Universal Access in the Information Society (2024) 23:395–410
https://doi.org/10.1007/s10209-022-00958-9

LONG PAPER

Integrating online meta-cognitive learning strategy and team regulation to develop students' programming skills, academic motivation, and refusal self-efficacy of Internet use in a cloud classroom

Chia-Wen Tsai[1] · Lan-Yu Lee[2] · Yih-Ping Cheng[3] · Chih-Hsien Lin[4] · Min-Ling Hung[5] · Jian-Wei Lin[6]

Accepted: 24 November 2022 / Published online: 3 December 2022

Abstract
With the development of technology and demand for online courses, there have been considerable quantities of online, blended, or flipped courses designed and provided. However, in the technology-enhanced learning environments, which are also full of social networking websites, shopping websites, and free online games, it is challenging to focus students' attention and help them achieve satisfactory learning performance. In addition, the instruction of programming courses constantly challenges both teachers and students, particularly in online learning environments. To overcome and solve these problems and to facilitate students' learning, the researchers in this study integrated two teaching approaches, using meta-cognitive learning strategy (MCLS) and team regulation (TR), to develop students' regular learning habits and further contribute to their programming skills, academic motivation, and refusal self-efficacy of Internet use, in a cloud classroom. In this research, a quasi-experiment was conducted to investigate the effects of MCLS and TR adopting the experimental design of a 2 (MCLS vs. non-MCLS) × 2 (TR vs. non-TR) factorial pre-test/post-test. In this research, the participants consisted of four classes of university students from non-information or computer departments enrolled in programming design, a required course. The experimental groups comprised three of the classes, labelled as G1, G2, and G3. G1 concurrently received both the online MCLS and TR intervention, while G2 only received the online MCLS intervention, and G3 only received the online TR intervention. Serving as the control group, the fourth class (G4) received traditional teaching. This study investigated the effects of MCLS, TR, and their combination, on improving students' programming skills, academic motivation, and refusal self-efficacy of Internet use in an online computing course. According to the results, students who received online TR significantly enhanced their programming design skills and their refusal self-efficacy of Internet use a cloud classroom. However, the expected effects of MCLS on developing students' programming skills, academic motivation, and refusal self-efficacy of Internet use were not found in this study. The teaching strategy of integrating MCLS and TR in an online programming course in this study can serve as a reference for educators when conducting online, blended, or flipped courses during the COVID-19 pandemic.

Keywords Online meta-cognitive learning strategy · Online team regulation · Programming skills · Academic motivation · Refusal self-efficacy of Internet use

1 Introduction

As an interdisciplinary field, the learning sciences are related to psychology, cognitive science, computer science, education, and sociology [77], well grounded in theory and methodology, along with a significant amount of empirical research that is relevant for the development, implementation, and application of educational technologies [30, 56]. Existing studies indicate that many students find the learning of programming difficult due to its conceptual complexity, including algorithms, variables, arrays, loops, and functions in programming languages, which may further raise barriers for learning programming and reduce students' learning motivation [107]. Thus, it is necessary to include and

✉ Chia-Wen Tsai
jawen12b@gmail.com

Extended author information available on the last page of the article

integrate innovative teaching methods with technologies to help students achieve better learning performance in programming courses.

In this study, the researchers considered and designed an online programming course according to students' specific needs for programming concepts and skills to help them develop essential computer competence needed in the workplace. Thus, the researchers adopted effective and appropriate online pedagogies to design a cloud classroom-based programming course aimed to meet students' needs and programming education goals appropriately. The following subsections introduce these.

1.1 Adoption of meta-cognitive learning strategy

Learning programming is considered as a difficult and challenging task for many novice programmers with high withdrawal rates from introductory programming courses [80]. In addition, learning programming may result in resistance to learn among non-information or non-computer majors when their learning experiences and performances are worse than those of computer science majors [25]. It is reported that programming courses typically have a large number of students who fail or drop out, whether computer science majors or not [104]. Many students regard programming courses as difficult and lowly motivating [2, 3, 14, 59, 104]. It is mentioned that the two key reasons for students' high failure rates in programming courses are teaching methods and curriculum organization [106]. The importance of and need for re-designing and re-developing introductory programming courses is indicated by educators [25].

In this regard, the researchers in this study searched for an effective and practical teaching method; meta-cognitive learning strategy (MCLS) is selected for improving non-computer students' learning outcomes. MCLS involves active control of learning through the phases of planning, monitoring, and evaluating learning processes [4, 23, 66, 88, 90], and it is noted that some educators provide or use different names for these phases [124]. It is reported that MCLS is a main factor influencing students' academic achievement [1, 87]. Thus, the researchers adapted MCLS in an online programming course and investigated its effects on developing students' programming skills, academic motivation, and refusal self-efficacy of Internet use in a cloud classroom.

1.2 The need for team regulation

Environmental structuring commonly refers to the digital and physical environments, which may result in students' distraction [121]. It is reported that the distracting nature of social media and technology may extremely increase the possibility of the mind wandering when students are engaged in an online learning environment [47]. For example, in online learning environments, it is difficult to help students concentrate on coursework due to the distraction of social networking websites (such as Twitter and Facebook), online games, and shopping websites [22, 108]. Therefore, developing and understanding students' regulation of attention during learning are important factors in the age of digital distraction [119].

In this regard, the researchers adopted team regulation (TR), which is aimed at the coordination between team members [101], to develop students' regular learning habits and achieve better learning effects in an online learning environment. Within a team, the leader may perform the function of planning, such as assigning tasks to members or allocating roles, so that remaining team members may engage in monitoring activities during the process [28]. In such a collaborative learning environment, learners should manage to regulate their joint activities as well as their individual tasks at hand throughout the learning process [102]. When students study in a collaborative environment, they not only have to regulate their individual learning process but also deal with collaborative activities. For instance, when students are assigned to a team, they have to understand the tasks at hand and communicate with other team members, exchange ideas, give explanations to confused members, and even negotiate about the designated workload [20, 102]. Therefore, the researchers in this study integrated TR with related educational technology to develop students' regulated learning habits and further improve their programming skills, academic motivation, and refusal self-efficacy of Internet use in a cloud classroom.

The instruction of programming courses faces great challenges all over the world (Martins, de Almeida Souza Concilio & de Paiva Guimarães, [84]). Many educators have indicated that various difficulties emerge in terms of programming instruction [7, 39, 45, 122], including lack of linking theory with practical education and low motivation for learning programming [17]. The limited availability of educational technology matched with appropriate teaching methods for learning programming can lead to students' low motivation for learning [114]. In order to help students develop practical programming skills, academic motivation, and refusal self-efficacy of Internet use, the researchers integrated MCLS and TR with educational technologies and investigated their effects in this research. For example, students' programming skills were measured based on the six success dimensions of D&M IS Success Model [27], and the difference between MCLS and non-MCLS groups, or TR and non-TR groups was investigated, to demonstrate whether MCLS and TR could improve students' programming skills. The research questions (RQ) are listed below.

- RQ1: Could online MCLS lead to students' better development in *programming skills, academic motivation, and refusal self-efficacy of Internet use* in a cloud classroom?
- RQ2: Could online TR lead to students' better development in *programming skills, academic motivation, and refusal self-efficacy of Internet use* in a cloud classroom?
- RQ3: Could the combined intervention of online MCLS and TR lead to students' better development in *programming skills, academic motivation, and refusal self-efficacy of Internet use* in a cloud classroom?

This paper first introduces the challenges in programming courses and the problems in online learning environments in Sect. 1. Related literature about the effects and validity of online MCLS, TR, and the dependent variables (programming skills, academic motivation, and refusal self-efficacy of Internet use) are individually portrayed in Sect. 2. Subsequently, Sect. 3 presents the research methodology, the experimental design and procedure, the intervention of online MCLS and TR, along with how students' programming skills, academic motivation, and refusal self-efficacy of Internet use were evaluated. Then, Sect. 4 illustrates the testing and analysis of data collected, and Sect. 5 discusses the findings in this study and the related literature that supports our research results. Finally, Sects. 6 provides the conclusion and implications for educational institutions and online educators.

2 Literature Review

2.1 Meta-cognitive learning strategy

The term "meta-cognitive learning strategies" (MCLS) and "meta-cognitive strategies" can often be seen used interchangeably in many studies. As Zahedi [124] mentioned, in the past, many scholars have developed their own theories or definitions surrounding the original concept of metacognition but may use different nomenclature. Overall, MCLS can be summarized as learners managing and thinking about the learning process and controlling their own cognition [23, 90, 124]. For the purpose of this study, the definition of MCLS refers to a learner's awareness of managing, controlling and regulating their learning as well as their thinking process [72], or, put more simply, "thinking about thinking" [4, 124].

Early on, the concept of meta-cognition was introduced by Flavell [31], who suggested it is comprised of meta-cognitive experiences or regulation and meta-cognitive knowledge. In O'Malley and Chamot's [88] opinion, meta-cognitive strategies include three major categories: self-planning, self-monitoring, and self-evaluating. Meta-cognitive strategies allow students to organize their learning activities, in other words, to plan, monitor, and evaluate the learning process. Nowadays, these strategies are widely used by teachers in different subjects, including language learning, mathematics and chemistry, and in different levels of educational institutions [8, 51, 63, 74, 96, 127].

Summarizing from several existing studies, it is found that there is a positive correlation between the use of MCLS with students' performance, whether it is in the reading comprehension field [16, 50, 126], computer-related courses, or other subjects [100, 127], and this effect is also observed in the MOOCs environment [58]. These studies show that deploying MCLS can lead students to better academic performance. Furthermore, some studies focus on other positive effects of MCLS; for example, the findings in Ho and Kuo's [46] study reveal that the positive impact on learning outcomes of students' attitudes was broadened by the feeling of being in control and the sense of concentration during the learning activity, as well as curiosity and intrinsic interest. Therefore, MCLS was adopted and implemented in our re-designed programming course in an online learning environment, and this research also explored the impact of MCLS on improving students' learning effects.

2.2 Team regulation

Team regulation (TR) is defined as the dynamic means through which "team members share their understanding of their task and environment, interpret their team feedback in comparison to their stated objectives, and enact coordinated effort toward their team goal" [61]: 276; [92]. In some studies, TR is referred to as co-regulation [15, 36, 102], which requires metacognitive interactions between group members, whether it is about sharing opinions, monitoring task processes, or evaluating learning progress [40, 65, 69]. These activities include communicating among team members, planning of activities, and monitoring of team [20, 102].

As team members set up their collective goals and act according to their assigned roles, they may receive feedback for their collective performance. Some researchers focus on the social aspects of TR, such as the influence of team feedback [93], and their findings show that feedback to teams could have significant effect on future team outcomes. De Jong and colleagues [26] found that, when in teams, students put more focus on interactive activities such as sharing opinions and reaching common ground. In addition, it is reported that group feedback (in the form of team performance appraisals or evaluation) and group goals are closely related (Van der Vegt, Emans & Van De Vliert [112]).

Moreover, it is also mentioned that students who are learning in computer-based learning environments require regulation in their learning process in order to avoid ill-structured learning tasks. Students who are assigned in teams often need to make extensive learning choices and need to keep monitoring and evaluating throughout the process. When they are assigned to teams, regulation of the collaborative learning process is essential to the outcomes of their learning [5]. There are also studies which point out that students perform better in monitoring progress and creating meaningful thinking or discussion when computer-based communication tools are provided [102]. Furthermore, it is also indicated that a user-friendly online learning platform could be helpful for the development of students' programming skills (Buyrukoğlu, in press, Moodle meets this criterion [37]) and was used as a platform in this study. Therefore, the researchers in this study adopted online TR to develop students' programming skills, academic motivation, and refusal self-efficacy of Internet use in an online programming course in this study.

2.3 Students' programming skills

Computer programming is a subject that requires strategies to develop students' ability of solving problems and involves many programming logic activities [41]. The practice of computer programming is a mechanism for students' development of computational thinking (CT) ([78], Restrepo-Calle, Ramírez Echeverry & González, [98]). However, it is indicated that developing students' programming skills is a very complex and hard task with a high rate of failure [53]. Moreover, it is important to evaluate students' work when they learn about computer programming (Restrepo-Calle, Ramírez Echeverry & González, [98]). The existing literature indicates that the efficiency of summative and formative assessment for novice programmers can be improved based on a computer-based or technology-enhanced learning environment which can provide comprehensive and strong feedback [10]. In this study, the researchers regard students' programming skills as their ability to design and develop a program, system, or application by using Visual Basic for Applications (VBA) with purposive functions. Then, the effects of online MCLS and TR on improving students' programming skills were investigated.

2.4 Academic motivation

Academic motivation refers to a set of motives associated with distinct achievement goals and includes both intrinsic and extrinsic motivation [67, 68, 111]. It is demonstrated to be an important element in both traditional and online learning environments when the positive relationship of students' grades with academic motivation was investigated [49]. For example, students' academic motivation as a substantial predictor of academic success has been demonstrated in online learning space [33, 52, 89, 123].

It is revealed that self-regulation and academic motivation are two of the critical "soft skills" for students to develop [38, 82, 99, 110]. It is also reported that SRL positively affects a sense of learning achievement, as well as learners' motivation and behaviour (Lee, Watson & Watson, 2019). Moreover, existing literature indicates that academic motivation is one of the crucial features when designing an effective online course [6]. Thus, the researchers in this study extended SRL to TR and integrated it with MCLS to help students achieve better development of academic motivation and programming skills in an online course.

2.5 Refusal self-efficacy of internet use

With the advancement of technology, Internet use, smartphones, and web-based applications have become an essential part of modern life. Despite the numerous advantages it brings, excessive Internet use can result in negative or even hazardous effect on people [44, 57, 117, 118]. The convenient and inexpensive Internet environment has resulted in generations of heavy users among college students [21]. Furthermore, due to the educational conditions in Taiwan, compared to their pre-college life, college students may be freer from restraints on using the Internet. Studies surrounding the topic of Internet addiction have increased in recent years, and diverse measurements of this worldwide phenomenon have been developed [44, 71, 75].

In the existing literature, refusal self-efficacy of Internet use is defined as an individual's belief that she/he can purposely refuse or resist using the Internet in a high-risk situation, such as when a smartphone or computer is turned on [75]. As it is difficult to help students concentrate on coursework in an online learning environment [108], it is critical to develop students' regular learning habits and their ability to refuse to use Internet before providing online courses to them. Thus, the researchers in this study integrated MCLS and TR in an online programming course to help students develop their refusal self-efficacy of Internet use and further improve their learning performance.

3 Empirical study

3.1 Course setting

In this research, the involved course was a semester-long, two credit-hourly course titled 'Programming Design', targeting first-year undergraduate students of a comprehensive university in Taiwan. This course mainly focuses on developing students' programming skills and concepts by using Visual Basic for Applications (VBA). The teacher in this course first introduced the algorithm, syntaxes, macros, and basic functions of VBA. Then, the teacher applied the approach of MCLS described in section '3.3.1. Intervention of meta-cognitive learning strategy', as well as the strategies of TR introduced in subsection '3.3.2. Intervention of team regulation' for the experimental groups. Then, from the 16th week of the semester, presentations by students began of the programs, applications, or systems they had designed.

3.2 Participants

In the context of the present research, the participants from non-computer, non-information departments took a compulsory course titled 'Programming Design' for two hours a week. There were 126 undergraduates from four class sections, all with the same instructor. These students comprised 31 males and 95 females. The mean age of participants was 18.89 years. Prior to taking the course, students possessed an average of 1.06 certifications each, related to Microsoft PowerPoint or Microsoft Word. The researchers set up four groups following this experimental design: the MCLS and TR class (G1, n = 26), the MCLS and non-TR class (G2, n = 29), the non-MCLS and TR class (G3, n = 44), and the non-MCLS and non-TR class (G4, control group, n = 27).

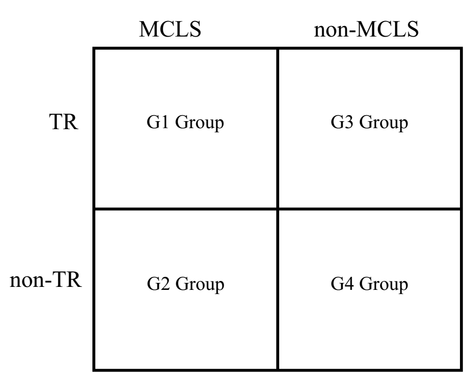


Fig. 1 The different instructional designs for this study

The experimental design of the four groups is shown in Fig. 1.

3.3 Experimental design and procedure

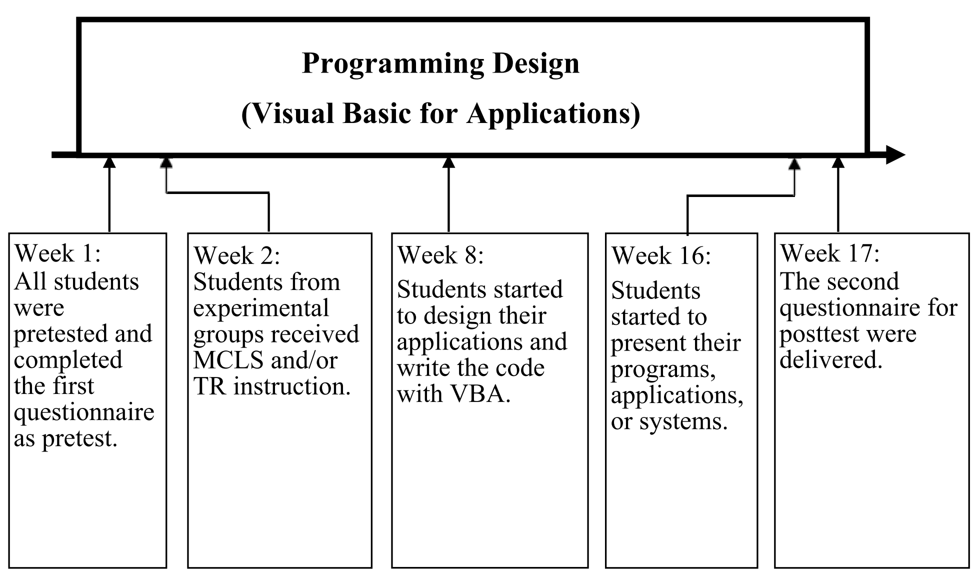
The experimental design comprised a 2 (MCLS vs. non-MCLS) × 2 (TR vs. non-TR) factorial pre-test/post-test design. G1 concurrently received the intervention of online MCLS and TR; G2 received only the intervention of online MCLS; G3 received only the intervention of online TR, with these three as the experimental groups. The non-MCLS and non-RL group (G4) received the traditional teaching method and served as the control group. The course schedule followed is illustrated in Fig. 2.

3.3.1 Intervention of meta-cognitive learning strategy (for G1 and G2)

In the existing literature, meta-cognitive models for instructing students have been developed by Winne and Hadwin [116] and Pintrich [94]. The former model suggests that learners initiate a process of four basic stages: defining tasks at hand, setting goals and constructing plans, enacting learning strategies, and making adjustments according to performance. The second model presented by Pintrich [94] is structured similarly, with forethought, planning and activation, monitoring, control, reaction, and reflection as its components [24]. In addition, meta-cognitive learning strategies such as goal setting, strategic planning, and self-evaluation are included in the useful strategies applied by MOOCs users [58].

When looking for the proper model for practical instruction in a programming course, the researchers discussed and reflected on previous teaching and adopted the Cognitive

Fig. 2 Schedule of the course and assessment during the semester



Academic Language Learning Approach (CALLA) first presented by Chamot & O'Malley [13]. The CALLA model consists of five steps: preparation, presentation, practice, evaluation, and expansion [1, 24]. Although it was originally used in language learning, the core concept of MCLS can be employed in other subjects. Thus, CALLA was adopted for students in G1 and G2 with the following approaches:

1. Preparation: In this initial phase, the educator provided assistance to learners who are developing their meta-cognitive awareness and made sure they realize the significance of meta-cognitive learning strategies;
2. Presentation: The educator further explained the nature of meta-cognitive learning strategies to learners through various examples, such as its characteristics, usefulness, and applications, so that they gained explicit instructions regarding how to use these strategies;
3. Practice: The learners had the opportunity to start employing the meta-cognitive learning strategies with the tasks at hand. They became aware of the multiple strategies available and understand the appropriate use of them;
4. Evaluation: Evaluation is one of the keys in meta-cognitive learning strategies, and the educator asked learners to document and evaluate their learning progress in the course;
5. Expansion: In the final phase, the educator encouraged learners to find out which are the most effective meta-cognitive learning strategies for them, let them discover new ways of applying these strategies (i.e. other subjects or aspects), or guided them to share their own combinations and interpretations of meta-cognitive learning strategies.

3.3.2 Intervention of team regulation (for G1 and G3)

Self-regulation-related theories have been extended to the team level [92], such as the team regulatory focus for team function and performance [73]. TR is associated with the process by which team members share individual knowledge regarding their task and environment, analyse and respond to team feedback, and coordinate actions toward team goal [61, 92]. TR focuses on coordination of the collaboration between students, while the intrinsic factors comprise planning of their activities and monitoring of their team process [101].

TR processes are critical factors of team performance and have the potential to be applied in a variety of interventions such as training, leadership, and provision of goals and feedback [62]. It is indicated that, given the potential for information technology to leverage TR, there has been little significant effort to apply this practical set of research findings [60]. In order to effectively implement TR in this study, the researchers in this study adopted Fleishman & Zaccaro's [32] and Kozlowski & Ilgen's [62] team performance functions to help G1 and G3 students benefit from this intervention, including the following seven functional categories:

1. Orientation functions, including information exchange regarding team member resources and limitations;
2. Resource-distribution tasks, which involve balancing the workload across team members;
3. Timing functions, which indicate when activities are conducted;
4. Response-coordination functions, including the synchronization and timing for coordination;
5. Motivational functions, comprising such aspects as balancing attention on goals of individuals and of the team;
6. Systems-monitoring functions, which enable the corrections of team and individual activities in response to errors. It is also reported that monitoring goal progress is a critical mechanism through which teams can attain the positive outcomes of team efficacy [97],
7. Procedure maintenance, which includes monitoring of general procedures and activities.

Furthermore, as it is reported that many students engage on social networks for considerable time, educational institutions could use this habit and technology for educational purposes [79]. Thus, in the implementation of TR, students from G1 and G3 were also required to form groups in an online chat APP (e.g. LINE, WeChat, or even Facebook), for goal setting, information sharing, interaction, reminder, monitoring, and resource sharing.

3.3.3 Intervention for control group (G4)

Students in the control group G4 received the identical learning materials, assignments, practice time, and class hours as those in G1, G2, and G3; however, they did not have to adopt MCLS nor implement TR. The teaching in the control group focused on traditional lectures on basic syntaxes and functions of VBA and required completion of the applications with expected functions by the involved students.

3.4 Measurement

3.4.1 Pre-tests of students' computing skills, academic motivation, and refusal self-efficacy of Internet use

Programming skills In this programming course, the researchers in this study took students' learned programming skills as their learning effect. In order to investigate whether our interventions of MCLS or TR were effective or not, the researchers in this study first checked if students had ever learned how to write programming code, had an experience of programming, or learned how to use VBA prior to this programming course. This could reduce the possibility and potential threat from students' initial differences in programming skills that might result in bias of evaluation. Thus, in the first week of the semester, all students were asked if they had the experience of programming or had learned VBA before this course, and none of them reported having done so. Therefore, it is believed that students in the course had similar levels of writing programming code prior to their receiving the intervention of MCLS and/or TR.

Academic motivation Students from the four groups were asked to complete the questionnaire of Motivated Strategies for Learning Questionnaire (MSLQ), developed by Pintrich et al. [95] as a pre-test of their academic motivation before the course started. MSLQ integrates knowledge of different research domains, including instructional psychology, traditional and online educational research [86], and cognitive psychology [85]. MSLQ includes 81 items and can be divided into two broad categories: (1) a motivation category (31 items) and a learning strategy category (50 items). All items are scored on a 7-point Likert scale, ranging from 1 (not at all true of me) to 7 (very true of me) [86]. In the pre-test, the researchers in this study investigated if any difference of students' academic motivation existed among the four groups before they received the intervention of MCLS and/or TR.

Refusal self-efficacy of Internet use The measurement of students' refusal self-efficacy of Internet use in the pre-test could confirm whether they had similar levels of refusal self-efficacy of Internet use in this computing course before the experiment begins. The refusal self-efficacy of Internet use questionnaire is a 6-point Likert scale self-reported questionnaire developed by Lin, Ko, and Wu [75]; it is a self-reported questionnaire measured with a 6-point Likert scale, with 1 being totally unconfident (0%) in resisting or refusing Internet use and 6 being 100% confident in resisting or refusing Internet use. When a person scores low on this questionnaire, it represents the person's level of refusal of Internet use is lower than a person who has a high score. The version of the questionnaire used in this study was adapted from the work of Lin et al. [76] and contains 19 items from the original questionnaire of 33 items, so the total score ranges from 19 to 114. All of the study participants were required to complete this refusal self-efficacy of Internet use pre-test.

3.4.2 Post-tests of students' programming skills, academic motivation, and refusal self-efficacy of Internet use

Programming skills In this research, students presented the program or application they designed in the 16th week of the semester. The teacher and researchers mainly graded these according to D&M IS Success Model, which includes six success dimensions: system quality, service quality, usage, user satisfaction, information quality, and net benefits [27]. The more complete and the more functions included in students' programs or applications, the higher the scores they received.

During students' presentations, the teacher in this study asked questions and provided comments on students' designed programs and presentations. Based on the rubrics mentioned above, the teacher graded students' system demonstration and their oral presentations and recorded the grades. In general, the same grade was given to students on the same team according to the rubric. However, students' individual grades may have varied because of individual presentation quality and his/her responses to the teacher's questions.

Academic motivation The post-test measurement of students' academic motivation was identical to that in the pre-test. In the post-test, all four groups of participants completed the MSLQ in the 17th week of the semester. Then, the differences among the four groups of students regarding academic motivation were analysed and reported.

Refusal self-efficacy of Internet use Students completed the same refusal self-efficacy of Internet use questionnaire adapted from the work of Lin et al. [76], in the seventeenth week for the post-test. The differences among the four groups of students regarding refusal self-efficacy of Internet use in this cloud classroom and course were analysed.

3.5 Cloud classroom used in the study

A cloud classroom was provided by the researchers, teacher, and university for students' learning. Besides the course website (Moodle), students in this study could also log in to the university-developed cloud classroom to use the learning material they needed. They could log in to this cloud classroom via a personal computer or Tablet PC, and review or practice the learned programming skills after class. The necessary software and materials were provided in this cloud classroom for students' use if they did not own them themselves.

3.6 Design of the course website

The involved programming courses in this study were delivered via Microsoft Teams. Moodle was also used as the teaching website for students in the four groups. The synchronous online classes were taught and recorded in Microsoft Teams, where students could review the course content after classes. In addition, the Moodle learning management system was used for providing course description, syllabus, learning materials, assignments, homework submissions, and course-related information. Moreover, students could download the necessary learning files to review or preview. Students from the same class could conduct team discussions or team-on-team discussions using the Moodle forum.

4 Results

4.1 Pre-tests

The researchers in this study attempted to avoid measurement bias before implementing the MCLS and TR teaching approaches by conducting pre-tests. According to the one-way ANOVA pre-tests shown in Table 1, the difference of students' academic motivation and the level of refusal self-efficacy of Internet use among G1, G2, G3, and G4 are not significant. Moreover, the authors analysed students' programming skills before the course began. During the first week of the semester, the teacher queried if students had previously learned the programming design tools that were about to be used. Students who knew the required programming skills would have been excluded from this experiment; however, prior to this course, none of them had learned how to program. According to the analysis in the pre-test and the teacher's precautions, it is believed that participating students possessed equal levels of programming skills, academic motivation, and levels of refusal self-efficacy of Internet use at the initiation of the experiment. Thus, the potential threat of pre-existing variance among students can be excluded.

4.2 Post-tests

4.2.1 Meta-cognitive learning strategy

To investigate the effects of web-based MCLS, the independent samples *t* test was applied to analyse and compare students' programming skills, academic motivation, and the level of refusal self-efficacy of Internet use in the MCLS group (G1 + G2) and non-MCLS group (G3 + G4). Table 2 shows that none of students' programming skills, academic motivation, or refusal self-efficacy of Internet use in the MCLS group were significantly different ($p > 0.05$). The results in Table 2 indicate that students who received MCLS did not have significant contribution to their development of programming skills, academic motivation, or the level of refusal self-efficacy of Internet use.

Table 1 One-way ANOVA: pre-test of students' academic motivation and refusal self-efficacy of Internet use

Dependent variable	Group (I)	Group (J)	Mean difference (I–J)	Std. error	Sig	F	*p*
Academic motivation	G1	G2	– 0.111331	0.192011	0.953	1.364	0.257
		G3	0.077315	0.188735	0.983		
		G4	0.219341	0.172859	0.658		
	G2	G1	0.111331	0.192011	0.953		
		G3	0.188646	0.186883	0.797		
		G4	0.330672	0.170835	0.295		
	G3	G1	– 0.077315	0.188735	0.983		
		G2	– 0.188646	0.186883	0.797		
		G4	0.142026	0.167144	0.868		
	G4	G1	– 0.219341	0.172859	0.658		
		G2	– 0.330672	0.170835	0.295		
		G3	– 0.142026	0.167144	0.868		
Self-efficacy of Internet use	G1	G2	0.505001	0.287474	0.382	1.676	0.176
		G3	0.494179	0.282569	0.387		
		G4	0.534684	0.258801	0.239		
	G2	G1	– 0.505001	0.287474	0.382		
		G3	– 0.010822	0.279797	1.000		
		G4	0.029683	0.255770	1.000		
	G3	G1	– 0.494179	0.282569	0.387		
		G2	0.010822	0.279797	1.000		
		G4	0.040505	0.250245	0.999		
	G4	G1	– 0.534684	0.258801	0.239		
		G2	– 0.029683	0.255770	1.000		
		G3	– 0.040505	0.250245	0.999		

Table 2 Comparison of students' programming skills, academic motivation, and the level of refusal self-efficacy of Internet use between MCLS and non-MCLS groups

Dependent variable	Group								t	df	Sig. (two-tailed)
	MCLS				non-MCLS						
	n	M	SD	SE	n	M	SD	SE			
Programming skills	55	77.25	9.314	1.256	71	78.00	6.780	0.805	– 0.500	124	0.618
Academic motivation	55	4.28211	0.777874	0.104889	71	4.29396	0.745564	0.088482	– 0.087	124	0.931
Refusal self-efficacy of Internet use	55	3.22010	1.032611	0.139237	71	3.08228	0.996620	0.118277	0.758	124	0.450

4.2.2 Team regulation

To investigate the effect of web-based TR, comparison of students' programming skills, academic motivation, and the level of refusal self-efficacy of Internet use in the TR group (G1 + G3) and non-TR group (G2 + G4) was carried out via the independent samples *t* test. The results shown in Table 3 reveal a significant difference ($p < 0.05$) in student's programming skills and level of refusal self-efficacy of Internet use between the TR group (G1 + G3) and non-TR group (G2 + G4). However, Table 3 shows that for those who received TR treatment, their academic motivation had no significant increase in this research ($p > 0.05$).

4.2.3 Meta-cognitive learning strategy and team regulation

One-way ANOVA was again applied to analyse students' programming skills (grades), academic motivation, and the level of refusal self-efficacy of Internet use under the four conditions (groups). Table 4 reveals that learners of G1, who received the intervention of web-based MCLS and TR, did not have better performance than other groups (G2 receiving MCLS & non-TR teaching method, G3 receiving non-MCLS & TR teaching method, and G4 receiving traditional teaching method). However, it is found that G3 had better development in programming skills than G4 (the control group).

5 Discussion and implications

Online education is currently implemented at all levels of educational institutions worldwide to provide students alternative channels for learning during the COVID-19 pandemic [120]. In addition, it is indicated that the adoption of web-enhanced active learning has been emphasized by online educators [81]. Thus, this study redesigned innovative online teaching methods to help students develop programming skills, as well as improve their academic motivation and level of refusal self-efficacy of Internet use in online programming courses. The researchers believe that this research could contribute to e-learning theory in three different ways, particularly during this time of COVID-19 pandemic. First of all, this research may specify how teachers can develop students' practical programming skills, academic motivation, and refusal self-efficacy of Internet use by applying MCLS in an online learning environment. Secondly, the adoption and implementation of online TR learning strategy is shown to help students develop regular learning habits and further improve their learning performance in the online environment, which is full of social networking websites, shopping websites, and free online games [22]. Finally, this research may be among the first efforts to explore the effects of the various combinations of MCLS, TR, and cloud classroom in an online programming course. For example, in the implementation of MCLS, the teacher asked students to

Table 3 Comparison of students' programming skills, academic motivation, and refusal self-efficacy of Internet use between TR and non-TR groups

Dependent variable	Group								t	df	Sig. (two-tailed)
	TR				non-TR						
	n	M	SD	SE	n	M	SD	SE			
Programming skills	70	78.96	7.180	0.858	56	76.07	8.638	1.154	2.048	124	0.043*
Academic motivation	70	4.22581	0.757933	0.090590	56	4.36751	0.754708	0.100852	– 1.045	124	0.298
Refusal self-efficacy of Internet use	70	3.31203	1.042334	0.124583	56	2.93045	0.936143	0.125097	2.136	124	0.035*

*$p < 0.05$

Table 4 One-way ANOVA: post-test of students' programming skills, academic motivation, and refusal self-efficacy of Internet use

Dependent variable	Group(I)	Group(J)	Mean difference (I–J)	Std. error	Sig	F	*p*
Programming skills	G1	G2	– 1.086	2.145	0.968	3.089	0.030*
		G3	– 3.570	1.981	0.359		
		G4	2.056	2.181	0.828		
	G2	G1	1.086	2.145	0.968		
		G3	– 2.484	1.868	0.623		
		G4	3.142	2.079	0.518		
	G3	G1	3.570	1.981	0.359		
		G2	2.484	1.868	0.623		
		G4	5.625	1.909	0.038*		
	G4	G1	– 2.056	2.181	0.828		
		G2	– 3.142	2.079	0.518		
		G3	– 5.625	1.909	0.038*		
Academic motivation	G1	G2	– 0.253708	0.210621	0.694	0.642	0.590
		G3	– 0.131970	0.194476	0.927		
		G4	– 0.250000	0.214124	0.715		
	G2	G1	.0253708	0.210621	0.694		
		G3	0.121737	0.183401	0.932		
		G4	0.003708	0.204118	1.000		
	G3	G1	0.131970	0.194476	0.927		
		G2	– 0.121737	0.183401	0.932		
		G4	– 0.118030	0.187414	0.941		
	G4	G1	0.250000	0.214124	0.715		
		G2	– 0.003708	0.204118	1.000		
		G3	0.118030	0.187414	0.941		
Refusal self- efficacy of Internet use	G1	G2	0.398215	0.276656	0.560	1.707	0.169
		G3	0.217360	0.255449	0.867		
		G4	0.598928	0.281258	0.215		
	G2	G1	– 0.398215	0.276656	0.560		
		G3	– 0.180855	0.240902	0.904		
		G4	0.200713	0.268115	0.905		
	G3	G1	– 0.217360	0.255449	0.867		
		G2	0.180855	0.240902	0.904		
		G4	0.381568	0.246173	0.496		
	G4	G1	– 0.598928	0.281258	0.215		
		G2	– 0.200713	0.268115	0.905		
		G3	– 0.381568	0.246173	0.496		

document and evaluate their learning progress in the course. Students had to submit their progress of programming skills and learned knowledge to the course website (Moodle) every week. In addition, in the implementation of TR, students in were required to submit a screenshot of their interaction and discussion for TR via in an online chat APP as homework every week. The teacher could thus take advantage of educational technologies to know and check students' development progress in programming skills. Based on these contributions, this study may provide references for researchers and educators responsible for online courses, who desire to design appropriate teaching methods, particularly for programming courses.

5.1 Effect of meta-cognitive learning strategy

In a recent trend, society and workplaces are beginning to be aware that information ability is a necessary competence for college students to cultivate, as developing computer skills and programming design skills is found to be increasingly crucial [12, 19, 109]. According to previous research [34, 113], MCLS could be more effective in developing students' programming skills with the integration with educational technology. Thus, the authors in this study were encouraged to apply MCLS in an online programming course to enhance students' learning performance and to investigate if MCLS could improve students' academic motivation, and refusal self-efficacy of Internet use.

With respect to our first RQ, the data in Table 2 indicate that MCLS did not significantly improve the MCLS group student's programming skills ($p = 0.618$), academic motivation ($p = 0.931$), or the level of refusal self-efficacy of Internet use ($p = 0.450$), when compared with the non-MCLS group. Although the expected effects of the online MCLS method on developing students' programming skills, academic motivation, or refusal self-efficacy of Internet use were not exhibited in this study, the non-significant results and differences may result from the following possible factors. First, based on the researchers' fifteen-year teaching experiences in private university in Taiwan, teachers have to follow overall policy, such as helping students pass licensure examinations and thus receive official certificates, and accepting the designed syllabus, schedule of teaching in each week, even using the unified textbooks [70]. In such teaching environments, teachers hardly have the freedom to design their courses according to their profession and experience to benefit their students. In this study, the teacher faced the abovementioned restrictions and thus could not effectively expand the effects of MCLS. That is, the expected effects of MCLS can hardly be found in the deadlocked framework of requirements (e.g. unified textbooks, pre-set syllabus) for teachers and students. Second, the length of the experiment period may be another factor of influence. It is pointed out that the one-semester experiment may be too short to result in significant development in students' learning [64, 108]. Nevertheless, it is still suggested that teachers can integrate MCLS in online courses in the teaching environments with full freedom for a longer period, to help students benefit from the intervention of MCLS and educational technologies.

5.2 Effect of team regulation

As the COVID-19 pandemic has led people and students to quarantine and isolation, it is critical to build a sense of community by developing the socio-emotional climate, reducing students' feelings of isolation and anxiety, and establishing environments for interaction in online courses [91, 105, 115]. Encouraging students' contributions and prompting discussion are important components of teaching presence in online learning environments [42]. In addition, it is reported that promoting students' autonomous and regular learning, that involves regulating their learning processes and emotions in different environments, is one of the main challenges in online and higher education [35]. In the present study, the authors adopted online TR and demonstrated its effects on facilitating students' learning.

As for the second RQ, according to the data shown in Table 3, students who received TR have significantly enhanced programming skills ($p = 0.043$) and level of refusal self-efficacy of Internet use ($p = 0.035$). This result is similar to existing research that TR had a positive effect on improving student's learning processes and outcomes [29, 101–103]. As students from G1 and G3 received the intervention of TR, when they presented their designed applications or systems in a team, the teacher asked questions, provided comments, and graded them based on D&M IS Success Model. However, their individual grades may be different due to each presenter's work quality and performance.

The data collected show that the difference of students' academic motivation between the TR group and the non-TR group did not reach statistical significance ($p = 0.298$). It is indicated that students' high engagement could limit their distractions; however, it may also lead to a loss of motivation [55]. That is, in the implementation of TR, teachers should pay attention to students' responses so as to not result in too much pressure and engagement. Based on the results, the authors suggest that teachers could consider applying TR in online programming courses to help students concentrate on their learning and further contribute to their learning performance.

5.3 Combined effects of online meta-cognitive learning strategy and team regulation

For our final RQ, we investigated whether the combined intervention of online MCLS and TR led to students' better development in programming skills, academic motivation, and refusal self-efficacy of Internet use. The data in Table 4 indicate that students who received both online MCLS and TR (G1) did not have significantly better development of programming skills, academic motivation, or refusal self-efficacy of Internet use than those who received traditional teaching (G4). The potential reasons for these non-significant results may be due to the inefficiency of MCLS, which are reported in subsection '5.1. Effect of Meta-Cognitive Learning Strategy'. That is, the intervention of online MCLS did not lead to expected effects for G1 students. Thus, the difference of students' programming skills, academic motivation, and refusal self-efficacy of Internet use between G1 and G4 is not statistically significant.

Although the combined intervention of MCLS and TR did not contribute to better development in students' programming skills, academic motivation, and refusal self-efficacy of Internet use, as the outcomes suggest, the sole treatment of online TR is found to be effective in developing students' programming skills. In Table 4, it is seen that G3 students (who only received the online TR intervention) had better development in their programming skills than those in G4 ($p = 0.038$). Thus, it is believed that the intervention of TR could contribute to students' learning effects in an online programming course.

Finally, based on the data shown in Table 4, there is a warning signal for teachers who are forced to provide online courses due to the COVID-19 pandemic. Teachers who plan to transform their traditional courses in the classrooms into online form, without re-designing the course or integrating practical and effective teaching methods, may find it hard to help their students gain satisfactory learning outcomes. For example, students who adopted neither MCLS nor TR, in G4, had the lowest programming skills, and refusal self-efficacy of Internet among the four groups, though insignificantly (see Table 4). According to our analysis and findings in this research and recommendations from a previous study [22], it is suggested that online teachers should first analyse their students' specific needs, adopt appropriate and innovative teaching methods, and redesign their courses, instead of directly transforming their course to the blended, flipped, or fully online form.

5.4 Potential problems and limitations of this study

In the present study, the researchers re-designed an online programming course, integrated the innovative and effective teaching methods of MCLS and TR with educational technologies, and examined their effects on improving students' programming skills, academic motivation, and refusal self-efficacy of Internet use in this course and in a cloud classroom. Conclusions drawn from a quasi-experimental design may inherently have some threats to validity, resulting in the potential of a few limitations and potential problems in drawing solid research conclusions from this research.

All of the students were first checked for previous experience with programming before this course and completed a pre-test to measure their academic motivation and refusal self-efficacy of Internet use before class. However, the researchers did not measure students' level of programming skills, rather assumed they had similar low level of skills, based on an oral check. Students' programming skills may not have been the same before they entered this course, and this may potentially affect the results. In addition, each student's computer competency and readiness for online learning may not necessarily be the same at the start of this course, even though a pre-test was conducted, which may result in bias in the evaluation. Moreover, some potential factors or experimental validity problems, such as Hawthorne effect, may have influenced students' learning effects. Hence, the validity of the results may potentially be affected by these factors. Teachers who are considering to adopt MCLS and TR in their online, blended, or flipped courses should be cognizant of these individual differences and problems associated with quasi-experimental design, as they may have affected the results and the claimed effects in this study.

6 Conclusion and directions for future work

As a result of rising demand for online courses, a considerable number of online or blended courses have been designed [83]. In addition, the importance of teachers' ability to design learning tasks and materials, and appropriately apply technologies in education is internationally recognized [48, 125]. Innovative teaching approaches, new learning strategies, and the use of innovative technologies are necessary to develop students' generic and specific competencies [11]. In this semester-long experiment, the TR strategy helped students significantly develop their programming skills and increased the level of refusal self-efficacy of Internet use; thus, the authors of this study propose that the TR strategy could enhance students' learning performance. However, the effect of MCLS teaching strategy on students' programming skills, academic motivation, and refusal self-efficacy of Internet use, did not show a significant increase in this experiment. Although the MCLS group cannot effectively expand the effects in this research, the MCLS strategy could still be effective with further adjustments and integrated with a flexible teaching environment.

In order to apply educational technology effectively in teaching, educators have to be able to integrate pedagogy, content, and technology well [43]. The findings of this study suggest that teachers of online courses could adopt TR and/or MCLS with appropriate modifications according to their situations, environments, challenges, or students' abilities and readiness. Finally, the authors suggest that online educators, researchers, and teachers could adapt and re-design their teaching methods and courses based on students' particular needs and characteristics, to aid them in achieving satisfactory learning performance.

Acknowledgements The authors would like to express appreciation for the financial support of NSC 109-2628-H-130-001- from the National Science and Technology Council, Taiwan, R.O.C.

References

1. Ahmadi, K., Ketabi, S., Rabiee, M.: The effect of explicit instruction of meta cognitive learning strategies on promoting Iranian intermediate language learners' writing skill. Theor. Pract. Language Stud. **2**(5), 938–944 (2012)
2. Ali, A. and Smith, D. (2014) Teaching an introductory programming language in a general education course, *Proceedings of the 2008 International Conference on Frontiers in Education: Computer Science and Computer Engineering,* 236–240.
3. Alturki, R.: Measuring and improving student performance in an introductory programming course. Inf. Educ. **15**(2), 183–204 (2016)

4. Anderson, N. J. (2002). The role of metacognition in second language teaching and learning. *Online Resources: Digest*. Retrieved from: https://files.eric.ed.gov/fulltext/ED463659.pdf
5. Azevedo, R.: Understanding the acomplex nature of self-regulatory processes in learning with computer-based learning environments: an introduction. Metacogn. Learn. **2**, 57–65 (2007)
6. Bhagat, K.K., Wu, L.Y., Chang, C.Y.: The impact of personality on students' perceptions towards online learning. Australas. J. Educ. Technol. **35**(4), 98–108 (2019)
7. Bosse, Y., Gerosa, M.A.: Why is programming so difficult to learn? Patterns of difficulties related to programming learning mid-stage. ACM SIGSOFT Softw. Eng. Notes **41**(6), 1–6 (2017)
8. Broadbent, J., Poon, W.L.: Self-regulated learning strategies & academic achievement in online higher education learning environments: a systematic review. Internet Higher Educ. **27**, 1–13 (2015)
9. Buyrukoğlu, S. (in press). A novel color labeled student modeling approach using e-learning activities for data mining. *Universal Access in the Information Society*, Retrieved from: https://doi.org/10.1007/s10209-022-00894-8.
10. Buyrukoğlu, S., Batmaz, F., Lock, R.: Improving marking efficiency for longer programming solutions based on a semi-automated assessment approach. Comput. Appl. Eng. Educ. **27**(3), 733–743 (2019)
11. Castillo-Manzano, J.I., Castro-Nuño, M., Díaz, M.T.S., Yñiguez, R.: Does pressing a button make it easier to pass an exam? evaluating the effectiveness of interactive technologies in higher education. Br. J. Edu. Technol. **47**(4), 710–720 (2016)
12. Çetinkaya, A., Baykan, Ö.K.: Prediction of middle school students' programming talent using artificial neural networks. Eng. Sci. Technol., Int. J. **23**(6), 1301–1307 (2020)
13. Chamot, A.U., O'Malley, J.M.: Language learner and learning strategies. In: Ellis, N.C. (ed.) Implicit and explicit learning of languages. Academic (1994)
14. Chan Mow, I.T.: Issues and difficulties in teaching novice computer programming innovative techniques in instruction technology, e-learning, e-assessment, and education. Springer (2008)
15. Chan, C.K.: Co-regulation of learning in computer-supported collaborative learning environments: a discussion. Metacogn. Learn. **7**(1), 63–73 (2012)
16. Chang, M.M.: Enhancing web-based language learning through self-monitoring. J. Comput. Assist. Learn. **23**(3), 187–196 (2007)
17. Chen, E. Z. (2014). Flipped classroom model and its implementation in a computer programming course. In *Lärarlärdom 2014 (Scholarship of Teaching and Learning), Blekinge Tekniska Högskola, 20 augusti 2014*. Retrieved from:
18. http://www.diva-portal.org/smash/get/diva2:777869/FULLTEXT01.pdf
19. Cheng, Y.P., Shen, P.D., Hung, M.L., Tsai, C.W., Lin, C.H., Hsu, L.C.: Applying online content-based knowledge awareness and team learning to develop students' programming skills, reduce their anxiety, and regulate cognitive load in a cloud classroom. Univ. Access Inf. Soc. **21**(2), 557–572 (2022)
20. Chi, M.T.H., Bassok, M., Lewis, M.W., Reimann, P., Glaser, R.: Self-explanations: how students study and use examples in learning to solve problems. Cogn. Sci. **13**, 145–182 (1989)
21. Chou, H.W.: Effects of training method and computer anxiety on learning performance and self-efficacy. Comput. Hum. Behav. **17**(1), 51–69 (2001)
22. Chyr, W.L., Shen, P.D., Chiang, Y.C., Lin, J.B., Tsai, C.W.: Exploring the effects of online academic help-seeking and flipped learning on improving students' learning. Educ. Technol. Soc. **20**(3), 11–23 (2017)
23. Cornford, I.R.: Learning-to-learn strategies as a basis for effective lifelong learning. Int. J. Lifelong Educ. **21**(4), 357–368 (2002)
24. Cubukcu, F.: Enhancing vocabulary development and reading comprehension through metacognitive strategies. Issues Educ. Res. **18**(1), 1–11 (2008)
25. Dawson, J. Q., Allen, M., Campbell, A., & Valair, A. (2018). Designing an introductory programming course to improve non-majors' experiences. In *Proceedings of the 49th ACM Technical Symposium on Computer Science Education* (pp. 26–31). ACM.
26. De Jong, F., Kollöffel, B., Van der Meijden, H., Kleine Staarman, J., Janssen, J.: Regulative processes in individual, 3D, and computer supported cooperative learning contexts. Comput. Hum. Behav. **21**, 645–670 (2005)
27. DeLone, W.H., McLean, E.R.: The DeLone and McLean model of information systems success: a ten-year update. J. Manag. Inf. Syst. **19**(4), 9–30 (2003)
28. Duffy, M.C., Azevedo, R., Sun, N.-Z., Griscom, S.E., Stead, V., Crelinsten, L., Wiseman, J., Maniatis, T., Lachapelle, K.: Team regulation in a simulated medical emergency: an in-depth analysis of cognitive, metacognitive, and affective processes. Instr. Sci. **43**(3), 401–426 (2015)
29. Duggan, S., Gott, R.: What sort of science education do we really need? Int. J. Sci. Educ. **24**(7), 661–679 (2002)
30. Ezzeldin, S.M.Y.: Using flipped classes to develop scientific communication and the attitude towards technology acceptance in science learning in intermediate schools. Int. J. Online Pedagog. Course Des. **12**(1), 1–15 (2022)
31. Flavell, J.H.: Metacognitive aspects of problem solving. In: Resnick, L. (ed.) The Nature of Intelligence. Lawrence Erlbaum Associates (1976)
32. Fleishman, E.A., Zaccaro, S.J.: Toward a taxonomy of team performance functions. In: Swezey, R.W., Salas, E. (eds.) Teams: their training and performance. Ablex (1992)
33. Francis, M.K., Wormington, S.V., Hulleman, C.: The costs of online learning: Examining differences in motivation and academic outcomes in online and face-to-face community college developmental mathematics courses. Front. Psychol. **10**, 2054 (2019)
34. Franklin, D., Salac, J., Crenshaw, Z., Turimella, S., Klain, Z., Anaya, M., & Thomas, C. (2020). Exploring student behavior using the TIPP&SEE learning strategy. In *Proceedings of the 2020 ACM Conference on International Computing Education Research* (pp. 91–101).
35. Gaeta, M.L., Gaeta, L., Rodriguez, M.D.S.: The impact of COVID-19 home confinement on Mexican university students: emotions, coping strategies, and self-regulated learning. Front. Psychol. **12**, 642823 (2021)
36. Garrison, D.R., Akyol, Z.: Toward the development of a metacognition construct for communities of inquiry. Internet Higher Educ. **24**, 66–71 (2015)
37. Ghina, N.N., Mustofa, M., Awaliyah, M.: The role of technology: moodle as a learning tool and its impact on the students' learning. ELT-Lectura Stud. Perspect. English Language Teach. **9**(2), 203–208 (2022)
38. Goleman, D.: Leadership that gets results. Harv. Bus. Rev. **78**(2), 4–17 (2000)
39. Gomes, A. & Mendes, A. J. (2007). Learning to program-difficulties and solutions. In International Conference on Engineering Education–ICEE, Vol. 2007.
40. Hadwin, A., Oshige, M.: Self-regulation, co-regulation, and socially shared regulation: exploring perspectives of social in self-regulated learning theory. Teach. Coll. Rec. **113**(2), 240–264 (2011)

41. Harimurti, R., Ekohariadi, E., Munoto, M., Winanti, E.T.: Analysis of programming skills concept in developing problem solving skills. Jurnal Pendidikan Teknologi dan Kejuruan **25**(1), 43–51 (2019)
42. Heilporn, G., Lakhal, S.: Investigating the reliability and validity of the community of inquiry framework: an analysis of categories within each presence. Comput. Educ. **145**, 103712 (2020)
43. Heitink, M., Voogt, J., Verplanken, L., van Braak, J., Fisser, P.: Teachers' professional reasoning about their pedagogical use of technology. Comput. Educ. **101**, 70–83 (2016)
44. Heo, J., Oh, J., Subramanian, S.V., Kim, Y., Kawachi, I.: Addictive internet use among Korean adolescents: a national survey. PLoS ONE **9**(2), e87819 (2014)
45. Hill, C. (2015). *Programming environments for children: Creating a language that grows with you*. Master thesis, California University, California.
46. Ho, L.A., Kuo, T.H.: How can one amplify the effect of e-learning? an examination of high-tech employees' computer attitude and flow experience. Comput. Hum. Behav. **26**(1), 23–31 (2010)
47. Hollis, R.B., Was, C.A.: Mind wandering, control failures, and social media distractions in online learning. Learn. Instr. **42**, 104–112 (2016)
48. International Society for Technology and Education, 2017. ISTE standards for Educators. Retrieved from: https://www.iste.org/standards/for-educators.
49. Isik, U., Tahir, O.E., Meeter, M., Heymans, M.W., Jansma, E.P., Croiset, G., Kusurkar, R.A.: Factors influencing academic motivation of ethnic minority students: A review. SAGE Open **8**(2), 1–23 (2018)
50. Jie, X.U.: High school students' autonomy in english learning: the study of previewing. Can. Soc. Sci. **12**(4), 81–86 (2016)
51. Johnson, R.D., Gueutal, H., Falbe, C.M.: Technology, trainees, metacognitive activity and e-learning effectiveness. J. Manag. Psychol. **24**(6), 545–566 (2009)
52. Jones, A., Issroff, K.: Learning technologies: affective and social issues in computer-supported collaborative learning. Comput. Educ. **44**(4), 395–408 (2005)
53. Joshi, G. S. S. (2019). Computer programming COMP103: Who does better? *Journal of Applied Sciences, 2009*(1), Retrieved from:
54. http://www.redelve.com/backend/images/article/1553690988.pdf
55. Karsenti, T., Bugmann, J.: The educational impacts of minecraft on elementary school students in research on e-learning and ICT in education. Springer (2018)
56. Kay, J., & Luckin, R. (2018). Rethinking learning in the digital age: Making the learning science count, *13th International Conference of the Learning Sciences,* pp. 1–4. London, UK: International Society of the Learning Sciences.
57. Kim, D.: The relationship between perceived quality, self-efficacy, flow, and addiction: focus on smartphone International Information Institute (Tokyo). Information **20**(6B), 4235–4242 (2017)
58. Kizilcec, R.F., Pérez-Sanagustín, M., Maldonado, J.J.: Self -regulated learning strategies predict learner behavior and goal attainment in massive open online courses. Comput. Educ. **104**, 18–33 (2017)
59. Koulouri, T., Lauria, S., Macredie, R.D.: Teaching introductory programming: A quantitative evaluation of different approaches. ACM Trans. Comput. Educ. **14**(4), 1–28 (2014)
60. Kozlowski, S.W.J., Grand, J.A., Baard, S.K., Pearce, M.: Teams, teamwork, and team effectiveness: Implications for human systems integration. In: Boehm-Davis, D.A., Durso, F.T., Lee, J.D. (eds.) APA handbook of human systems integration, pp. 555–571. American Psychological Association (2015)
61. Kozlowski, S.W.J., Gully, S.M., Salas, E., Cannon-Bowers, J.A.: Team leadership and development: theory, principles, and guidelines for training leaders and teams. In: Beyerlein, M.M., Johnson, D.A., Beyerlein, S.T. (eds.) Advances in interdisciplinary studies of work teams: Team leadership, vol. 3, pp. 253–291. Elsevier Science/JAI Press (1996)
62. Kozlowski, S.W., Ilgen, D.R.: Enhancing the effectiveness of work groups and teams. Psychol. Sci. Publ. Interest **7**(3), 77–124 (2006)
63. Ku, K.Y., Ho, I.T.: Metacognitive strategies that enhance critical thinking. Metacogn. Learn. **5**(3), 251–267 (2010)
64. Lai, C.L., Hwang, G.J.: A self-regulated flipped classroom approach to improving students' learning performance in a mathematics course. Comput. Educ. **100**, 126–140 (2016)
65. Lajoie, S., Lee, L., Bassiri, M., Cruz-Panesso, I., Kazemitabar, M., Poitras, E., Hmelo-Silver, C., Wiseman, J., Chan, L., Lu, J.: The role of regulation in medical student learning in small groups: regulating oneself and others' learning and emotions. Comput. Hum. Behav. **52**, 601–616 (2015)
66. Leaver, B.L., Ehrman, M., Shekhtman, B.: Achieving success in second language acquisition. Cambridge University Press (2004)
67. Lee, D., Watson, S.L., Watson, W.R.: Systematic literature review on self-regulated learning in massive open online courses. Australas. J. Educ. Technol. **35**(1), 28–41 (2019)
68. Lee, J., Chang, E.C., Lucas, A.G., Hirsch, J.K.: Academic motivation and psychological needs as predictors of suicidal risk. J. Coll. Couns. **22**(2), 98–109 (2019)
69. Lee, L., Lajoie, S.P., Poitras, E.G., Nkangu, M., Doleck, T.: Co-regulation and knowledge construction in an online synchronous problem based learning setting. Educ. Inf. Technol. **22**(4), 1623–1650 (2017)
70. Lee, T.H., Shen, P.D., Tsai, C.W.: Applying web-enabled problem-based learning and self-regulated learning to add value to computing education in Taiwan's vocational schools. J. Educ. Technol. Soc. **11**(3), 13–25 (2008)
71. Lee, Y.H., Ko, C.H., Chou, C.: Re-visiting Internet addiction among Taiwanese students: a cross-sectional comparison of students' expectations, online gaming, and online social interaction. J. Abnorm. Child Psychol. **43**(3), 589–599 (2015)
72. Leutwyler, B.: Metacognitive learning strategies: differential development patterns in high school. Metacogn. Learn. **4**(2), 111–123 (2009)
73. Levine, J.M., Higgins, E.T., Choi, H.S.: Development of strategic norms in groups. Organ. Behav. Hum. Decis. Process. **82**(1), 88–101 (2000)
74. Li, Z., Peng, M.: Meta-cognitive strategies in college students' WeChat mobile english learning. Adv. Soc. Sci. Res. J. **6**(5), 83–89 (2019)
75. Lin, M.P., Ko, H.C., Wu, J.Y.W.: The role of positive/negative outcome expectancy and refusal self-efficacy of Internet use on Internet addiction among college students in Taiwan. Cyberpsychol. Behav. **11**(4), 451–457 (2008)
76. Lin, M.P., Wu, J.Y.W., You, J., Hu, W.H., Yen, C.F.: Prevalence of internet addiction and its risk and protective factors in a representative sample of senior high school students in Taiwan. J. Adolesc. **62**, 38–46 (2018)
77. Luckin, R., Cukurova, M.: Designing educational technologies in the age of AI: a learning sciences - driven approach. Br. J. Edu. Technol. **50**(6), 2824–2838 (2019)
78. Lye, S.Y., Koh, J.H.L.: Review on teaching and learning of computational thinking through programming: what is next for K-12? Comput. Hum. Behav. **41**, 51–61 (2014)
79. Maletić, M., Barać, D., Naumović, T., Bogdanović, Z., Radenković, B.: Blending crowdvoting in modern e-learning

environments. Int. Rev. Res. Open Distrib. Learn. **20**(2), 1–23 (2019)
80. Malik, S.I.: Assessing the teaching and learning process of an introductory programming course with Bloom's Taxonomy and Assurance of Learning (AOL). Int. J. Inf. Commun. Technol. Educ. **15**(2), 130–145 (2019)
81. Manganello, F., Falsetti, C., Leo, T.: Self-regulated learning for web-enhanced control engineering education. Educ. Technol. Soc. **22**(1), 44–58 (2019)
82. Marques, J.: Understanding the strength of gentleness: soft-skilled leadership on the rise. J. Bus. Ethics **116**(1), 163–171 (2013)
83. Martin, F., Wang, C., Jokiaho, A., May, B., Grübmeyer, S.: Examining faculty readiness to teach online: a comparison of US and German educators. Eur. J. Open, Distance and E-learn. **22**(1), 53–69 (2019)
84. Martins, V.F., de Almeida Souza Concilio, I., de Paiva Guimarães, M.: Problem based learning associated to the development of games for programming teaching. Comput. Appl. Eng. Educ. **26**(5), 1577–1589 (2018)
85. McClendon, R.C.: Motivation and cognition of preservice teachers: MSLQ. J. Instr. Psychol. **23**(3), 216–221 (1996)
86. Meijs, C., Neroni, J., Gijselaers, H.J., Leontjevas, R., Kirschner, P.A., de Groot, R.H.: Motivated strategies for learning questionnaire part B revisited: new subscales for an adult distance education setting. Internet Higher Educ. **40**, 1–11 (2019)
87. Mohammadi, Y., Kaykha, A., Sadeghi, A., Kazemi, S., Raeisoon, M.R.: Relationship of metacognition learning strategy and locus of control with academic achievement of students. Educ. Strategies Med. Sci. **8**(5), 323–328 (2015)
88. O'Malley, J.M., Chamot, A.U.: Learning strategies in second language acquisition. Cambridge University Press (1990)
89. Ortiz-Rodríguez, M., Telg, R.W., Irani, T., Roberts, T.G., Rhoades, E.: College students' perceptions of quality in distance education: the importance of communication. Q. Rev. Distance Educ. **6**(2), 97–105 (2005)
90. Oxford, R.L.: Language learning strategies: what every teacher should know. Heinle & Heinle (1990)
91. Oyarzun, B., Hancock, C., Salas, S., Martin, F.: Synchronous meetings, community of inquiry, COVID-19, and online graduate teacher education. J. Digital Learn. Teacher Educ. **37**(2), 111–127 (2021)
92. Park, G., Spitzmuller, M., DeShon, R.P.: Advancing our understanding of team motivation: Integrating conceptual approaches and content areas. J. Manag. **39**(5), 1339–1379 (2013)
93. Peterson, R.S., Behfar, K.J.: The dynamic relationship between performance feedback, trust, and conflict in groups: a longitudinal study. Organ. Behav. Hum. Decis. Process. **92**(1–2), 102–112 (2003)
94. Pintrich, P.R.: The role of goal orientation in self-regulated learning. In: Boekaerts, M., Pintrich, P.R., Zeidner, M. (eds.) Handbook of self-regulation. Academic Press (2000)
95. Pintrich, P.R., Smith, D.A.F., Garcia, T., McKeachie, W.J.: Reliability and predictive validity of the motivated strategies for learning questionnaire (MSLQ). Educ. Psychol. Measur. **53**, 801–803 (1993)
96. Qiong, W.: A comparative study on english metacognitive language learning strategy by Chinese EFL learners of different age groups. Can. Soc. Sci. **12**(9), 59–63 (2016)
97. Rapp, T.L., Bachrach, D.G., Rapp, A.A., Mullins, R.: The role of team goal monitoring in the curvilinear relationship between team efficacy and team performance. J. Appl. Psychol. **99**(5), 1–12 (2014)
98. Restrepo-Calle, F., Ramírez Echeverry, J.J., González, F.A.: Continuous assessment in a computer programming course supported by a software tool. Comput. Appl. Eng. Educ. **27**(1), 80–89 (2019)
99. Robles, M.M.: Executive perceptions of the top 10 soft skills needed in today's workplace. Bus. Commun. Q. **75**(4), 453–465 (2012)
100. Rum, S., Ismail, M.: Metacognitive awareness assessment and introductory computer programming course achievement at university. Int. Arab J. Inf. Technol. **13**(6), 667–676 (2016)
101. Saab, N.: Team regulation, regulation of social activities or co-regulation: different labels for effective regulation of learning in CSCL. Metacogn. Learn. **7**(1), 1–6 (2012)
102. Saab, N., van Joolingen, W., van Hout-Wolters, B.: Support of the collaborative inquiry learning process: influence of support on task and team regulation. Metacogn. Learn. **7**(1), 7–23 (2012)
103. Schraw, G., Crippen, K.J., Hartley, K.: Promoting self-regulation in science education: metacognition as part of a broader perspective on learning. Res. Sci. Educ. **36**, 111–139 (2006)
104. Solarte Pabón, O., Villegas, L.E.M.: Fostering motivation and improving student performance in an introductory programming course: an integrated teaching approach. Revista EIA **16**(31), 65–76 (2019)
105. Tan, C.: The impact of COVID-19 pandemic on student learning performance from the perspectives of community of inquiry. Corp. Gov. **21**(6), 1215–1228 (2021)
106. Tavares, J., Brzezinski, I., Huet, I., Cabral, A., & Neri, D. (2001). "Having coffee" with professors and students to talk about higher education pedagogy and academic success. In 24th international HERDSA conference, Newcastle, Australia.
107. Topalli, D., Cagiltay, N.E.: Improving programming skills in engineering education through problem-based game projects with Scratch. Comput. Educ. **120**, 64–74 (2018)
108. Tsai, M.C., Shen, P.D., Chen, W.Y., Hsu, L.C., Tsai, C.W.: Exploring the effects of web-mediated activity-based learning and meaningful learning on improving students' learning effects, learning engagement, and academic motivation. Univ. Access Inf. Soc. **19**, 783–798 (2020)
109. Tsai, M.C., Tsai, C.W.: Applying online externally-facilitated regulated learning and computational thinking to improve students' learning. Univ. Access Inf. Soc. **17**(4), 811–820 (2018)
110. Tseng, H., Yi, X., Yeh, H.T.: Learning-related soft skills among online business students in higher education: grade level and managerial role differences in self-regulation, motivation, and social skill. Comput. Hum. Behav. **95**, 179–186 (2019)
111. Vallerand, R.J., Pelletier, L.G., Blais, M.R., Briere, N.M., Senecal, C., Vallieres, E.F.: The academic motivation scale: a measure of intrinsic, extrinsic, and amotivation in education. Educ. Psychol. Measur. **52**(4), 1003–1017 (1992)
112. Van der Vegt, G.S., Emans, B.J., Van De Vliert, E.: Patterns of interdependence in work teams: a two-level investigation of the relations with job and team satisfaction. Pers. Psychol. **54**(1), 51–69 (2001)
113. VanLehn, K., Zhang, L., Burleson, W., Girard, S., Hidago-Pontet, Y.: Can a non-cognitive learning companion increase the effectiveness of a meta-cognitive learning strategy? IEEE Trans. Learn. Technol. **10**(3), 277–289 (2016)
114. Vosinakis, S., Anastassakis, G., Koutsabasis, P.: Teaching and learning logic programming in virtual worlds using interactive microworld representations. Br. J. Edu. Technol. **49**(1), 30–44 (2018)
115. Wang, J., Yang, Y., Li, H., van Aalst, J.: Continuing to teach in a time of crisis: the Chinese rural educational system's response and student satisfaction and social and cognitive presence. Br. J. Edu. Technol. **52**(4), 1494–1512 (2021)
116. Winne, P.H., Hadwin, A.F.: Studying as self-regulated learning. In: Hacker, D.J., Dunlosky, J., Graesser, A. (eds.) Metacognition in educational theory and practice. Erlbaum, Cham (1998)

117. Wu, J.Y.: The indirect relationship of media multitasking self-efficacy on learning performance within the personal learning environment: Implications from the mechanism of perceived attention problems and self-regulation strategies. Comput. Educ. **106**, 56–72 (2017)
118. Wu, J.Y.W., Ko, H.C., Tung, Y.Y., Li, C.C.: Internet use expectancy for tension reduction and disinhibition mediates the relationship between borderline personality disorder features and Internet addiction among college students – One-year follow-up. Comput. Hum. Behav. **55**, 851–855 (2016)
119. Wu, J.Y., Cheng, T.: Who is better adapted in learning online within the personal learning environment? Relating gender differences in cognitive attention networks to digital distraction. Comput. Educ. **128**, 312–329 (2019)
120. Yan, L., Whitelock-Wainwright, A., Guan, Q., Wen, G., Gašević, D., Chen, G.: Students' experience of online learning during the COVID-19 pandemic: a province-wide survey study. Br. J. Edu. Technol. **52**(5), 2038–2057 (2021)
121. Yen, C. J., Bozkurt, A., Tu, C. H., Sujo-Montes, L., Rodas, C., Harati, H., & Lockwood, A. B. (2019). A predictive study of students' self-regulated learning skills and their roles in the social network interaction of online discussion board. *Journal of Educational Technology Development and Exchange*, *11*(1), Retrieved from: https://aquila.usm.edu/cgi/viewcontent.cgi?article=1096&context=jetde.
122. Yildiz-Durak, H.: Flipped learning readiness in teaching programming in middle schools: modelling its relation to various variables. J. Comput. Assist. Learn. **34**(6), 939–959 (2018)
123. Yoo, S.J., Huang, W.D.: Engaging online adult learners in higher education: motivational factors impacted by gender, age, and prior experiences. J. Contin. High. Educ. **61**(3), 151–164 (2013)
124. Zahedi, K.: Metacognitive learning strategies and academic success of TEFL MA students in distance education. Int. J Criminol. Sociol. Theory **1**(2), 161–176 (2008)
125. Zalavra, E., Papanikolaou, K.: Exploring the potential of the learning designer as a teacher support tool. Electron. J. e-Learn. **17**(2), 107–117 (2019)
126. Zheng, J.: The metacognitive strategy in English listening comprehension. Theor. Pract. Language Stud. **8**(2), 226–231 (2018)
127. Zhu, Y., Au, W., Yates, G.: University students' self-control and self-regulated learning in a blended course. Internet Higher Educ. **30**, 54–62 (2016)

Authors and Affiliations

Chia-Wen Tsai[1] · Lan-Yu Lee[2] · Yih-Ping Cheng[3] · Chih-Hsien Lin[4] · Min-Ling Hung[5] · Jian-Wei Lin[6]

Lan-Yu Lee
lynne@mail.mcu.edu.tw

Yih-Ping Cheng
ypcheng@mail.mcu.edu.tw

Chih-Hsien Lin
chlin0112@mail.mcu.edu.tw

Min-Ling Hung
mlhong@mail.mcu.edu.tw

Jian-Wei Lin
jwlin@g2.usc.edu.tw

[1] Department of Information Management, Ming Chuan University, No.5 De-Ming Rd., Guishan, Taoyuan 333, Taiwan, ROC

[2] International Business and Trade Program, Ming Chuan University, 250 Zhong-Shan N. Road Sec. 5, Taipei, Taiwan, ROC

[3] Department of Information Management, Ming Chuan University, 250 Zhong-Shan N. Road Sec. 5, Taipei, Taiwan, ROC

[4] International Academic Publications Research Center, Ming Chuan University, 250 Zhong-Shan N. Road Sec. 5, Taipei, Taiwan, ROC

[5] Teacher Education Center, Ming Chuan University, 5 De Ming Rd., Gui Shan District, Taoyuan 333, Taiwan, ROC

[6] Department of Information Technology and Management, Shih Chien University, No.70, Dazhi St., Zhongshan Dist., Taipei 104, Taiwan, ROC