

Applying Virtual Grouping Strategy in an IoT Programming Learning Course to Investigate Students' Creativity and Learning Effectiveness

Yu-Lin Jeng, Li-Yu Chen

Department of Information Management, Southern Taiwan University of Science and Technology

jackjeng@stust.edu.tw, mb290203@stust.edu.tw

Abstract.

This research focuses on the development of logical abilities, thinking skills, and problem-solving capabilities in programming courses, with an emphasis on the role of creativity in problem-solving. Previous studies have suggested that creativity is closely linked to problem-solving abilities, and that programming courses significantly influence the cultivation of creativity. In particular, this study explores the application of a virtual group discussion strategy in an Internet of Things (IoT) programming course, incorporating online group discussions and World Café teaching activities. The aim is to enhance students' computational thinking and learning performance in the IoT course. With 57 university students participating, results showed significant gains in creativity, cooperation, and critical thinking, as well as better exam performance. The approach proved effective in supporting student learning and engagement.

Keywords: Online Learning, Programming Course, Learning Outcome

Introduction

With the advancement of technology, the development of information and media has become increasingly diverse. For example, in the past, when smartphones were not yet widely available, accessing web information mainly relied on computers. Today, with just a smartphone, we can access the internet anytime and anywhere. However, alongside the convenience of smartphones and the ability to access the internet at any time and place, many business opportunities have emerged. For instance, major shopping websites have launched dedicated apps to make it easier for users to purchase products. According to Sensor Tower's (2021) statistical analysis, the number of downloads from the Apple Store and Google Play is estimated to reach 230 billion by 2025 (see Figure 1). This indicates that the number of apps is growing rapidly and that cultivating excellent APP developers is a future trend. From this, we can see that the progress of the information industry has brought many conveniences to our lives, but it also means that the demand for information professionals is increasing.

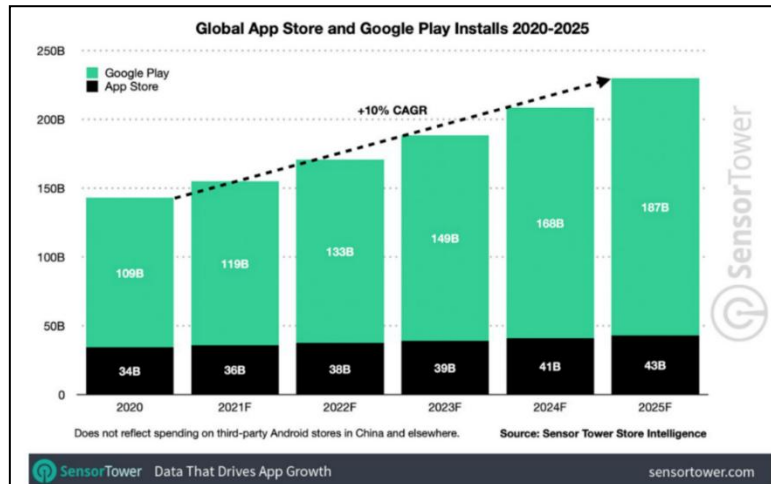


Fig. 1. Estimated APP Downloads of the World's Top 2 Channels from 2020 to 2025
(Source: Sensor Tower)

Programming courses are highly specialized, and the current teaching environment still tends to follow traditional teaching models. In classroom teaching, the teacher plays the active role of conveying key knowledge and content, while students take on the passive role of receiving the content delivered by the teacher. However, this one-way learning environment often results in unsatisfactory learning outcomes because students may not be able to effectively digest and internalize the knowledge they receive during the process. This is one of the reasons why students generally perform poorly in learning (Qiu Wenjie, 2015).

In order to differentiate vocational students from general university students, it is important not only to train vocational students to handle practical problems in the workplace but also to cultivate their ability to actively identify, understand, solve problems, and engage in creative thinking. This will strengthen their competitiveness in the workplace. Therefore, the key goal of this project is to focus on how to cultivate vocational students' problem-solving abilities and creativity, enabling them to address workplace challenges arising from emerging industries in the future (Clinton & Hokanson, 2012).

Peer learning can help students gain deeper knowledge. On the other hand, students can listen to other opinions and ideas to complete group tasks, which can also enhance their learning outcomes. Therefore, there are two key factors in peer learning: interaction and communication. To promote student interaction and establish opportunities for connection, this study adopts the "World Café" as a method for participatory discussion. Literature suggests that World Café can facilitate constructive dialogue, which helps assess the potential for collective intelligence, creativity, and innovation. Additionally, in the World Café dialogue environment, participants can use their own wisdom and

creativity to explore issues and allow a group of people to engage in discussions on important matters (MacFarlane et al., 2017; Fallon & Connaughton, 2016). In short, this is a method that emphasizes dialogue, giving students more opportunities to listen to and share ideas and perspectives with other students. In the World Café learning environment, students can use their wisdom to explore issues and attempt to solve problems, which can help them gain rich learning experiences while deepening their learning.

Programming courses should be able to cultivate students' logical abilities, thinking abilities, and problem-solving skills (Volet & Lund, 1994; Schollmeyer, 1996; Lai Yi-Chun, 2008). The importance of creativity lies in its close relationship with problem-solving abilities. In the past, some scholars have argued that problem-solving ability is a manifestation of creativity (Runco & Sakamoto, 1999). From this, it can be seen that programming courses have a significant impact on the development of creativity, with both elements complementing each other. Therefore, this research project applies a virtual group discussion strategy to the Internet of Things (IoT) programming course, allowing students to engage in online group discussions, supported by social media and World Café teaching activities. This approach aims to increase students' creativity ability and learning outcomes in the IoT course, and further, it is expected to effectively enhance students' creativity in such courses.

Literature Review

Programming skills are one of the core competencies that students in information-related programs hope to acquire before graduation (Law et al., 2010). Therefore, to fully understand students' learning outcomes and motivation in programming, researchers must gain a deep understanding of the students' learning process (Chang et al., 2017). This understanding helps to address the fear and anxiety students may have about learning programming and aims to increase the motivation that students lack in programming (Yuana & Maryono, 2016). Only then can systems be designed to effectively support students' learning, enhancing both learning efficiency and enjoyment.

Peer learning is a reciprocal learning approach aimed at sharing experiences and engaging in discussions. In this method, learning occurs through mutual sharing and discussion among peers, and it also represents collaboration and mutual assistance. Additionally, the unique characteristic of peer learning is that the groups are typically composed of individuals who are of similar age or social status. As a result, group members are often classmates, friends, or playmates (Boud, 1999; Yeh Chao-Chi, Zhang Li-Yun, 2006). In such groups, there is no "teacher" role, meaning that without the guidance of a teacher, each student must seek answers by sharing learning experiences and engaging in discussions with peers. Lai Qiuru (2017) mentioned in her research that peers play a significant role in learning, mainly because peers usually share common interests and have closer ages, making interactions more natural. When students encounter problems, they tend to seek help from their peers rather than asking teachers. Therefore, a classroom with a good learning and mutual support atmosphere can significantly benefit students' learning.

The key difference between peer learning and traditional teaching lies in the roles involved. Traditional teaching methods are usually led by the teacher, which may reduce students' opportunities for independent thinking. For example, in programming courses, many students fail to understand the concepts or significance behind programming practices. In such cases, students often rely entirely on the teacher's steps, lacking the process of independent thought. As a result, many students do not grasp the key points of the practice. Through peer learning, each student can express their thoughts and opinions, regardless of whether the result is correct, and everyone has the opportunity to think and share. Topping (2005) mentioned that peer learning is most effective in goal-oriented courses, where students can achieve better learning outcomes and show more significant academic growth. Fantuzzo, King, & Heller (1992) pointed out that peer cooperation, guidance, and discussion help solve learning difficulties and reduce learning pressure. Moreover, during the discussion process, students become more actively involved in the learning environment, which leads to better learning outcomes. Some scholars in Taiwan have combined peer learning with programming courses and integrated social platforms to provide more opportunities for interaction. Students can engage in real-time discussions on the platform, for example, when a student raises a question, peers can immediately discuss and explain it. Furthermore, research has shown that when students guide slower learners or those who encounter difficulties, the tutors gain a sense of accomplishment (Zhan Guohui, 2012).

Knowledge sharing is an issue derived from knowledge management, meaning that tacit and explicit knowledge between individuals is continuously undergoing a cycle of "internalization, externalization, combination, and socialization" (Crossan, 1996). Knowledge can be exchanged through knowledge-sharing channels within enterprises, between organizations, and in academic circles. However, in the context of the increasing popularity of Web 2.0 tools combined with digital learning (E-Learning) technologies (A. S. Lau, 2011), interactions between teachers and students can occur through various online platforms or forums for knowledge sharing and learning behaviors (Hou et al., 2009). Additionally, the effective integration of knowledge management with digital learning can provide students with a good learning environment and learning resources (A. Lau et al., 2009). Whether digital learning platforms can truly facilitate learning interactions and exchanges between teachers and students, or between students themselves, and directly address students' academic problems and questions, is an important consideration. For example, Lin Jinlang (2016) offered practical suggestions for providing university students with a digital learning platform for knowledge sharing, and many scholars have taken "knowledge sharing" as their research focus to explore the impact and satisfaction between student learning motivation, learning interaction, and learning platform support (Gao Shuzhen, 2012). In today's rapidly advancing era of information technology, traditional classroom education has evidently been unable to meet the needs of lifelong learning and personalized learning (Zhang et al., 2003). Therefore, in recent years, educational institutions have gradually implemented virtual learning communities to encourage knowledge sharing between teachers and students (Chen et al., 2009).

Based on the above literature, peer learning has been shown to help improve students' learning outcomes, and it can further give rise to online learning communities. Through community interaction and the use of the internet as a medium for sharing knowledge and ideas, the goal of peer learning can be achieved. The application of peer learning

strategies and community interaction strategies can effectively enhance learning motivation (Yuana & Maryono, 2016), which has a positive impact on learning programming. Therefore, this research project will be conducted over the course of one year to explore the impact of creativity teaching strategies and virtual community group discussion strategies integrated into programming courses on the creativity and learning outcomes of vocational university students. The study will analyze learners' learning creativity ability and learning outcomes through a Computational Thinking Scale (CTS), academic performance. Most importantly, the study aims to determine whether the application of virtual group discussion strategies can enhance students' creativity. Furthermore, it is expected that the findings of this research project can be promoted to information-related departments in vocational and technical universities, thereby improving the overall information creation abilities of vocational university students.

Research Design

The virtual group discussion strategy teaching activities proposed in this study mainly include the World Café teaching activity and virtual group discussion tools, integrated into two aspects: teaching strategies and teaching activities. These are applied to the Internet of Things (IoT) programming course, with the aim of evaluating and exploring students' learning outcomes and creative application abilities. The overall activity flowchart is shown in Figure 2. In the traditional World Café activity, students have the opportunity to engage in in-depth discussions on specific topics related to IoT, providing more opportunities for communication and interaction. After transitioning into the virtual World Café activity, students can participate in discussions and exchanges within a virtual environment using virtual group discussion tools. Additionally, through the extra features of social media, such as posting articles, recommending materials, and sharing information, it is expected that under multiple forms of interaction and real-time communication, students will be encouraged to engage in more active discussions and provide feedback.

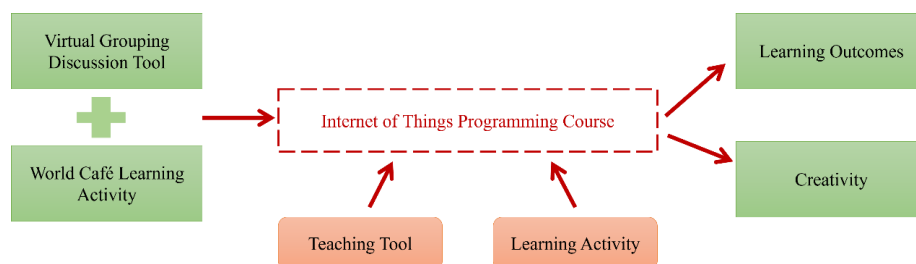


Figure 2. The overall activity flowchart

World Café Teaching Strategy

In the World Café learning environment, students are encouraged to use their own wisdom to explore and attempt to solve problems. This approach not only fosters deep learning but also provides rich learning experiences. Based on this concept, we incorporated the World Café into our learning activities, which were divided into three main parts with a total of 57 participating students.

Students were randomly assigned to several groups, each tasked with a different learning objective related to the central theme of IoT (Internet of Things) applications. Each table had an average of 5–6 participants, and a total of three discussion rounds were conducted, with each round lasting approximately 15–20 minutes.

In addition, following the guidelines of World Café (2015) and Schieffer, Isaacs & Gyllenpalm (2004), three distinct roles were assigned: “Table Host,” “Participant,” and “Café Host.” The discussion model was executed as described below.

- (1) Topic Selection
 - Set a main topic
 - Develop sub-topics
- (2) Environment Creation
 - Arrange space to simulate a café atmosphere
 - Prepare materials: pens, paper, tablecloths, etc.
 - Arrange tables and seats (4–5 people per table)
- (3) Round Table Discussions
 - Begin multiple rounds of small group discussions
 - Designate a host to stay at the table to summarize
 - Other participants rotate to different tables
 - Build upon previous discussions and deepen content
- (4) Summary and Feedback
 - Share and present insights from each table
 - Summarize key points and common themes

Google Meet Breakout Room Tool

The virtual breakout discussion strategy proposed in this project utilizes Google Meet's breakout room feature to conduct an online version of the World Café activity. The core World Café processes are adapted and implemented within the Google Meet platform. This virtual teaching activity mainly relies on two key features of Google Meet:

- The breakout room function
- The timing function

The following section introduces how these two features are applied to facilitate the World Café activity in a virtual environment.

(1) Google Meet Breakout Room Feature

As shown in Figure 3, Google Meet includes a "Breakout rooms" feature within its activity settings. This feature allows instructors to customize the number of breakout groups according to the needs of the course activity.

After setting the number of groups, instructors can assign specific names to each group based on their discussion topics, as illustrated on the right side of the figure. Using this tool, the breakout discussions for the World Café activity can be effectively carried out within the Google Meet environment.

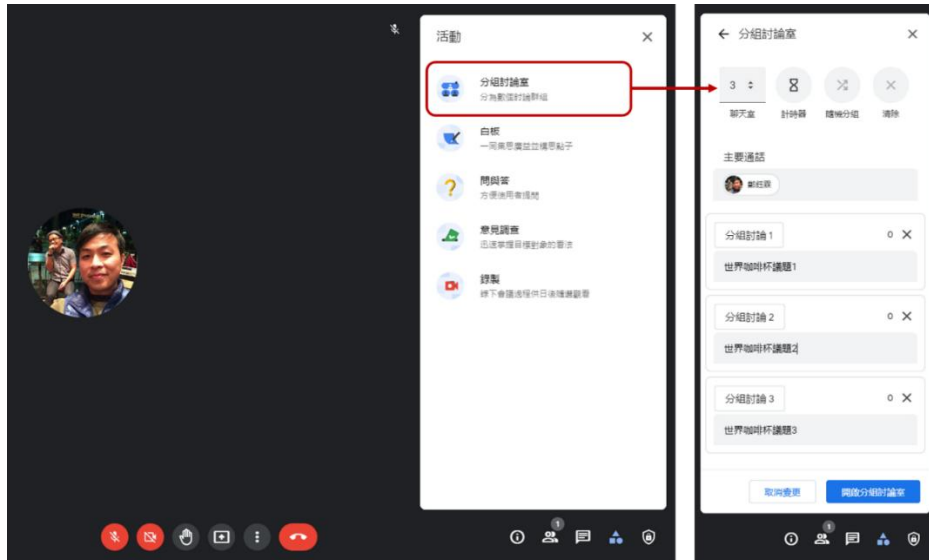


Figure 3. Breakout room settings

(2) Google Meet Breakout Room Timer Feature

In a World Café activity, each discussion round requires a specific time limit. Google Meet's breakout room feature allows for setting a discussion timer, as shown in Figure 4. Once the discussion time is set, the teacher can instruct all groups to begin their conversations. When the allotted time is up, the breakout rooms automatically close, and participants return to the main session, waiting for the teacher to initiate the next round.

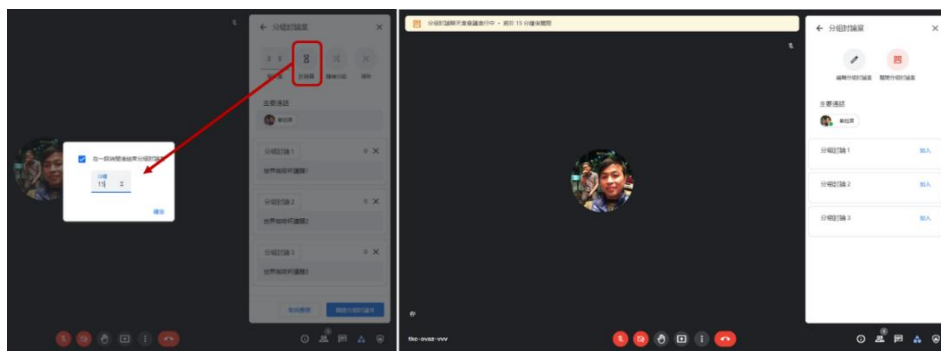


Figure 4. Discussion time settings

By utilizing Google Meet's breakout room settings and timer features, the requirements for conducting a virtual World Café activity can be effectively met.

Another key aspect of the World Café model is the rotation of participants between discussion rounds. This requires the teacher to play an active role in hosting and guiding

the process—informing students when to switch groups and directing them to their next assigned room.

During the virtual breakout discussions, the teacher can also enter any group at any time to listen, observe, and provide guidance as needed.

Research Results

Based on the above process, this study targeted third-year undergraduate students enrolled in the IoT App Development course. A total of 57 students from the Department of Information Management participated in the course.

Regarding group formation, it is suggested that each group should not be too large in order to maintain close interaction between students and the instructor (Wang, 2000). A group size of approximately 5 to 8 students is considered ideal, as having too many members can negatively impact group discussions.

In this study, each group consisted of about 5 to 6 students. The experiment was conducted over the course of one semester. The following figures presents snapshots of the actual classroom activities.



Figure 5. Group Reports

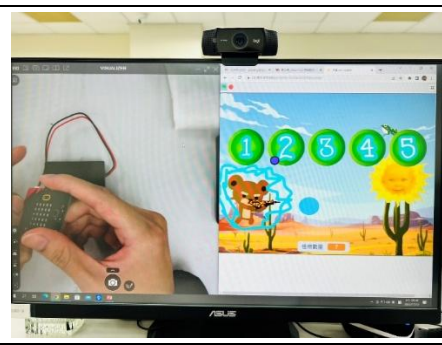


Figure 6. Group Reports

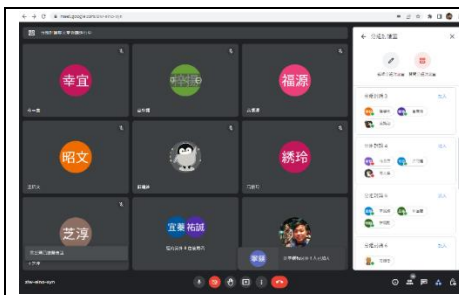


Figure 7. Online Group Reports

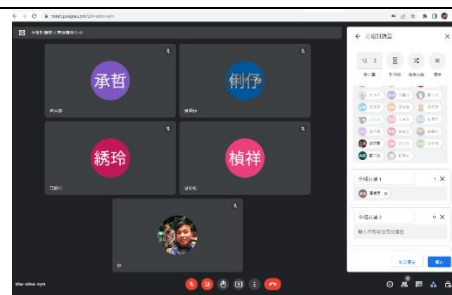


Figure 8. Online Group Reports

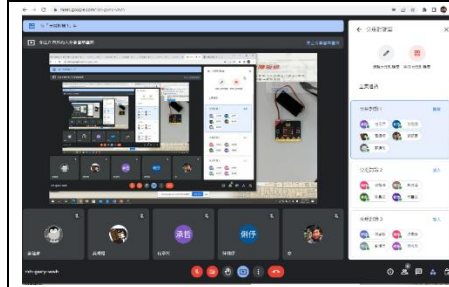


Figure 9. Online Group Discussions

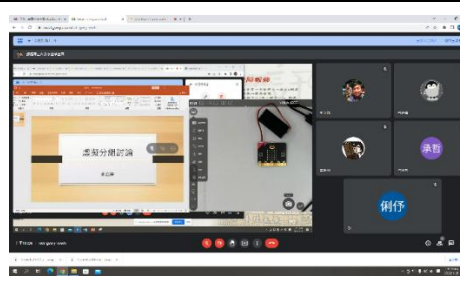


Figure 10. Online Group Discussions with Teacher

Does the Proposed Instructional Strategy and Environment Improve Students' Learning Performance in Programming Courses?

To examine whether the instructional activities and strategies implemented in this study could improve students' learning performance, learning assessments were conducted at both midterm and final stages of the semester. These assessments, designed by the course instructor, reflected the knowledge and programming concepts covered during the course. A total of 57 students participated in the tests.

Table 1 presents the results of the midterm and final exams, including the overall mean scores, standard deviations, and t-test results. The average midterm score was 79.86, while the average final score was 80.48. Further analysis revealed a significant improvement in students' scores, indicating that the instructional strategies and activities used in this study effectively supported students in enhancing their learning outcomes.

Table 1. Learning outcomes analysis

Participant	Mid-Term		Final-Exam		<i>t</i>	<i>p</i>
	M	SD	M	SD		
Students (n=57)	79.86	27.94	84.26	80.48	-3.74	.0002**

* $p < 0.05$

** $p < 0.01$

The instructional model proposed in this study has a positive impact on the development of computational thinking skills.

For the assessment of computational thinking, we adopted the Computational Thinking Scale (CTS) developed by Korkmaz, Cakir, and Özden (2017). The CTS includes five dimensions of evaluation: creativity, cooperation, algorithmic thinking, critical thinking, and problem-solving ability.

Table 2 shows the results of a study using the Computational Thinking Scale (CTS) with 57 students. It compares students' scores before and after the learning activity (pre-test and post-test) across five dimensions of computational thinking.

According to the analysis in Table 2, students' computational thinking abilities showed a positive improvement after the experiment. The CTS data indicates an overall enhancement in students' computational thinking skills, with significant gains in the dimensions of creativity, cooperation, and critical thinking. The learning activity had a positive impact on most computational thinking skills, especially creativity, cooperativity, and critical thinking.

These results suggest that the instructional design in this study effectively guided students to solve problems through structured steps, encouraged collaboration and help-seeking when facing challenges, and—most importantly—enabled students to apply the knowledge and skills learned in the course to evaluate and solve real problems.

Table 2. CTS Analysis Results

Participant	Dimensions	Pre-test		Post-test		<i>t</i>	<i>p</i>
		M	SD	M	SD		
Students (n=57)	Creativity	3.48	0.33	3.84	0.46	-3.62	.001**
	Algorithmic Thinking	3.62	0.36	3.78	0.32	-1.58	.032
	Cooperativity	3.36	0.33	3.55	0.54	-2.76	.005**
	Critical Thinking	3.24	0.52	3.78	0.46	-2.46	.014*
	Problem Solving	3.48	0.48	3.65	0.46	-0.88	.188

* $p < .05$

** $p < .01$

Conclusions

This study aimed to explore the effectiveness of a World Café-based instructional strategy integrated into an IoT App Development course to enhance university students' computational thinking and learning performance in programming.

The proposed instructional model, implemented over the course of one semester with 57 third-year undergraduate students majoring in Information Management, demonstrated several positive outcomes. Through structured group discussions, guided by the World Café method and supported by virtual tools such as Google Meet breakout rooms and timed sessions, students were able to actively engage in collaborative learning and knowledge construction.

Quantitative analysis using the Computational Thinking Scale (CTS) revealed significant improvements in students' creativity, cooperation, and critical thinking skills.

Although not all dimensions showed statistically significant gains, the overall results indicate a positive trend in students' computational thinking development.

Additionally, the comparison between midterm and final exam scores showed a significant improvement in academic performance, suggesting that the instructional strategy not only promoted deeper thinking but also enhanced students' mastery of programming concepts.

The group size of 5–6 students was found to be effective in maintaining meaningful interaction while avoiding the drawbacks of overly large groups. The study concludes that the integration of a structured discussion model like World Café, along with supportive online tools, can be a powerful approach for improving both computational thinking and learning performance in programming-related courses.

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