrates attention, relevance, confidence, and satisfaction (ARCS) model and problem-based learning (PBL) and applied the proposed model to a flipped classroom to improve learners' learning motivation and effectiveness.
- According to the experiment, the system significantly increased students' learning motivation across all four ARCS dimensions and learning outcomes. Finally, learners gave positive evaluations of the developed learning system.
- Applying the proposed model to flipped classroom potential in education field can be as the important reference for the researchers and educators.

emerging teaching approaches). People born after the 1980s who grew up in technology-rich environments are known as "digital natives" (Prensky, 2001). They like to be self-paced and flexible, and have a preference for exploration and instant feedback while disliking standardization, texts, static listening, and delayed feedback. Conventional teaching models possess many features that these "digital natives" dislike, and the flipped classroom enables these students to enhance their thinking capabilities during mutual collaboration (Chu, Hwang, Tsai, & Tseng, 2010). Bergmann and Sams (2012) believed that the flipped classroom teaching method can improve the shortcomings of conventional teaching approaches.

Flipped classrooms have been adopted by numerous researchers in various subjects in recent years, although some of their results indicated that despite the significant improvements in learning outcomes, a timely understanding of the students' internal problems could not be achieved; in addition, no significant differences were observed in the students' learning motivation, independent learning, and conventional classroom performance. Lowman (1990) argued that enhancing learning motivation can improve learning outcomes, whereas maintaining attention and learning objectives are also conducive to learning. Even though arousing students' attention is not difficult, enabling students to focus and maintain their attention on the course content is difficult.

Although, many researchers found that students have positive attitudes toward, and it improves students' performance in the area of programming language syntax and structure, using flipped classroom teaching, there are still some challenges that should be considered when planning to use this approach in the future. Alhazbi (2016) pointed out that the main challenge is how to encourage students to study the subject in advance and come to class prepared. This involves addressing how to improve students' self-learning skills. Antti et al. (2016) also describe the importance of appropriate self-learning material. Sharp (2016) found the following weakness for the flipped classroom teaching: use of online resources; increase time requirements and lack of preparation/participation. Sharp also suggested that teacher must encourage more collaboration between students during the in-class activity. This might assist those who do not come to class prepared to get up to speed more quickly, provide some peer motivation, and allow stronger students to help those who are having trouble.

The ARCS model of motivation proposed by Keller (1984) illustrates a fixed pattern in students' learning motivation that can be followed, and the application of this pattern in programming courses has been studied. However, relevant studies showed that students' learning motivation is not only improved by the teaching materials as teachers' guidance also affects learning motivation, thus the relevant teaching method in this study was determined and designed based on this model.

The main purpose of problem-based learning (PBL) is to train students to analyze and solve problems through practice. Albanese and Mitchell (1993) and Vernon and Blake (1993) carried out a meta - analysis of 20 years of PBL evaluation studies and concluded that a problem-based approach to instruction was equal to traditional approached in terms of conventional tests of knowledge. Besides, the students who studied using PBL exhibited better clinical problem-solving skills.

Based on these ideas, this study integrated the ARCS model of motivation and PBL into a flipped classroom, and applied it to programming learning to enhance learners' learning outcomes and motivation in programming. Therefore, this study explored:

- Whether integrating the ARCS model of motivation and PBL into a flipped classroom can improve learning outcomes.
- Whether integrating the ARCS model of motivation and PBL into a flipped classroom can enhance learning motivation.

LITERATURE REVIEW

Flipped Classroom

Flipped classrooms are not a brand new teaching strategy, and relevant studies were conducted in the 1990s by Mazur (2009), a physics professor at Harvard University, whose research showed that mutual-aid teaching can help students solve some common but undetected misconceptions. In "From Sage on the Stage to Guide on the Side", King (1993) argued that teachers should transition from the sage on the stage to the guide by the students' side. Baker (2000) argued that teachers can use "online courses" to flip their teaching, thereby achieving the spirit of "from the sage on the stage to the guide by the side." The flipped classroom is a pedagogical model that revises the central roles of traditional components of teaching, namely lectures and homework. The formerly emphasized topics become optional strategies to expand learning and achievement. Class time is mainly used for collaboration to learn high-level capabilities such as understanding and problem solving (Acedo, 2013; EDUCAUSE, 2012).

A flipped classroom thus reforms the classroom to address several conventional classroom problems. Teachers can give students the space to absorb others' ideas and stimulate new thinking (Phillips & Trainor, 2014). It not merely highlights how technology and education complement each other to improve learning outcomes, but also transforms classroom models. Teachers are no longer confined to the existing teaching frameworks and can independently seek to teach in differing models.

Many studies have applied flipped classroom to numerous fields in recent years, such as physics (Aşıksoy & Özdaml, 2016; Zhao & Liu, 2017), chemistry (Bergmann & Sams, 2012), electronic business (Zhu & Xie, 2018), etc. For example, Bergmann and Sams (2012), two chemistry teachers at Woodland Park High School in Colorado, the United States of America, adopted flipped classrooms to enable absent students to make up for their missed classes and keep up with their lessons, in which the teachers achieved a great success. They believed that the flipped classroom method was not invented by a particular individual; they did not specify what constitutes a flipped classroom; they claimed that the relevant pedagogy can differ based on the needs of the school.

In computer science the method has been used to teach introductory programming (Alhazbi, 2016; Antti et al., 2016; Elmaleh & Shankararaman, 2017; Horton & Craig, 2015; Latulipe, Long, & Seminario, 2015; Marasco, Moshirpour, & Moussavi, 2017; Sharp, 2016) and also advanced topics, such as software engineering (Paez, 2017). The paper proposed by Sharp (2016) was to report on what students had to say about the flipped C# programming classroom in terms of its strengths, its weaknesses, etc. An open-ended survey was used to collect data from two sections of an introductory C# programming course in fall 2015 and spring 2016. The results indicated that overall the participants viewed the flipped C# classroom positively. Antti, et al. (2016) compared existing literature to two case studies where flipped classroom was introduced to teaching. They discussed the lessons learned in these cases and presented recommendations based on their experiences. The experimental results showed that flipping the classroom has been found to be more efficient than traditional lecture-exercises method and the findings in this study supported this.

The above studies on the application of flipped classrooms in programming courses demonstrated improvements in the learners' learning outcomes and motivation, although their learning attitudes such as confidence, satisfaction, technological attitude, and collaborative learning did not obtain a positive result. This indicated that although flipped classrooms can break through the predicament of conventional classrooms, other approaches are still required to improve various hidden problems.

ARCS Model of Motivation and Application

The ARCS model of motivation proposed by Keller (1984) comprises four elements: attention, relevance, confidence, and satisfaction. Its objective is to assist curriculum design or improve teaching, emphasizing the triggering of learners' motivation through these four elements to stimulate students' learning. Keller (2009) compiled the relevant theories of motivation into an integrated analysis, and proposed a Macro Model of Motivation and Performance to stimulate and strengthen learning motivation and enhance systematic teaching design, as shown in [Figure 1](#).

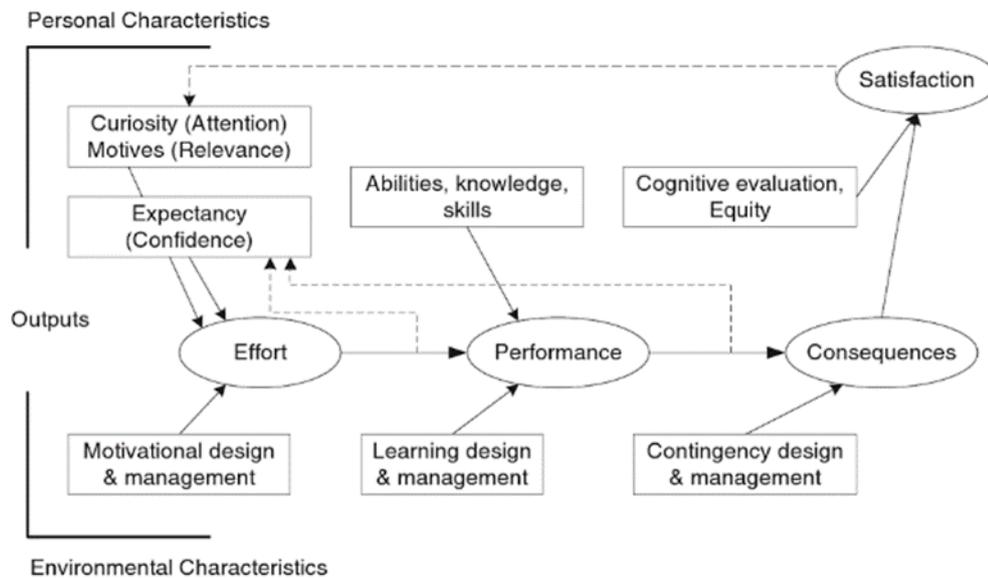


Figure 1. Macro model of motivation and performance (Keller, 2009)

In **Figure 1**, Keller divided the teaching and learning processes into two major inputs and one output. The inputs consist of personal characteristics and environmental characteristics, whereas the output comprises effort, performance, and consequences. According to the output results, learners' effort exhibited the greatest effect on their learning outcomes. Personal characteristics and environmental characteristics interact with each other to form a circulatory system that affects the learners' effort, performance, and consequences. From the perspective of teaching designers, inspiring learners' curiosity, enhancing students' confidence, and improving learners' satisfaction in their learning outcomes will cause learners to work harder and lead to a virtuous cycle. This study thus revised this model and applied it to flipped classroom teaching.

In recent years, the ARCS model has been variously applied to investigate whether it enhances learning motivation, and the results have generally been positive. For example, Chang and Chen (2015) proposed an ARCS-based research model that used a set of ARCS-oriented certified digital general education information literacy materials for higher education initiated by the Ministry of Education in Taiwan, to determine the motivation for learning in a blended learning environment. The research model was tested using an online questionnaire survey of 292 participants. Confirmatory factor analysis was used to evaluate the reliability and validity of the results and the partial least squares method was used to validate the measurement and hypotheses. The findings supported the validity of the four motivational elements in the ARCS model. Lee and Hao (2015) combined the ARCS motivation model, and humor to design a set of multimedia applications to develop a Cat's Cradle Multimedia Learning System. Zhang (2017) designed a micro-lecture teaching platform based on ARCS model theory, where the platform could carry out teaching practice on intelligent mobile devices, and had some features like mobility, seamlessness and strong advancement. The research found that the platform paid attention to the stimulation and maintenance of learners' motive, focuses on the interest in learning, and strengthens and kept the interest of learners through a series of strategies to achieve the purpose of learning.

In addition, numerous relevant studies have introduced the ARCS model of motivation into programming. The main methods employed have been visual graphics or questions to trigger learners' learning motivation. The teachers served as guides by the students' sides during the teaching process to influence learning motivation. Alhazbi (2015) followed the ARCS model of motivation for programming teaching and explored its impact on students' results, discovering that the model did improve students' learning motivation and effectiveness. Also, the approaches of posing questions and using students' names in classes to draw students' attention and improve teacher-student relationships, respectively, were employed. Tsukamoto, et al. (2015) employed ARCS to evaluate the suitability of using textual programming language (TPL) for elementary school programming teaching, discovering that both the use of cartoons in TPL environments and the staff acting as guides by the students' sides triggered and influenced learning motivation. Tsukamoto, et al. (2016) assessed the learning outcomes of using TPL and visual programming language (VPL) in elementary school programming teaching through ARCS, and results indicated that VPL was more suitable than TPL for the task under ARCS.

Based on the aforementioned studies, ARCS model can really promote the learners' learning motivation.

Problem-Based Learning (PBL)

Problem-based learning (PBL) is an instructional approach that has been used successfully for over 30 years and continues to gain acceptance in multiple disciplines (Savery, 2015). Numerous scholars have considered various aspects of PBL such as question posing followed by students' application of a set of systematic steps to resolve questions (Barrows & Tamblyn, 1980) and guidance through nonstructural and open-ended questions (Fogarty, 1997). Barrows and Tamblyn (1980) stated that "problem-oriented learning is also known as problem-based learning and problem-guided learning," which encourages learners to break away from previous learning approaches and integrate relevant knowledge through a unique question. However, this does not mean that learners do not require teachers' guidance, which is still needed for acquiring the capabilities to analyze, solve, and explore problems through practice during learning.

Many researches have applied PBL to numerous fields in recent years, such as management education (Delaney et al., 2015), medical education, etc. In medical education settings, numerous studies have found that relative to lecture-based learning models, the PBL model presents certain advantages with respect to improving student abilities in inactive learning, two-way communication, clinical thinking, and teamwork (Enarson, 2001; Mahdizadeh et al., 2008; Raham et al., 2008). Zhang et al. (2015) also found that PBL teaching model application in introductory undergraduate medical courses can increase course examination excellence rates and scores in Chinese medical education system. It is more effective when applied to laboratory courses than to theory-based courses.

TEACHING DESIGN

Teaching Model Design

The strategies for flipped classroom in computer science education has been introduced in a study by Maher et al. (2015), we concentrate on the in-class activities. That is, through practical exercises to understand what the teacher is teaching in-class activities. Therefore, the study integrated ARCS and PBL to propose an ARCS_PBL_FC flipped classroom model, as shown in Figure 2. The model formulated teaching objectives for each teaching, and the teaching process was divided into four parts: conceptual explanation, free discussion, goal provision, and report and practice work. In addition, the teachers' role was extremely crucial as they were required to observe and assist the learners from the side: when learners encountered difficulties in the searching process, the teachers were required to help them find the right learning direction. The main features of this teaching model are: the application of ARCS theory to design relevant learning content that can enhance learners' motivation to learn; the practice of PBL learning to cultivate students' thinking and problem-solving capabilities; the design of flipped classroom worksheets to enable learners to understand the learning objectives before solving the problems, follow the guiding steps on the worksheet during learning, and finally complete the objectives, thereby enhancing their learning outcomes.

The relevant illustrations are shown in [Figure 2](#).

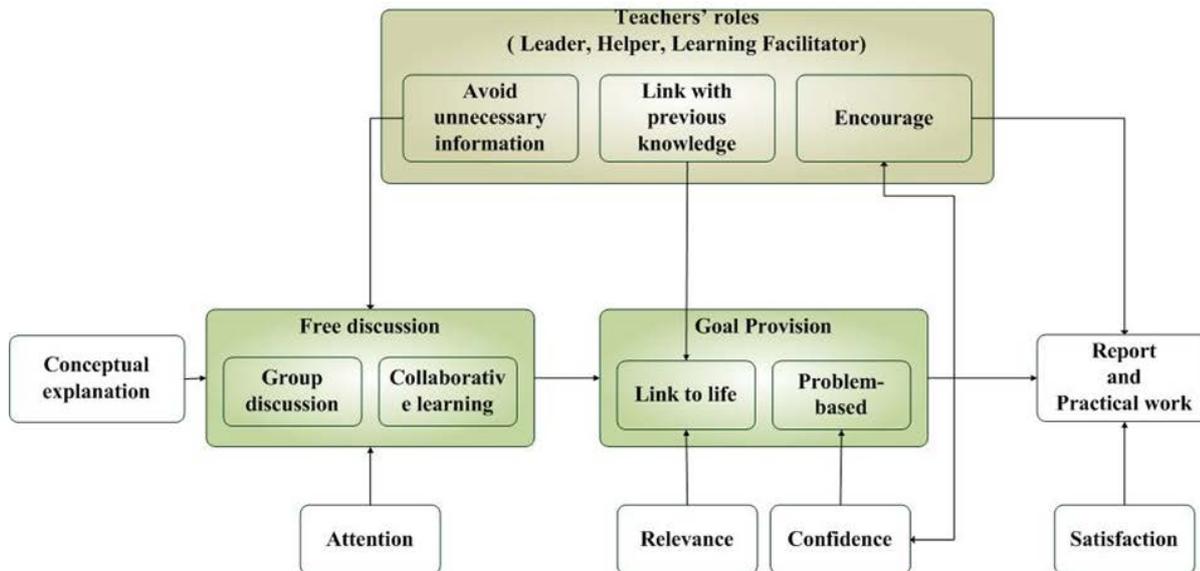


Figure 2. ARCS_PBL_FC model

Conceptual explanation

At the beginning of each flipped classroom course, the course objectives are introduced to orient the learners' attention, followed by an explanation of the learning themes and processes, and teaching contents must correspond to those in the worksheet. The learners passively receive knowledge at this stage, which is similar to the conventional teaching approaches.

Free discussion

After the conceptual explanation, an atmosphere for peer discussion is created with the guidance of the teachers to open the learners up for a free discussion. This design references the "Attention" from the ARCS model; this design focuses the learners' attention on the learning content to be implemented following the sudden change in their surrounding environment. This method also maintains the students' attention through group discussion and collaborative learning.

In referencing the connotation of flipped classroom, the teachers are no longer the knowledge providers but guides in students' learning. Through the teachers' guidance, the learners can avoid unnecessary information and wrong directions while discussing and searching for information.

Goal provision

While preparing the students for free discussion, the teachers use worksheets to achieve specific learning objectives. Learners can help themselves complete the worksheet by using the teachers' conceptual explanations and may supplement their knowledge from relevant videos and Internet exploration. This stage mainly references the "Relevance" and "Confidence" from the ARCS model; this stage corresponds to the spirit of the flipped classroom wherein "teachers can help learners link with previous knowledge during the process of guidance." It enables learners to establish considerable links through conceptual explanations and relevant educational videos, and allows learners to achieve specific objectives and enhance their confidence while establishing the correlation between effort and success.

- (a) **Link to life:** Referencing the concept of flipped classroom, teachers should provide assistance at this stage to help students link to past knowledge. All worksheets should be related to students' daily lives to enhance "relevance," as explained by the ARCS model.
- (b) **Problem-based learning:** Worksheets are designed mainly by integrating the elements of "using problems as teaching materials," "learner-based problems," "learning through discussions," and "group-based problems" in PBL. The learners integrate relevant knowledge through specific problems on the worksheets. Teachers can encourage the learners in the process of completing the worksheet to improve the latter's confidence, which is also enhanced when learners complete the problems as well as the learning objectives of the day ("confidence" in the ARCS model).

Report and practice work

Learners follow the guidance in the previous stage and receive a presentation and report as feedback when they achieve the goal. This step references the “satisfaction” from ARCS because students feel satisfied when they achieve natural results. When learners complete their tasks, teachers also encourage them to enhance their satisfaction; in addition, when learners reflect on their learning, their enhanced satisfaction leads to a virtuous cycle of improved learning motivation.

Learning Materials Design

The teaching materials in this study were designed for a 1-year C# programming course. The course topics in the first semester consisted of program logic, basic design of C# applications, variables, data types, operators, basic output of window applications, selection of control items and conditional statements, loop structures, C# functions, and .NET Framework type libraries. The course topics in the second semester consisted of strings and arrays, categories and objects, window application event handling, toolbars and menus for windows, multiple document interface applications, and file and folder processing.

This study used the course themes of “array application – sorting,” “string learning and application,” “toolbar and menu – 1,” and “toolbar and menu – 2” after the midterm exam in the second semester for teaching material design. “Array application – sorting” and “toolbar and menu – 2” are illustrated as follows:

Array application – sorting

A. Teaching Goals

The goal of this topic is to help students understand bubble sort and selection sort, and present and compare their differences. Sorting entails an arrangement of data according to a specific principle such as ascending or descending order.

B. Teaching Process

- a. Learn about bubble sort through prerecorded teaching videos, slideshows, and the lessons taught by teachers.
- b. Learn about selection sort through group-based online research.
- c. Compare the similarities and differences between the two sorting methods.
- d. Identify how sorting is completed using arrays? The array size is determined based on the number of sorting operations. Algorithms are designed using relevant sorting methods and are converted into actual programs for testing.

C. Worksheet Designs

The following worksheet was designed based on teaching goals and processes:

Program Design (2)

Theme: Array Application – Sorting

- Goal: understand the differences between bubble sort and selection sort
 - What is bubble sort?
 - What is selection sort?
 - What are the differences in the practices of bubble sort and selection sort?
 - How are they completed using arrays?
- Implementation Procedure
 - Understand the practices of bubble sort through the teaching videos.
 - Conduct an online search on selection sort and its practices.
 - (After compiling the relevant information) produce a program and report and submit them online. The report should include (using five data – 200 95 45 35 25 – as an example and arrange them in ascending order, a total of four passes are required)
 - Sorting order of bubble sort (write out the execution step of each pass)
 - Sorting order of selection sort (write out the execution step of each pass)
 - The similarities and differences between the two sorting methods
 - Data structure completed using the arrays (refer to the relevant code)

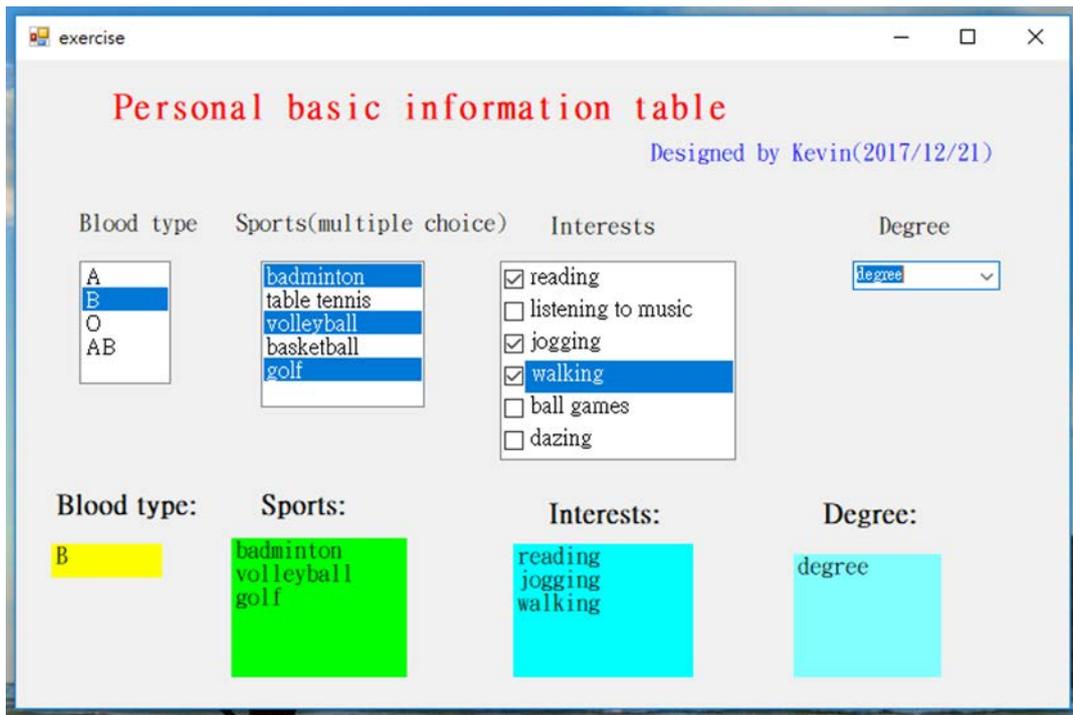


Figure 3. Sample Files

Toolbar and menu-2

A. Teaching Goals

Understand the uses and applications of ListBox, CheckedListBox, and ComboBox.

B. Teaching Process

- a. Understand the control items in the program through prerecorded teaching videos and slideshows.
- b. Learn the uses of ListBox, CheckedListBox, and ComboBox.
- c. Produce a program containing ListBox, CheckedListBox, and ComboBox

C. Worksheet Design

Program Design (2)

Theme: Toolbar and Menu-2

■ Goal: Understand the usage and application of ListBox, CheckedListBox, and ComboBox

- What is ListBox? How should it be designed? What is its usage timing?
- What is CheckedListBox? How should it be designed? What is its usage timing?
- What is ComboBox? How should it be designed? What is its usage timing?

■ Implementation Procedure

- Produce an application for a personal basic information table as shown in Figure 3, wherein ListBox is used for the single selection of blood type as well as the multiple selection of sports; CheckedListBox is used for the multiple selection of interests; and ComboBox is used for answering education level.
- Use SelectedIndexChanged event for instant update.

Development Tools

- Video: the EverCam is used to record slides as instructional videos.
- Learning management system: the flip.stust.edu.tw is used as the teaching management system. This system includes the functions of teaching video uploading, grouping, homework uploading, etc.

Table 1. Pretest analysis

| | Number | Mean | SD | T Value |
|--------------------|--------|--------|--------|---------|
| Control Group | 51 | 65.765 | 2.4612 | -0.169 |
| Experimental Group | 52 | 66.404 | 2.8743 | |

P > 0.05

Table 2. Independent sample t-test analysis of the first experiment

| | Number | Mean | SD | T Value |
|--------------------|--------|--------|---------|---------|
| Control Group | 51 | 76.569 | 18.0413 | -3.001 |
| Experimental Group | 51 | 86.923 | 14.6725 | |

**P < 0.01

EXPERIMENT AND RESULTS

In this study, teaching experiments were conducted on the four aforementioned courses based on the ARCS_PBL_FC model.

Research Participants

A total of 103 freshmen from two classes in the Information Management Department of Southern Taiwan University of Science and Technology were recruited as research participants. The experimental group and control group consisted of 52 students and 51 students, respectively. The experimental group engaged in group-based collaborative learning with four learners per group. The experiment time was 4 weeks after the midterm exam during the second semester and consisted of three lessons per week (150 minutes).

Experimental Procedures

Step 1. The teaching materials for the experimental group and control group were announced on the teaching platform in advance.

Step 2. Control group: The teachers explained the course content in accordance with the conventional teaching method (80 minutes).

Experimental group: The teachers explained the course concept (30 minutes).

Step 3. Control group: The students began practicing (40 minutes).

Experimental group: The students engaged in independent learning based on the worksheets, during which they referred to textbooks, teaching videos, and online searches; each student finally produced a report or practical work based on the worksheet requirements (100 minutes).

Step 4: The experimental group and control group were subjected to posttests (20 minutes).

Step 5: After the four experiments had been completed, the experimental group was subjected to a questionnaire survey and interview; the control group was subjected to an interview (conducted on the 5th week after the midterm exam for 20 minutes).

Learning Achievement Analysis

Pretest analysis

The midterm exam results for the experimental group and control group were analyzed using an independent sample t-test, and the results are shown in **Table 1**. The average difference for the pretests between the two groups was 0.669, $P = .866 > 0.5$, which did not achieve a significant level of difference between the class results in the two groups.

Posttest analysis

A total of four teaching experiments were conducted, after which the posttest results of the two groups were analyzed using an independent sample t-test. The number of participants in each experiment differed due to a slight difference in the number of students in each class. The experimental results are as follows:

Table 2 shows the first experimental results, wherein the average scores of the experimental group and control group were 86.923 and 76.569, respectively, $P = .004 < 0.05$, thus achieving a significant level of difference.

Table 3. Independent sample t-test analysis of the second experiment

| | Number | Mean | SD | T Value |
|--------------------|--------|--------|---------|---------|
| Control Group | 51 | 75.882 | 16.7244 | -1.053 |
| Experimental Group | 49 | 79.490 | 17.5073 | |

P > 0.05

Table 4. Independent sample t-test analysis of the first experiment

| | Number | Mean | SD | T Value |
|--------------------|--------|--------|---------|---------|
| Control Group | 45 | 54.667 | 19.8403 | -2.442 |
| Experimental Group | 46 | 65.000 | 20.5210 | |

*P < 0.05

Table 5. Independent sample t-test analysis of the first experiment

| | Number | Mean | SD | T Value |
|--------------------|--------|--------|---------|---------|
| Control Group | 47 | 70.213 | 19.1662 | -3.019 |
| Experimental Group | 47 | 80.638 | 13.8947 | |

**P < 0.01

Table 6. Cronbach's reliability analysis test

| Scale Name | Number of Questions | Cronbach's α |
|--------------|---------------------|---------------------|
| Attention | 4 | 0.834 |
| Relevance | 6 | 0.856 |
| Confidence | 6 | 0.898 |
| Satisfaction | 5 | 0.888 |
| Overall | 21 | 0.958 |

Table 3 shows the second experimental results, wherein the average scores for the experimental group and control group were 79.490 and 75.882, respectively, $P = .295 > 0.05$, which did not achieve a significant difference.

Table 4 shows the first experimental results, wherein the average scores of the experimental group and control group were 65 and 54.667, respectively, $P = .017 < 0.05$, thus achieving a significant level of difference.

Table 5 shows the first experimental results, wherein the average scores of the experimental group and control group were 80.638 and 70.213 respectively, $P = .003 < 0.05$, thus achieving a significant level of difference.

Statistical analysis of the aforementioned four test scores showed that three of them reached a significant level. Even though one score failed to achieve a statistical significance, the average score of the experimental group was higher than that of the control group, indicating that this teaching approach can improve students' results.

Questionnaire Analysis

A 5-point Likert scale was adopted in the questionnaire to understand their acceptance of this teaching method, which addressed the four dimensions of the ARCS model. The original number of items in the questionnaire is 25. The content of this questionnaire was reviewed by 3 experts and finally revised to 21 items, where each dimension had 4, 6, 6, 5 items, respectively. A total of 46 out of the 52 questionnaires distributed were recovered, and all 46 of them were valid.

Reliability analysis

The questionnaire reliability was tested using Cronbach's α , whereas the internal consistency of the scale was tested using the α coefficient, with an α value of greater than 0.7 indicating high reliability. According to the results in **Table 6**, the reliability of each dimension was greater than 0.7, and the overall α value was 0.958, indicating a satisfactory reliability for the scale in this study.

Descriptive statistics analysis

The total average for the question items on "attention" was 4.165, with each item achieving a score greater than 4, as shown in **Table 7**.

Table 7. Statistical results for question items on "attention"

| No | Question Items | Average | SD |
|---------------|---|---------|--------|
| A1 | The teaching method used in this course inspires my curiosity. | 4.227 | 0.6048 |
| A2 | The teaching method used in this course is very interesting for me. | 4.273 | 0.6943 |
| A3 | Compared with other courses, I can maintain my attention longer in this class. | 4.023 | 0.7310 |
| A4 | I think that following the steps in the worksheet differs from the previous learning methods. | 4.136 | 0.6679 |
| Total Average | | 4.165 | 0.6745 |

Table 8. Statistical results for question items on "relevance"

| No | Question Items | Average | SD |
|---------------|---|---------|--------|
| R1 | I want to complete the contents of the worksheet | 4.205 | 0.6317 |
| R2 | I am more willing to complete the contents of the worksheet because of the group discussions. | 4.295 | 0.6317 |
| R3 | I will take the initiative to provide assistance if my classmates encounter any problems. | 4.341 | 0.5683 |
| R4 | I will ask my classmates for help if I encounter any problems with the worksheet. | 4.477 | 0.5494 |
| R5 | I will ask my teachers / TA for assistance if I encounter any problems with the worksheet. | 4.227 | 0.6773 |
| R6 | I think the contents of the worksheet are very practical. | 4.045 | 0.5687 |
| Total Average | | 4.275 | 0.6045 |

Table 9. Statistical results for question items on "confidence"

| No | Question Items | Average | SD |
|---------------|---|---------|--------|
| C1 | I think my programming skills have improved. | 4.227 | 0.6773 |
| C2 | I think my performance is better than before. | 4.068 | 0.6954 |
| C3 | I am confident that I can solve any problems I encounter. | 3.818 | 1.0842 |
| C4 | This course enables me to reflect on how to express the problems I encounter. | 4.182 | 0.6567 |
| C5 | I will use differing approaches to describe my problems in this course. | 3.841 | 0.8611 |
| C6 | I will discuss with my classmates on how to solve problems in this class. | 4.477 | 0.5494 |
| Total Average | | 4.102 | 0.7540 |

Table 10. Statistical results for question items on "satisfaction"

| No | Question Items | Average | SD |
|---------------|---|---------|---------|
| S1 | The feedback and praises from the teacher give me a satisfaction. | 4.341 | 0.6078 |
| S2 | I am proud of my performance whenever I finish my homework. | 4.227 | 0.6421 |
| S3 | The smooth execution of the program gives me a sense of satisfaction. | 4.409 | 0.5834 |
| S4 | The skills I learn in this course can be applied to other courses. | 4.205 | 0.5937 |
| S5 | Completing the goals of the worksheet gives me a satisfaction. | 4.250 | 0.6147 |
| Total Average | | 4.2864 | 0.60834 |

The total average of the question items on "relevance" was 4.275, with each item achieving a score greater than 4, as shown in [Table 8](#).

The total average of the question items on "confidence" was 4.102, as listed in [Table 9](#); the item with the lowest score was "I am confident that I can solve any problems I encounter." The average for that item was 3.818 with a standard deviation of 1.0842.

The total average of the question items on "satisfaction" was 4.2864, with each item achieving a score greater than 4, as shown in [Table 10](#).

Discussion

The descriptive statistical analysis yielded the following conclusions: the respective averages for the four dimensions of "attention," "relevance," "confidence," and "satisfaction" were 4.165, 4.275, 4.102, and 4.2864, which were more than satisfactory. The results show that ARCS model can indeed improve learning motivation of learners and are consistent with previous related research of scholars on programming language. The top four items with the highest scores were C6, S3, S1, and R3, among which C6 and R3 showed that collaborative learning among peers was crucial and enhanced students' confidence in learning. The result meets the suggestion of Sharp (2016) that the teacher must encourage more collaboration between learners during the in-class activity. In addition, S3 and S1 demonstrated that problems were solved by using programs and the appropriate provision of feedback and encouragement by teachers increased students' satisfaction.

The average scores of the two items R1 and R2 are 4.205 and 4.295 respectively. It means that the learners have better self-learning skills. Thus, the proposed model can enhance the learners' self-learning ability suggested by Antti et al. (2016).

The two items with the lowest average scores were C3 and C5 from the "confidence" dimension, with scores of 3.818 and 3.841, which were barely satisfactory. This study asserted that even though the learners attended programming courses, they may not have the confidence to solve problems in other fields. In addition, the learners were not confident about using their programming skills in other fields, and were also unsure about how to apply them. Therefore, the teachers should cite more problems from other fields and increase the learners' capacities to solve various problems through the capabilities taught in programming courses.

This course is once a week, 3 lessons per class, 50 minutes per lesson, and taught in the computer classroom. To allow learners to complete the content of the worksheet during each class time, we give the following suggestions when designing the worksheet.

- Learning content must meet learning objectives.
- Learning content should not be too simple or too difficult. That is, we must allow learners to complete the learning content in time.
- About 75% of the learning content was taught by the teacher at the beginning and the remaining content should allow learners to learn online.
- The final results (report and program) are obtained through the teamwork.

CONCLUSION AND FUTURE STUDIES

In this study, a flipped classroom was tested based on the proposed ARCS_PBL_FC model. The statistical results from the quantitative experiment showed no significant difference in the midterm exam results between the experimental group and control group, although the experimental group's programming scores were always higher than those of the control group after the experiment, with significant and highly significant differences. The results demonstrated that the students in the experimental group had a significant improvement in their learning results after the implementation of the teaching method in this study. Therefore, this study argued that the proposed teaching method can improve learners' learning outcomes.

The results from the qualitative research showed that the participating classes achieved satisfactory levels in the average scores for all four dimensions in the questionnaire, thus this study contended that the proposed teaching approach can enhance learners' learning motivation and also improve the shortcomings of flipped classroom proposed by Antti, et al. (2016) and Sharp (2016). The main factors are as follows: the flipped classroom method differs from conventional teaching methods in that it can attract students' attention, and establishing relevance between the learning objectives and students can bring a sense of achievement to the students after they have completed the learning objectives. Appropriate worksheet content can trigger students' learning motivation, and the satisfaction from achieving worksheet objectives can sustain their learning motivation, thereby bringing about a positive cycle. In addition, the questionnaire analysis results also revealed that teachers have an impact on learners' satisfaction, illustrating that apart from the changes in teaching methods during the implementation of a flipped classroom, the teachers' mentality and ideas also require changes to improve learners' learning outcomes and motivation in a flipped classroom.

Considering the time of each class, we also provide four suggestions of designing the worksheet when applying the ARCS_PBL_FC model into flipped classroom. These suggestions can be provided to experts and scholars as an important reference.

This study conducted four experiments, each having a duration of 150 minutes. Future studies can increase the number of experiments and increase or decrease the duration to explore the effects on learning outcomes and motivation. In addition, the control group can be interviewed after their results have been cross-checked with those of the experimental group to learn the problems that are not discovered by learners during the learning process, thereby ameliorating the interference factors in the learning process. Situated learning can also be included; for example, real-life examples can be added into the conceptual explanation stage to lead learners into situations for learning, through which their learning motivation and effectiveness may be improved. In terms of collaborative learning, question item C6 from the questionnaire showed that each group in the experimental class discussed problem-solving tactics with other groups during the learning process. Open collaboration is characterized by its capacity to enable learners to discuss topics with each other and to solve problems in a collaborative manner, thus the impacts of such collaboration on learning outcomes and motivation will be further explored in the future.

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