A Project entitled

Investigating the Effectiveness of Pattern-Oriented Instruction in Enhancing Self-regulated Learning Ability and Programming Performance in Learning Programming

Submitted by

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Declaration

I, *Lin Qiu Tong*, declare that this research report represents my own work under the supervision of *Dr. Cheng Kwok Shing Gary*, and that it has not been submitted previously for examination to any tertiary institution.

Signed

Lin Qiu Tong

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Abstract

Pattern-oriented instruction (POI) is one of the pedagogies in teaching and learning programming. It has been scrutinised to reinforce problem decomposition and problem-solving skills with cognitive schemas and patterns. Self-regulated Learning (SRL) abilities in learning programming reflect an individual's cognitive schemas for approaching tasks, followed by other phrases of the undertaking and evaluating self-performance. Although POI shares the common ground of cognitive and metacognitive theories and is considered as an intervention for active schema recalling and monitoring on which SRL ability reflects as well, there is little research examining the potential of POI as an instructional intervention adoption for the change of students' SRL abilities in learning programming. Besides, to understand more about POI intervention in a secondary school context, this research aims to investigate the effectiveness of POI adoption on students' programming performance under the learning objectives of the Hong Kong technology education curriculum. Therefore, this research aims to research the capacity of POI in enhancing SRL ability in programming learning and programming performance among secondary school students. This study adopted a pretest-posttest control group design with random assignment of student subjects to two groups and the explanatory mixed-methods design (QUAN-QUAL model). It involved ten senior secondary school students and one class teacher. Student participants are divided into a POI intervention group and a control group to explore the research questions further. The results

indicated that POI intervention significantly enhances SRL abilities, mainly on self-efficacy, intrinsic value and strategy use. Moreover, the results from the comparison of the two groups suggested that POI intervention has relative enhancement in programming performance. However, some negative feedback was observed in POI instruction about the current standardised tests. Students' test anxiety is increased afterwards due to the time limitation for comprehending programming patterns and preparing for public exams.

Introduction

The concepts of algorithms and programming have been widely emphasised in technology education. Computer Science Teachers Association (2017) advises that sub-concepts of algorithms, variables, control, modularity and program development can be introduced by Grade 2 in primary school in the K-12 Computer Science Standard. In Information and Communication Technology education in Hong Kong, Key Learning Area Curriculum Guide (Curriculum Development Council [CDC], 2017) attaches high importance to programming concepts and algorithm design. Students are instructed to define problems, analyse problems, design suitable algorithms, code programs and test and debug programs. The strong emphasis on the concepts of algorithms design and programming procedure shows its significance in education curricula aiming to strengthen students' problem-solving skills.

However, educational studies on the programming performance of college students or novice programmers have pointed out that they have difficulties with algorithm design, writing and tracing programs (McCracken et al., 2001; Robins, Rountree & Rountree, 2003). In the public assessment of the Hong Kong Diploma of Secondary Education Examination 2020, examiners reviewed that candidates with low achievement had a minimal understanding of algorithm design and a weak ability to trace and modify algorithms (Hong Kong Examination and Assessment Authority [HKEAA], 2020). Secondary school students find it challenging to understand abstract programming concepts such as logical data structures, nested loops, recursion and initialisation (Vrachnos & Jimoyiannis, 2017). Pedagogically, some syllabi and textbooks of programming courses focus more on the programming language syntax and features than on establishing algorithms and algorithmic problem-solving skills in the course instruction (Muller, 2005). Researchers point out that students could not develop systematic programming knowledge due to fragile mental models about programming objects, attributes, methods and constructs under non-algorithm-based learning (Eckerdal, & Thuné, 2005; Garner, Haden & Robins, 2005). Some students cannot approach a problem by basically figuring out "where to start" and "what to solve".

Pattern-oriented instruction (POI) is one of the pedagogical approaches and design principles in the computer science curriculum, especially programming learning (Levy & Paz, 2005). It offers a workable solution for constructing students' algorithm design and scaffolding programming knowledge. Many studies on POI intervention observe a positive correlation between students' programming performance, analogical reasoning, and cognitive and behavioural self-monitoring and self-regulation (Muller, Haberman, Averbuch, 2004; Muller, 2005; Muller, Haberman & Ginat, 2007).

Self-regulated learning (SRL) ability reflects the regulation and organisation of cognition, motivation, behaviour and context (Pintrich, 2000). The Education Bureau promotes SRL capability in the Secondary Technology Education Curriculum Guide (Education Bureau, 2017). SRL abilities can be trained by an organised environment, materials and instruction (Pintrich, 2000), in which POI offers the pedagogical approach.

Hence, this research tried to investigate the effectiveness of POI intervention in enhancing SRL abilities among secondary school students by conducting an experimental study with a pretest-posttest control group design, together with analysing the efficacy of POI in improving programming performance among those students.

Literature Review

Pattern-oriented Instruction

Grounded in the theoretical base of Cognitive Theory in Cognitive Psychology, Muller (2005) proposes POI as a pedagogical methodology by incorporating algorithmic patterns into programming courses instruction design. This approach aims at developing the algorithmic problem-solving skills of the students who are learning to program. Examples of algorithmic patterns proposed in POI include targeted item search, condition judgement in a list, extreme value computation, and order reverse in a list (Muller, Haberman & Ginat, 2007).

Guidelines in POI in School Context

For better implementation of POI in programming courses, Muller and his colleagues proposed nine guidelines in the computer science teachers' training workshops (Muller, Haberman, Averbuch, 2004):

Guideline 1. Representative example: This instruction provides a comprehensive and concrete problem as an example. It scaffolds students to firstly access programming.

Guideline 2. Pattern definition: A pattern is abstracted from analogical problems or generalised from the previous solutions of more minor issues solved. Algorithmic patterns are recommended to introduce in the second stage.

Guideline 3. Pattern name: The pattern name is given for illustrating and analysing the problems and solutions, and it leads to a higher level of discussion among students at later stages.

Guideline 4. Similar patterns and problems: This instruction tries to link other similar problems and patterns by pointing out the similarities and differences among the discussed patterns.

Guideline 5. Comparison of solutions: This instruction allows students to compare alternative solutions to a given problem, including those related to different patterns. The comparison of the efficiency of algorithms should be discussed in this stage as well.

Guideline 6. Typical uses: This instruction starts to conclude the representative contexts where the patterns are applied before.

Guideline 7. Common mistakes and difficulties: Students are instructed to conclude common errors and difficulties related to the patterns to avoid wrong solutions, based on the previous programming exercise and patterns discussion.

Guideline 8. Pattern composing: This instruction discusses problems with solutions from several patterns or multiple uses of the same pattern.

Guideline 9. Entry and turning point: Students are instructed to modify their pattern-related solutions for similar problems and construct an algorithm solution for a new problem and corresponding patterns. The instruction works as a transition point from one specific issue to another.

Analysis of A Sample POI

A sample of POI with teaching Maximum Value Pattern is illustrated below in Figure 1. From the demonstration of Muller's instruction, the sample indicates a simple pattern used to find the maximum values in a list and a nesting pattern used to process each number of the given list. Similar problems and solutions can be finding minimum values in a given list and finding maximum odd values in a given list. They are the subset patterns of searching particular values in a collection. A further proposed pattern is "searching an element in a collection". For a higher level of discussion for students, the alternative solution is the initialisation of Max to the lower bound. By composing solutions and reconstructing patterns, other aspects of real-life problems with similar pattern collections can be analysed, such as the furthest distance on a city map and the computation of fireworks stations (Muller, Haberman, Averbuch, 2004).

Figure 1 *Representative Example of the Maximum Value Algorithmic Patterns (Muller, Haberman, Averbuch, 2004)*

Name: *Maximum Value*

Initial state: collection of values.

Goal: maximal value in the collection

Algorithm:

```
Initialize   Max to First_value
While there are more items do
    Assign next element to Next_Element
    If Next_Element > Max then
        Assign Next_Element to Max
```

Remarks: Here important highlights concerning the pattern and its use are indicated, as well as its related patterns.

Importance of POI Adoption in Programming Learning

Pattern-based and schema-based models have been adopted in Mathematics learning for raising Mathematics awareness and problem-solving skills (Philippou & Christou, 1999). In the programming educational community context, POI has been researched to advance problem-solving competencies in coding. In longitude research of Muller and his colleagues, they examined the influence of POI on 275 high-school students majoring in computer science (Muller, Haberman & Ginat, 2007). Data showed that POI had improved students' abstraction and problem-solving skills. Other research scrutinised the importance and advantages of POI, including problem decomposition and solution construction (Muller, Haberman & Ginat, 2007), analogical reasoning (Muller, 2005), and meaningful learning (Nakar, 2019).

Self-regulated Learning

There are various theoretical orientations and models toward self-regulated learning (SRL). A common conceptualisation of SRL is assumed that learners with SRL ability can progressively construct their meanings, goals, and strategies and actively interact with available information both in the external and internal environment (Pintrich, 2000). Rather than learning passively or destructively, those students can potentially regulate their learning in a virtuous circle, explicitly planning, monitoring, controlling, reacting and reflecting (Zimmerman, 2013).

Importance of SRL

Pintrich (2000) summarises a framework for classifying the different phases of SRL regulation. The area for regulation includes cognition, motivation, behaviour and context. Under the cognitive areas in SRL, students with higher SRL ability are observed to have the characteristics such as task-specific goals setting (Lee, Watson, & Watson, 2019), better problem construction and presentation (English, & Kitsantas, 2013), organisational and elaboration strategies (Cho, 2004), learning judgment (Azevedo, Moos, Johnson, & Chauncey, 2010), better analogical reasoning (Aminah, Kusumah, Suryadi, & Sumarmo, 2018), critical mathematical thinking (Retnaningsih, & Sugandi, 2018) and problem-solving (Fuchs et al., 2003).

SRL Ability during Programming Learning

Garcia and her colleagues summarise the alignment of 15 SRL strategy categories and students' usage in programming learning (Garcia, Falkner & Vivian, 2018). The categories are listed below.

Category 1. Goal setting and planning. Students can set goals for programming assignments and time limits.

Category 2. Organising and transforming. Students can initiate design plans prior to programming exercises.

Category 3. Seeking information. Students can initiate information-seeking through others, textbooks or online resources for further understanding of programming.

Category 4. Keeping records and monitoring. Students can initiate information-saving and self-work monitoring of learning materials collection.

Category 5. Environmental structuring. Students can initiate a comfortable environment for conducting learning.

Category 6. Self-consequences. Students can initiate rewards or punishments based on corresponding conditions during the learning process.

Category 7. Self-evaluation. Students can validate their programming exercises by self-assessment.

Category 8. Rehearsing and memorising. Students can initiate remembering the objectives in programming through exercises.

Category 9-11. Seeking social assistance from peers [9], teachers [10], and adults [11]. Students can initiate assistance-seeking from the external human environment.

Category 12-14. Reviewing records from tests [12], notes [13], textbooks [14]. Students can initiate to reread the learning materials collection for reviewing and another programming.

Category 15. Other learning strategies are prompted by external environments such as teachers, parents and the Internet.

Relationship between Pattern-oriented Instruction and Self-regulated Learning

Based on the theoretical framework of POI and SRL, similarities can be spotted under their common ground of cognitive and metacognitive theories. Whilst POI relies on cognitive schemas and patterns on which students construct and repeat for algorithmic solutions (Muller, 2005), the level of SRL ability also reflects an individual's cognitive general schemas for approaching and accomplishing tasks and evaluating their performance on the task (Pintrich, 2000).

Besides, students instructed by POI and trained by SRL perceive a common goal: to solve problems actively instead of passively. Muller and his colleagues point out in the main guidelines of POI that programming patterns should be well-planned selection for guiding students toward problem-solving (Muller, Haberman & Ginat, 2007). Similarly, SRL promotes students' skills of problem-solving with approach-performance orientation (Pintrich, 2000).

In addition, the usefulness of POI in programming learning focuses on the related boosted outcomes, which can also be received from SRL training. It is observed that POI contributes to students' self-confidence and enriches their strategies selection (Muller, Haberman & Ginat, 2007), whilst students in SRL training are observed to enhance their level of self-efficacy and resource management (Zimmerman & Martinez-Pons, 1990).

Research Purpose and Questions

Research Purpose 1: Investigating the Effectiveness of POI in Enhancing SRL Ability in Learning Programming

In the computer science education domain, especially programming learning, studies of the efficacy of the instructional intervention in SRL ability improvement mainly focuses on metaphors and pair programming (Hui & Umar, 2011), solution-based intelligent tutoring system (Hooshyar, Ahmad, Yousefi, Fathi, Horng & Lim, 2018), automated feedback generation system (Kuening, Jeuring & Heeren, 2016), web-based environment (Kauffman, 2004; Narciss, Proske & Koerndle, 2007), and hypermedia (Azevedo & Cromley, 2004).

Although POI works as one of the pedagogical approaches for teaching programming and works as an intervention for active schemas recalling and monitoring that SRL ability also reflects on, there is little research examining the potentiality of POI as an instructional intervention adoption to the change of students' SRL ability. Therefore, this research aims to bridge the research gap. Accordingly, a research question (RQ1) is proposed.

RQ1: Can pattern-oriented instruction enhance self-regulated learning ability in programming learning among secondary school students?

Research Purpose 2: Investigating the Effectiveness of POI in Enhancing Programming Performance

Previous research on POI to students' programming performance found that high school students in Israel tended to formulate improved written and verbal ideas, program more efficient and stylish algorithmic solutions, and acquire a better knowledge of algorithms (Muller, 2005). Students are also examined to meet learning outcomes in computer science concepts presented in the framework of Bloom's taxonomies (Nakar, 2019). It evidences a positive relationship between POI adoption in class and students' programming performance from previous research.

In Information and Communication Technology education in Hong Kong, Key Learning Area Curriculum Guide (CDC, 2017) lists the learning outcomes for secondary students in programming, including applying different and systematic approaches to solve problems, developing related programming capabilities and concepts, and programming simple codes to solve problems. Secondary 4-6 students majoring in Information and Communication Technology are assessed to formulate suitable programming styles, illustrate different programming paradigms and systematically apply concepts underlying software development (Curriculum Development Council, Hong Kong Examinations and Assessment Authority [CDC & HKEAA], 2015). Based on the curriculum guides in different Key Stages, students' programming performance is measured with understanding and application of problems identification, data manipulation, and algorithm design. For example, the public assessment in The Hong Kong Diploma of Secondary Education Examination examines students' acquisition of flowcharts and pseudocode in programming performance (CDC & HKEAA, 2015).

To understand more about POI intervention in the secondary school context, this research aims to investigate the effectiveness of POI adoption on students' programming performance under the learning objectives of the Hong Kong curriculum. Accordingly, a research question (RQ2) is proposed:

RQ2: Does pattern-oriented instruction enhance students' programming performance in a secondary school context?

Research Design and Methods

Design

A pretest-posttest control group design with random assignment of student subjects to two groups and an explanatory mixed-methods design (QUAN-Qual model) was adopted to explore the effectiveness of the POI intervention and traditional strategy instruction self-regulated learning abilities and programming performance improvement.

Participants

This study recruited ten students (four males and six females) from a secondary school whose elective in the public examination is Information and Communication Technology. All student participants were in Grade 11 and 17 years old. At the outset of this study, all participants reported no experience with text-based programming. At the same time, the class teacher stated that the selected students had minimal experience with text-based programming such as Java and Python, where the learning experience was very unsatisfactory. Students were randomly divided into a POI Group and a Control Group. A subject teacher who teaches Information and Communication Technology and Computer Literacy was invited to participate and observe the research process. All participants were invited as individual subjects under the consent of the school.

Table 1 presents the personal information concerning student participants' gender and standardised achievement scores in Mathematics and Computer courses.

Table 1 *Demographic Information*

Variable	POI Group	Control Group
Gender		
Male	2	2
Female	3	3
Standardised achievement scores		
Computer		
M	73.40	81.80
SD	10.64	17.81
Mathematics		
M	85.20	91.60
SD	9.50	7.09

Note: POI = pattern-oriented instruction. Standardised achievement scores in Computer and Mathematics were obtained from the school teacher provided information.

Data Collection and Analysis

There were two critical phases of data collection in the study, the pre-intervention phase for quantitative data collection and the post-intervention phase for quantitative and qualitative data collection. The QUAN-QUAL model was applied in the data analysis (Mills & Gay, 2019). A pre-test and post-test of a revised Chinese version of The Motivated Strategies for Learning Questionnaire (MSLQ-RCV) and computer programming performance test (CPPT) were conducted in the pre-intervention and post-intervention stages. After the intervention, semi-structured interviews with two groups of students and a class teacher were conducted. Accordingly, the verbal data can support, explain or elaborate on the quantitative results (Cohen, Manion & Morrison, 2007).

Quantitative Data Collection

The original MSLQ co-designed by Pintrich and his colleagues (Pintrich, Smith, Garcia, & McKeachie, 1991) is used to assess college students' motivational orientations and learning strategies. As the original MSLQ was developed in the 1990s and designed for college students, this study adopts a revised MSLQ for data collection methods to ensure validity and reliability. Under the Hong Kong Chinese context, a revised Chinese version of MSLQ (MSLQ-RCV) is examined with the data from 2,005 Hong Kong secondary students (Lee, Yin, & Zhang, 2010). It assesses students' self-efficacy (7 items), intrinsic value (9 items), extrinsic value (4 items), and test anxiety (4 items) for the motivational section (24 items). Additionally, the questionnaire evaluates students' strategy use (19 items) and peer learning (7 items) for the learning strategies (26 items). The sample MSLQ-RCV is attached in Appendix 1a, and the scale of analysis is in Appendix 1b.

CPPT is a paper-based assessment revised from the Hong Kong Diploma of Secondary Education Examination (Information and Communication Technology subject core paper) based on students' grades and pre-knowledge of programming. The test consists of seven multiple questions and three long questions with 100 points. The CPPT test is attached in Appendix 2. The assessment objectives in the CPPT align with the learning objectives in the Key Learning Stage (CDC, 2017).

Quantitative Data Analysis

The purpose of conducting two quantitative pre-tests is to obtain baseline data and measure the initial differences in SRL ability level and programming knowledge between the two student groups before POI intervention and traditional teaching. The purpose of conducting the two quantitative post-tests aims to analyse the difference in SRL ability level and programming performance compared to the pre-tests between the two student groups.

This study analysed quantitative data using the statistical software platform, IBM® SPSS® Statistics (version 26) (IBM, n.d.). First, two sets of descriptive statistical analyses were performed separately to analyse the MSLQ-RCV score and CPPT score. Both kinds of scores were recognised as interval data types.

For research question 1 (RQ1), a null hypothesis "there is no statistically significant relationship between POI intervention and SRL ability level enhancement" is assumed. After assessing the normality of the distribution of scores, a parametric technique (paired-sample t-tests) or a non-parametric method (Wilcoxon Signed-Rank Test) was applied to compare the two groups.

Determining and comparing the p-value to the predetermined significance level was applied to determine any significant difference between students with POI intervention and SRL ability level improvement in programming learning. One independent variable (POI intervention) and one dependent variable (SRL ability level change of scores calculated from

MSLQ-RCV in pre-test and post-test).

For research question 2 (RQ2), a null hypothesis "there is no statistically significant relationship between POI intervention and programming performance enhancement" is assumed. After assessing the normality of the distribution of scores, a parametric technique (paired-sample t-tests) or a non-parametric method (Wilcoxon Signed-Rank Test) was applied to compare the two groups.

Determining and comparing the p-value to the predetermined significance level was applied to determine any significant difference between students with POI intervention and programming performance improvement in programming learning. One independent variable (POI intervention) and one dependent variable (programming performance change of scores calculated from CPPT in pre-test and post-test).

Qualitative Data Collection and Analysis

Apart from quantitative data, verbal data collection as a qualitative method was conducted through semi-structured interviews with students and the class teacher who teach Information and Communication Technology and Computer Literacy. It was used to explore further differences in SRL ability level and programming performance from the perspectives of the students and the class teacher's observation. Standardised open-ended interviews were conducted with five students from the treatment group, five from the control group and one class teacher. They were invited to share their new sight and personal observation of the changes individually. The interview question samples for students and the class teacher are attached in Appendix 3a, 3b and 3c, respectively. Those verbal data were converted into transcripts analysis and classified into different SRL ability categories (self-efficacy, intrinsic value, extrinsic value, test anxiety, strategy use, and peer learning) and programming performance assessment objectives (understanding and application of problems identification, data manipulation, and algorithm design).

Research Procedures

The study conducted five classes in the treatment group with POI intervention (X1) and five courses in the control group without POI intervention. The POI intervention was designed based on nine guidelines from Muller, Haberman and Ginat (2007). Five selected patterns discussed in the POI class are attached in Appendix 4. The first class of both groups finished the pre-test of MSLQ-RCV (O1) and CPPT (O2). After five lessons of programming learning, students in two groups completed the post-test of MSLQ-RCV (Q3) and CPPT (Q4). Students from the treatment group (I1) and the control group (I2) were invited to have the semi-structured interview. The class teacher (I3) was interviewed after the post-test as well. The analysis of semi-structured interview transcript is attached in Appendix 5.

The experimental research procedure with the pretest-posttest control group design is illustrated in Table 2. Each pattern would be discussed in the POI Group, and traditional learning content would be delivered in the Control Group is listed in Appendix 6, with the alignment of the learning objectives in Information and Communication Technology (CDC &

HKEAA, 2015).

Table 2 *Experimental Procedures*

Group	**Pre-test**	**Intervention (POI)**	**Post-test**
POI Group	O1, O2	X1	O3, O4
Control Group	O1, O2		O3, O4
Participant	**Pre-test**	**Intervention (POI)**	**Post-test**
5 students from POI Group			I1
5 students from Control Group			I2
Class teacher			I3

Figure 2 *Students in Two Groups Finishing the Pre-test*

Figure 3 *Lesson 3 Class Activity in POI Group*

Result and Discussion

Prior to conducting statistical analyses to compare the two groups with samples lower than 50, seven Shapiro-Wilks Normality Tests were conducted to assess the normality of the distribution of scores for seven domains in the study. After determining the Sig. values in tests of normality in six fields in SRL ability, a non-significant result (Sig. value of more than 0.05) indicates normal distribution in the sample. Therefore, a parametric technique, paired-samples t-test, was conducted to determine any significant change in SRL ability between two groups of students. On the other hand, a significant result (Sig. value of less than 0.05) was found in the normality test in CPPT, which signifies a non-normal distribution in the sample. Hence, a non-parametric technique, Wilcoxon Signed-Rank Test, was conducted to determine any significant change in programming performance between two groups of students.

Table 3 *Statistical Techniques to Compare Groups in Each Domain*

Domain		Statistical Techniques to Compare Groups	
SRL ability	Self-efficacy Intrinsic value Extrinsic value Test anxiety Strategy use Peer learning	Parametric technique	Paired-Samples t-test
Programming performance	Computer programming performance test (CPPT)	Non-parametric technique	Wilcoxon Signed-Rank Test

Effectiveness of POI in Enhancing SRL Ability in Learning Programming

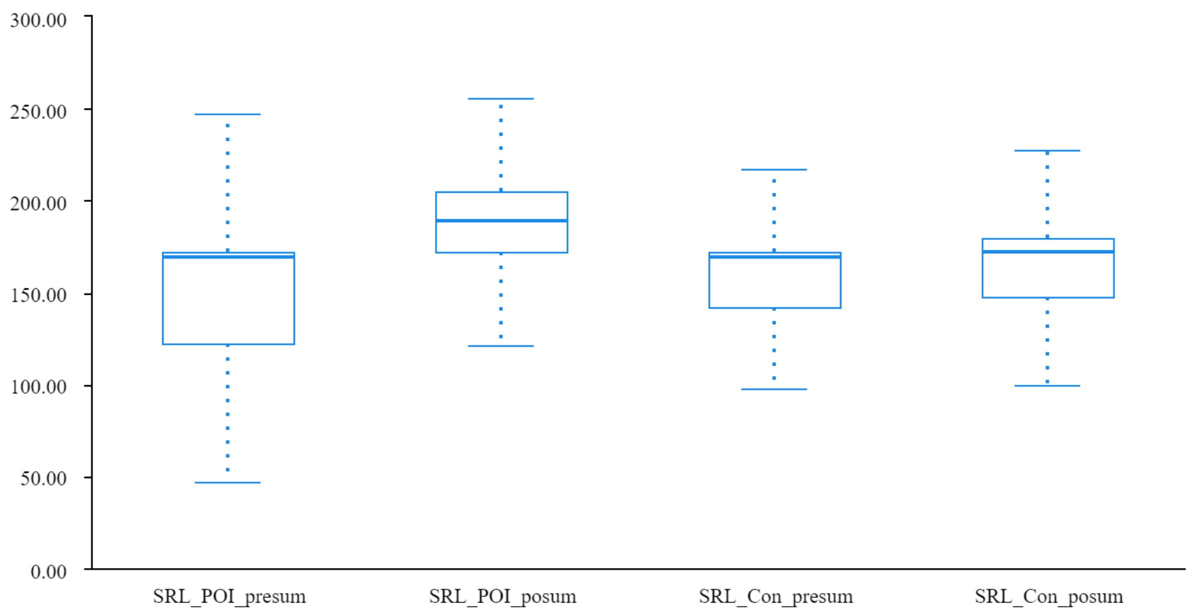
The student participants in the POI Group and the Control Group completed the MSLQ-RCV questionnaire. The result from Table 4 reported higher SRL ability scores compared to the mean in pre-test and post-test in general. The box-plot graph (Figure 4) also visually illustrates the distribution of changes in SRL sum scores in the two groups of students. Students who received POI intervention significantly increased their SRL ability in learning programming, which positively responds to the RQ1. A detailed discussion on different six aspects of SRL ability, namely self-efficacy, intrinsic value, extrinsic value, test anxiety, strategy use and peer learning, is below.

Table 4 *Comparison in Pretest-Posttest of Mean and Standard Deviation in Two Groups*

	n		**M**		**SD**	
Test	POI	Control	POI	Control	POI	Control
Pre-test	5	5	151.40	159.40	27.62	20.50
Post-test	5	5	188.40	164.80	17.90	21.32

Note: POI = pattern-oriented instruction group; Control = control group without intervention

Figure 4 *Box-plot Graph on the SRL Scores of Pretest-Posttest in Two Groups*



A Significant Enhancement in Self-efficacy Domain

A significant enhancement was found in the POI Group compared to the Control Group in the self-efficacy domain, which was implied by the pre-test and post-test questionnaires statistics. Two paired-samples t-tests were conducted to evaluate the impact of POI intervention and traditional teaching on students' self-efficacy scores (7 items) in MSLQ-

RCV. Pair 1 was grouped from the POI Group's pre-post-test sum data, and Pair 2 was summarised from the Control Group's numeric data in Table 5. Comparing two pairs' mean (M_{POI} = -5.8, $M_{Control}$ = -1.6), students' self-efficacy ability was strengthened through programming learning in general. However, there was a statistically significant enhancement in the POI Group from pre-test (M = 17.40, SD = 3.78) to post-test (M = 23.2, SD = 2.17), t (4) = -6.328, $p < .05$ (two-tailed). The mean increase in self-efficacy scores was 5.80, with a 95% confidence interval ranging from -8.34 to -3.26. The eta squared statistic (.90) implied a large effect size (Cohen, 1988). The statistical result suggests a significant increase in the POI Group's self-efficacy through the experiment.

Table 5 *Paired-Samples Test of Self-efficacy Domain*

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	SelfEfficacy_POI_presum	17.4000	5	3.78153	1.69115
	SelfEfficacy_POI_posum	23.2000	5	2.16795	.96954
Pair 2	SelfEfficacy_Con_presum	21.2000	5	2.77489	1.24097
	SelfEfficacy_Con_posum	22.8000	5	3.49285	1.56205

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	SelfEfficacy_POI_presum & SelfEfficacy_POI_posum	5	.903	.036
Pair 2	SelfEfficacy_Con_presum & SelfEfficacy_Con_posum	5	.934	.020

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	SelfEfficacy_POI_presum - SelfEfficacy_POI_posum	-5.80000	2.04939	.91652	-8.34465	-3.25535	-6.328	4	.003
Pair 2	SelfEfficacy_Con_presum - SelfEfficacy_Con_posum	-1.60000	1.34164	.60000	-3.26587	.06587	-2.667	4	.056

Students agreed they had improved self-efficacy during the programming courses in the semi-structured interview with the two groups. Two groups of students mentioned they believed they could understand the content taught in the class and overcome complex programming problems, which inferred their self-efficacy increased after the programming learning from their verbal data. Furthermore, one student in the POI Group mentioned, “These (POI) programming exercises seem different from the traditional one. I like this way, so I believe I can do a better job in later coding class.” It suggested that students may find the POI instruction was interesting enough and had the potential to enhance their learning motivation. Accordingly, their self-efficacy toward programming learning was reinforced.

However, the self-efficacy items related to peer competition and examination present a decreasing tendency in the POI Group. Compared to the mean difference (pre-post-test) in the mentioned items in Table 6, the POI Group reported their expectation of achievement in peers was not much higher than the Control Group. One student said, "The case studies were funny, but I am not sure whether I can do better in exams." in the semi-structured interview. It implied that POI students might not have much confidence in dealing with peer pressure from the examination.

Table 6 *Mean Differences in Two Groups on Items of Peer Competition and Examination*

Item	Mean Difference	
	POI Group	Control Group
12. I think I will receive good grades in my exams.我認為我在考試中可以得到優異成績。	0	-0.2
17. I know that I will be able to learn the materials for the tests and exams. 我認為我將學會用於考試和測驗的課堂材料。	0.2	-0.2

A Significant Enhancement in Intrinsic Value Domain

In the intrinsic value domain, a more significant increase was observed in the POI Group compared to the Control Group. Table 7 displays two paired-sample t-tests of the intrinsic value domain (9 items) in MSLQ-RCV. Two paired tests, Pair 3 as POI Group pre-post-test and Pair 4 as Control Group pre-post-test, denoted that students' intrinsic motivation was improved after the programming courses. Apparently, POI Group students were much more intrinsically motivated than the Control Group with the POI Group from pre-test (M = 24.60, SD = 4.34) to post-test (M = 34.80, SD = 3.27), t (4) = -4.896, p < .05 (two-tailed). The mean increase in intrinsic value scores was 10.20, with a 95% confidence interval ranging from -15.98 to -4.42. The eta squared statistic (.80) revealed a large effect size (Cohen, 1988). It indicates a more significant enhancement in intrinsic value after receiving POI instruction.

Table 7 *Paired-Samples Test of Intrinsic Value Domain*

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 3	IntrinsicValue_POI_presum	24.6000	5	4.33590	1.93907
	IntrinsicValue_POI_posum	34.8000	5	3.27109	1.46287
Pair 4	IntrinsicValue_Con_presum	29.0000	5	2.34521	1.04881
	IntrinsicValue_Con_posum	30.8000	5	3.63318	1.62481

Paired Samples Correlations

		N	Correlation	Sig.
Pair 3	IntrinsicValue_POI_presum & IntrinsicValue_POI_posum	5	.275	.654
Pair 4	IntrinsicValue_Con_presum & IntrinsicValue_Con_posum	5	.968	.007

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 3	IntrinsicValue_POI_presum - IntrinsicValue_POI_posum	-10.20000	4.65833	2.08327	-15.98408	-4.41592	-4.896	4	.008
Pair 4	IntrinsicValue_Con_presum - IntrinsicValue_Con_posum	-1.80000	1.48324	.66332	-3.64169	.04169	-2.714	4	.053

The comparison of intrinsic value items indicated that POI Group students were more inculcated in the inner meaning and joy of learning programming. The mean difference of Items 1, 14 and 16 presented a more positive effect on dealing with challenging tasks and finding practicality and fun during the POI class time. In the interview, POI students mentioned they enjoyed the real-life examples applied and analysed in the patterns and even tended to apply pattern-oriented thinking to other subjects and daily life. The class teacher also noticed that the POI students were much "happier and more engaging" in thinking about patterns in daily life examples. It reflected that POI had the potential to extend the degree to which students perceive themselves to participate in a programming task for internal reasons, such as challenge, curiosity and mastery.

Table 8 *Mean Differences in Two Groups on Items Related to Internal Reasons*

Item	Mean difference	
	POI Group	Control Group
1. I prefer class work that is challenging so I can learn new things. 我更喜歡具有挑戰性的課業，因此我能學會新知識。	-1.8	-0.2
14. I think that what I am learning in school is useful for me to know. 我認為現時在課堂所學習的東西對我有用。	-2.2	-0.4
16. I think that what we are learning in school is interesting. 我認為我們在學校所學的很有趣。	-2.2	0

No Statistically Significant Difference in Enhancing Extrinsic Value Domain

The paired-samples test revealed no statistically significant change in the POI Group in the extrinsic value domain. Table 9 shows the paired-sample test of the extrinsic value domain (4 items) in MSLQ-RCV. Pair 5 was compared to the POI Group pre-post-test, and Pair 6 was grouped from Control Group pre-post-test data. The p-value in Pair 5 (p=0.074) is higher than 0.05, which provided statistical evidence to interpret the null hypothesis that "there is no statistically significant relationship between POI intervention and extrinsic value enhancement".

Table 9 *Paired-Samples Test of Extrinsic Value Domain*

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 5	ExtrinsicValue_POI_presum	12.6000	5	2.07364	.92736
	ExtrinsicValue_POI_posum	14.8000	5	2.94958	1.31909
Pair 6	ExtrinsicValue_Con_presum	12.4000	5	1.67332	.74833
	ExtrinsicValue_Con_posum	14.2000	5	2.16795	.96954

Paired Samples Correlations

		N	Correlation	Sig.
Pair 5	ExtrinsicValue_POI_presum & ExtrinsicValue_POI_posum	5	.719	.171
Pair 6	ExtrinsicValue_Con_presum & ExtrinsicValue_Con_posum	5	.868	.056

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 5	ExtrinsicValue_POI_presum - ExtrinsicValue_POI_posum	-2.20000	2.04939	.91652	-4.74465	.34465	-2.400	4	.074
Pair 6	ExtrinsicValue_Con_presum - ExtrinsicValue_Con_posum	-1.80000	1.09545	.48990	-3.16017	-.43983	-3.674	4	.021

Comparing the mean difference of the POI Group, there was a slight increase in the extrinsic value domain ($M = -2.2 < 0$). The class teacher stated that the students selected for the experiments did not obtain as high academic achievement as the top students in their class. Students who participated in this study may not orient themselves to the programming task for the external rewards and competition. Nevertheless, POI Group students shared that they believed learning alternative ways of solving problems in programming can “get a good grade like them (top students)”, which infers they valued the learning progress and were extrinsically motivated by the peer competition.

A Significant Decrease in Handling Test Anxiety Domain

In the handling test anxiety domain, a statistically significant decrease was observed in the POI Group compared to the Control group of traditional teaching. Table 10 shows the paired-sample test of the test anxiety domain (4 items) in MSLQ-RCV. POI Group from pre-test (M = 12.60, SD = 1.14) to post-test (M = 15.80, SD = 1.64), t (4) = -3.72, $p < .05$ (two-tailed), in which signified the ability of handing anxiety was weaker than before. On the contrary, the Control Group from pre-test (M = 14.00, SD = 2.35) to post-test (M = 11.00, SD = 1.87), t (4) = 3.87, $p < .05$ (two-tailed), indicating students who received the tradition teaching perceived more positive thoughts towards exams. The mean increase in test anxiety scores was 3.20, with a 95% confidence interval ranging from -5.59 to -.81. The eta squared statistic (.80) meant a large effect size (Cohen, 1988). The statistical results suggest a significant decrease in handling test anxiety in the POI Group.

Table 10 *Paired-Samples Test of Test Anxiety Domain*

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 7	TestAnxiety_POI_presum	12.6000	5	1.14018	.50990
	TestAnxiety_POI_posum	15.8000	5	1.64317	.73485
Pair 8	TestAnxiety_Con_presum	14.0000	5	2.34521	1.04881
	TestAnxiety_Con_posum	11.0000	5	1.87083	.83666

Paired Samples Correlations

		N	Correlation	Sig.
Pair 7	TestAnxiety_POI_presum & TestAnxiety_POI_posum	5	.080	.898
Pair 8	TestAnxiety_Con_presum & TestAnxiety_Con_posum	5	.684	.203

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 7	TestAnxiety_POI_presum - TestAnxiety_POI_posum	-3.20000	1.92354	.86023	-5.58839	-.81161	-3.720	4	.020
Pair 8	TestAnxiety_Con_presum - TestAnxiety_Con_posum	3.00000	1.73205	.77460	.84937	5.15063	3.873	4	.018

After receiving the POI intervention, it was found that the degree of anxiety was increased, especially in the cognitive and emotional components. One POI Group student shared that "I like the patterns and examples in class, but I know public exams would not test them", implying that they were worried about the quizzes and exams which do not directly assess programming patterns. Another POI Group student stated that "I think I need more time to prepare for the exam later, though I will try my best to think to code in patterns". It inferred that students might need time to comprehend programming patterns in preparation for standardised public exams. The class teacher also proffered that when it comes to taking the current standardised examinations, the POI instruction may not provide the best approach to assist senior secondary students in preparing for the public exam. Nevertheless, POI instruction can be applied in the junior secondary cohort to meet learning objectives for understanding the programming concepts and algorithms design.

A Significant Enhancement in Strategy Use Domain

A statistically significant enhancement was observed for the strategy use domain in the POI intervention group. Table 11 presents the paired-samples test of the strategy use domain (19 items) in MSLQ-RCV. Pair 9 compared the pretest-posttest in the POI Group and Pair 10 compared the pretest-posttest in the Control Group. Two groups enhanced their strategy use of SRL ability after the programming course series when taking mean differences is a negative value (M_{POI} = -14.2, $M_{Control}$ = -2.4). It appears that students in POI Group enhanced increasingly their learning strategy usage from pre-test (M = 59.20, SD = 10.92) to post-test (M = 73.40, SD = 6.47), t (4) = -4.293, p < .05 (two-tailed). The mean increase in strategy use scores was 14.20, with a 95% confidence interval ranging from -23.38 to -5.02. The eta squared statistic (.80) displayed a large effect size (Cohen, 1988). The statics data suggest a significant enhancement in strategy use after receiving POI intervention.

Table 11 *Paired-Samples Test of Strategy Use Domain*

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 9	StrategyUse_POI_presum	59.2000	5	10.91788	4.88262
	StrategyUse_POI_posum	73.4000	5	6.46529	2.89137
Pair 10	StrategyUse_Con_presum	58.8000	5	11.23388	5.02394
	StrategyUse_Con_posum	61.2000	5	10.13410	4.53211

Paired Samples Correlations

		N	Correlation	Sig.
Pair 9	StrategyUse_POI_presum & StrategyUse_POI_posum	5	.753	.142
Pair 10	StrategyUse_Con_presum & StrategyUse_Con_posum	5	.989	.001

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 9	StrategyUse_POI_presum - StrategyUse_POI_posum	-14.20000	7.39594	3.30757	-23.38328	-5.01672	-4.293	4	.013
Pair 10	StrategyUse_Con_presum - StrategyUse_Con_posum	-2.40000	1.94936	.87178	-4.82045	.02045	-2.753	4	.051

To further analyse the items in the learning strategy use domain, cognitive and metacognitive strategies such as elaboration and organisation were frequently applied in the POI Group. Table 12 highlights five items evidencing the more significant difference between the two groups of students. To build long-term memory, they focus on assessing how learners connect new information with organisation strategies (Item 26, 36) and elaboration strategies (Item 27, 34, 39).

Table 12 *Mean Differences in Two Groups on Items Related to Internal Reasons*

Item	Mean difference	
	POI Group	Control Group
26. When I study I put important ideas into my own words. 我會把所學到的重要知識，用自己的方式說給自己聽。	-1.8	0
32. I use what I have learned from old homework assignments and the textbook to do new assignments. 我會使用以前所完成的功課和課本，來幫助我完成新的功課。	-1.4	0
34. When I am studying a topic, I try to make everything fit together. 我嘗試把跟這一個課程有關的內容，全部貫通起來。	-1.6	-0.2
36. When I read materials for my classes, I say the words over and over to myself to help me remember. 當我閱讀課堂材料時，我會重複默讀，來幫助記憶。	-1.8	-0.4
39. When I am studying I try to connect the things I am reading about with what I already know. 我嘗試把我已經知道，和現在所學的組合起來。	-1.2	-0.4

All students in the POI Group reported they had used daily examples and patterns discussed in previous classes to assist them in understanding and analysing the patterns involved. It evidences that students acquired the learning strategies to integrate the information with prior knowledge and construct internal connections among real-world problems. They can activate their previous learning and evaluate the patterns acquisition. Three of five students reported that they learned how to name and create new patterns during and after class times, which indicated that the POI intervention assisted students in cultivating active and effortful habits to construct connections among the information to be learned.

No Statistically Significant Change in Peer Learning Domain

The paired-samples test evidenced no statistically significant change in the POI Group in the peer learning domain. Table 13 displays the paired-sample test of the peer learning domain (7 items) in MSLQ-RCV. Pair 11 was compared to the POI Group pretest-posttest, and Pair 12 was grouped from Control Group pretest-posttest data. The p-value in Pair 11 (p=0.108) is higher than 0.05, which provided statistical evidence to interpret the null hypothesis that "there is no statistically significant relationship between POI intervention and peer learning enhancement".

Table 13 *Paired-Samples Test of Peer Learning Domain*

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 11	PeerLearning_POI_presum	25.0000	5	7.58288	3.39116
	PeerLearning_POI_posum	26.4000	5	6.46529	2.89137
Pair 12	PeerLearning_Con_presum	24.0000	5	5.83095	2.60768
	PeerLearning_Con_posum	24.8000	5	5.40370	2.41661

Paired Samples Correlations

		N	Correlation	Sig.
Pair 11	PeerLearning_POI_presum & PeerLearning_POI_posum	5	.989	.001
Pair 12	PeerLearning_Con_presum & PeerLearning_Con_posum	5	.984	.002

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 11	PeerLearning_POI_presum - PeerLearning_POI_posum	-1.40000	1.51658	.67823	-3.28308	.48308	-2.064	4	.108
Pair 12	PeerLearning_Con_presum - PeerLearning_Con_posum	-.80000	1.09545	.48990	-2.16017	.56017	-1.633	4	.178

Taking the mean difference in the POI Group, there was a slight enhancement after receiving POI intervention (M = -1.4 < 0). In the semi-structured interview, four of five students in the POI Group shared that they would like to discuss exciting patterns in daily life and work together to analyse programming problems. However, two of them reported that they preferred to ask teachers rather than their groupmates due to negative judgment or misunderstanding from peers, which made them unpleasant. It demonstrated that students in POI intervention might not provide sufficient peer support or tutoring as the programming patterns are not so standardised among all students. Students prefer to learn and solve problems by themselves and seek help from one-on-one teachers' assistance to facilitate their achievement.

Effectiveness of POI in Enhancing Programming Performance

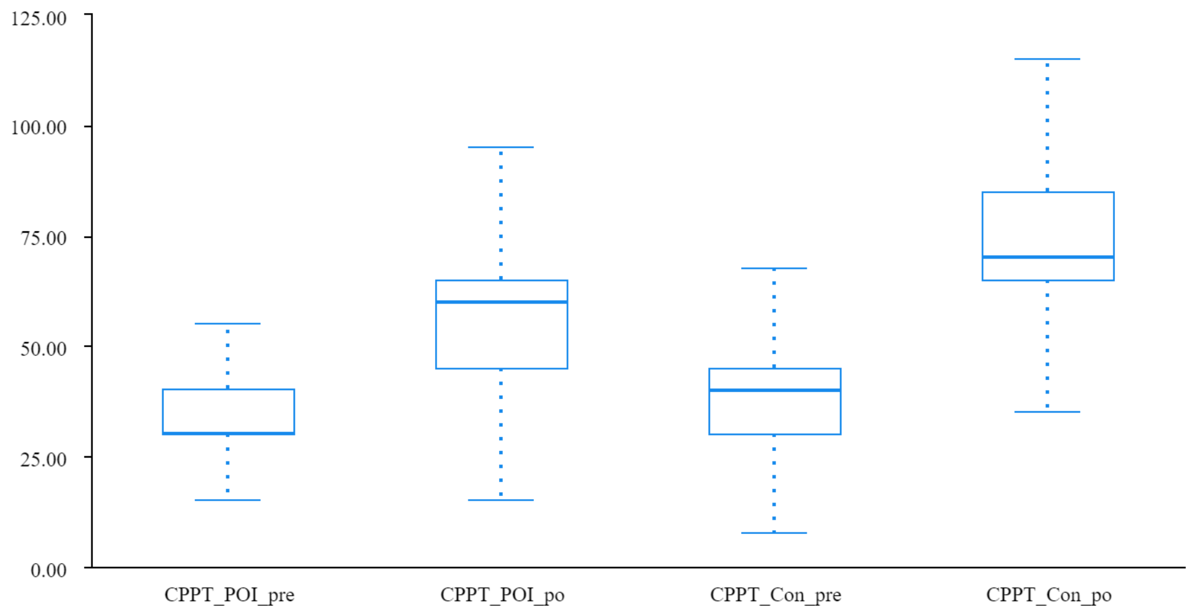
The student participants in the POI Group and the Control Group completed the CPPT in pre-test and post-test. Table 14 presented that two groups of students received higher computer programming scores compared to the pre-test and post-test mean. The box-plot graph (Figure 5) also visually illustrates the distribution of changes in CPPT scores in the two groups of students.

Table 14 *Comparison in Pretest-Posttest of Mean and Standard Deviation in Two Groups*

	n		**M**		**SD**	
Test	POI	Control	POI	Control	POI	Control
Pre-test	5	5	34.00	38.00	5.48	8.37
Post-test	5	5	56.00	74.00	11.40	11.40

Note: POI = pattern-oriented instruction group; Control = control group without intervention

Figure 5 *Box-plot Graph on CPPT Scores of Pretest-Posttest in Two Groups*



Comparing the CPPT pretest-posttest, a statistically significant enhancement in programming performance was observed. Table 15 presents the Wilcoxon Signed-Rank Test of CPPT, which assesses students' performance in solving programming problems. The mean rank in the two groups is positive, indicating the programming improvement after the experiment. Furthermore, the Wilcoxon Signed-Rank Test revealed a statistically significant enhancement in CPPT of POI Group, $z = -2.041$, $p < 0.05$, with a large effect size ($r = .90$) (Cohen, 1988). The median score on the CPPT scores increased from pre-test (*Md* = 30) to post-test (*Md* = 40). The statistical data reveals a significant enhancement in the POI Group in improving their programming knowledge in the standardised test. The results can respond to RQ2.

Table 15 *Wilcoxon Signed-Rank Test of CPPT*

Descriptive Statistics

		Percentiles		
	N	25th	50th (Median)	75th
CPPT_POI_pre	5	30.0000	30.0000	40.0000
CPPT_Con_pre	5	30.0000	40.0000	45.0000
CPPT_POI_po	5	45.0000	60.0000	65.0000
CPPT_Con_po	5	65.0000	70.0000	85.0000

Ranks

		N	Mean Rank	Sum of Ranks
CPPT_POI_po - CPPT_POI_pre	Negative Ranks	0[a]	.00	.00
	Positive Ranks	5[b]	3.00	15.00
	Ties	0[c]		
	Total	5		
CPPT_Con_po - CPPT_Con_pre	Negative Ranks	0[d]	.00	.00
	Positive Ranks	5[e]	3.00	15.00
	Ties	0[f]		
	Total	5		

a. CPPT_POI_po < CPPT_POI_pre

b. CPPT_POI_po > CPPT_POI_pre

c. CPPT_POI_po = CPPT_POI_pre

d. CPPT_Con_po < CPPT_Con_pre

e. CPPT_Con_po > CPPT_Con_pre

f. CPPT_Con_po = CPPT_Con_pre

Test Statistics[a]

	CPPT_POI_po - CPPT_POI_pre	CPPT_Con_po - CPPT_Con_pre
Z	-2.041[b]	-2.070[b]
Asymp. Sig. (2-tailed)	.041	.038

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

Although students in the POI Group improved their CPPT pre-test and post-test scores, the absolute mean of difference is lower than the Control Group ($M_{POI} < M_{Control}$), which suggests that the POI Group's improvement is not as apparent as the traditional class. In the semi-structured interview, the class teacher mentioned that students who received POI intervention might need more extra assistance from teachers to prepare for the public examination within serval weeks. It inferred that the POI instruction might not play a pivotal role in quickly improving students' academic achievement in standardised test preparation within a short period. Students might take time to understand and follow the assessment objectives in the public examination when applying the programming patterns.

In the post-test CPPT, POI Group students can spot the patterns to which the questions are applied. Figure 6 displays that one student left the remark “Pattern 5” (conditional count), discussed and learnt in previous lessons. She stated that it was vital for her to have pattern identification, and it was the first step to solving the questions. It indicated that POI students could apply pattern-oriented thinking and improve analogic reasoning to the problem-solving of standardised tests.

Figure 6 *A Post-test Sample from POI Group Student*

Q1. 以下算法的輸出是什麼?

What is the output of the following algorithm?

5

```
LENGTH   ← 6
HEIGHT   ← 5
AREA     ← LENGTH * HEIGHT
LENGTH   ← 4
HEIGHT   ← 3
輸出 AREA
```

A. 12

B. 20

C. 24

D. 30

Concluding Remarks and Future Work

This study has reported how pattern-oriented instruction pedagogy can enhance students’ SRL ability in learning programming and their programming performance in a secondary school context. This study adopted a pretest-posttest control group design with random assignment of student subjects to two groups and the explanatory mixed-methods design (QUAN-QUAL model) to investigate the effectiveness of the POI and traditional teaching instruction. After analysing the quantitative data from MSLQ-RCV questionnaires and students' programming performance scores, and their qualitative verbal data, the study results indicate that POI intervention can significantly enhance the SRL ability in three domains: self-efficacy, intrinsic value and strategy use. The results also reveal that POI intervention can significantly enhance the programming performance in standardised tests. Additionally, this study observed the POI intervention potentially led to increased test anxiety, with the students' and class teachers' concern about more extra preparation and assistance required for public examinations. Moreover, students who received POI intervention tended to learn independently and decrease the desire to have peer learning due to the different elaborations on different programming patterns.

To generalise the findings of this study, further research work should be undertaken with a larger sample size in the study such as a larger group of secondary school students, together with more powerful effect size, such as a longer time of testing and repeated measures of the assessment including maintenance test during the experiment and follow-up test after a period of the study. Furthermore, additional data such as students' self-evaluation and reflective learning journals can be collected and analysed to provide more information in the experiments. Those data assists in triangulating the findings and releasing more substantial evidence.

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Appendix

Appendix 1a: Pre-post test revised Chinese version of motivated strategies for learning questionnaire (MSLQ-RCV). (Lee, Yin, & Zhang, 2010) for students

All items are given 1-5 points scale from 1 (not at all true of me) to 5 (very true of me).
請各位同學依照自我的感覺，給出每個句子分數（1 表完全不符合，5 表完全符合）。

	完全不符合	大部分不符合	一般	大部分符合	完全符合
1. I prefer class work that is challenging so I can learn new things. 我更喜歡具有挑戰性的課業，因此我能學會新知識。	1	2	3	4	5
2. Compared to other students in this class I expected to do well. 我期望能比同班同學做得更好。	1	2	3	4	5
3. I have an uneasy, upset feeling when I take a test or exam. 當我考試或測驗時，我感覺不安、煩惱。	1	2	3	4	5
4. It is important for me to learn what is being taught in school. 學習學校所教授的東西對我來說是重要的。	1	2	3	4	5
5. I like what I am learning in school. 我喜歡我在學校所學習的。	1	2	3	4	5
6. I am certain that I can understand the ideas taught in my classes.	1	2	3	4	5

我確認我能懂得課堂所教的內容。					
7. I think I will be able to use what I learn in one subject in another. 我覺得我將能利用在課堂所學的，到其他不同的學科中。	1	2	3	4	5
8. Compared with others in this class, I think I am a good student. 與同班同學相比，我認為我是一名好學生。	1	2	3	4	5
9. I often do more than is required of me for homework assignments. 我常常完成老師要求以外的功課。	1	2	3	4	5
10. I am sure I can do an excellent job on the class assignments and homework. 我確認我能在堂課和功課上表現出色。	1	2	3	4	5
11. I worry a great deal about tests and exams. 我非常擔心考試和測驗。	1	2	3	4	5
12. I think I will receive good grades in my exams. 我認為我在考試中可以得到優異成績。	1	2	3	4	5
13. Even when I do poorly on a test or exam I try to learn from my mistakes. 即使我在考試或測驗中做得不好，我嘗試從錯誤中學習。	1	2	3	4	5
14. I think that what I am learning in school is useful for me to know. 我認為現時在課堂所學習的東西對我有用。	1	2	3	4	5
15. My study skills are excellent compared with others in this class. 與同班同學相比，我擁有良好的學習技巧。	1	2	3	4	5
16. I think that what we are learning in school is interesting.	1	2	3	4	5

我認為我們在學校所學的很有趣。					
17. I know that I will be able to learn the materials for the tests and exams. 我認為我將學會用於考試和測驗的課堂材料。	1	2	3	4	5
18. When I take a test I think about how poorly I am doing. 考試時，我會擔心做得有多差。	1	2	3	4	5
19. Understanding the subject is important to me. 明白此學科對我來說是重要的。	1	2	3	4	5
20. When I take tests, I think of the consequences of failing. 考試時，我會想到失敗的後果。	1	2	3	4	5
21. When I study for a test, I try to put together the information from class and from the textbook. 當我為考試測驗溫書時，我嘗試把課堂所學到的東西和課本結合起來。	1	2	3	4	5
22. When I do homework, I try to remember what the teacher said in class so I can answer the question correctly. 當我做功課時，我嘗試回憶老師教了什麼，以便我能正確回答問題。	1	2	3	4	5
23. I ask myself questions to make sure I know the material I have been studying. 我會自己提出問題，自問自答，以確保我能明白學會了什麼。	1	2	3	4	5
24. It is not difficult for me to decide what the main ideas are when I study. 確定主要學習內容對於我來說是不困難的。	1	2	3	4	5
25. Although work is hard, I neither give up nor study the easy part. 當我覺得功課很困難，我不會放棄，也不會只溫習容易的部分。	1	2	3	4	5

26. When I study I put important ideas into my own words. 我會把所學到的重要知識，用自己的方式說給自己聽。	1	2	3	4	5
27. I always try to understand what the teacher is saying even if it doesn't make sense. 我經常嘗試去理解老師所說的內容，即使老師所說的難以理解。	1	2	3	4	5
28. When I study for a test I try to remember as many facts as I can. 當我為考試測驗溫書時，我會盡自己所能記憶內容。	1	2	3	4	5
29. Even when study materials are dull and uninteresting, I keep working until I finish. 即使功課很沉悶和不有趣，我也會繼續工作直至完成。	1	2	3	4	5
30. When I study for a test I practice saying the important facts over and over to myself. 當我為考試測驗溫書時，我會一遍又一遍地默讀重要的內容。	1	2	3	4	5
31. Before I begin studying I think about the things I will need to do to learn. 在我開始學習之前，我會考慮我需要學習的內容。	1	2	3	4	5
32. I use what I have learned from old homework assignments and the textbook to do new assignments. 我會使用以前所完成的功課和課本，來幫助我完成新的功課。	1	2	3	4	5
33. The materials I use for studying are not difficult to understand for me. 我所使用的學習材料對於我來說是不難明白的。	1	2	3	4	5
34. When I am studying a topic, I try to make everything fit together. 我嘗試把跟這一個課程有關的內容，全部貫通起來。	1	2	3	4	5
35. When I am studying I stop once in a while and go over what I have read.	1	2	3	4	5

當我學習時，我會暫停下來，多讀幾次已學部分。					
36. When I read materials for my classes, I say the words over and over to myself to help me remember. 當我閱讀課堂材料時，我會重複默讀，來幫助記憶。	1	2	3	4	5
37. I outline the chapters in my book to help me study. 我會概述書本章節，來幫助學習。	1	2	3	4	5
38. I work hard to get a good grade even when I do not like a class. 即使我不喜歡某課堂，我也會努力以獲得好成績。	1	2	3	4	5
39. When I am studying I try to connect the things I am reading about with what I already know. 我嘗試把我已經知道，和現在所學的組合起來。	1	2	3	4	5
40. Getting a good grade in this class is the most satisfying thing for me right now. 現在在班上得到好成績對於我來說是最滿意的。	1	2	3	4	5
41. When I am reviewing the lessons, I often try to explain the material to a classmate or friend. 當我重溫課堂所學時，我經常嘗試將課堂資料向同學或朋友解釋。	1	2	3	4	5
42. The most important thing for me right now is improving my average score in exams, so my main concern in this class is getting a good grade. 我認為現在最重要的事情是提高我的考試平均分，因此我的主要關注點是在班上得到好成績。	1	2	3	4	5
43. I try to work with other students from this class to complete the assignments. 我嘗試與其他同班同學合作完成習作。	1	2	3	4	5

44. When I am reviewing the lessons, I often spare time to discuss with some classmates. 當我重溫課堂所學時，我常常抽時間和其他同學討論。	1	2	3	4	5
45. In classroom discussion, I cooperate with other students to complete the learning tasks. 在課堂討論時，我和其他同學一起討論和合作，以完成學習任務。	1	2	3	4	5
46. If I can, I want to get better grades in this class than most of the other students. 如果我努力的話，我認為我能夠得到比大部分同學更好的成績。	1	2	3	4	5
47. I consult other students when I have problems in review. 當我在溫習遇到問題時，我會請教其他同學。	1	2	3	4	5
48. I want to do well in this class because it is important to show my ability to my family, friends, or others. 我會想要表現得好一點，因為證明給家庭、朋友等其他人看我有這個能力是重要的。	1	2	3	4	5
49. I often work with other students to complete the tasks in project learning. 在專題研習中，我常常和其他同學一起完成學習任務。	1	2	3	4	5
50. I usually ask classmates for help when I meet difficulties in a quiz. 當我在小測遇到難題時，我經常向其他同學請教。	1	2	3	4	5

Qualtrics link: https://eduhk.au1.qualtrics.com/jfe/form/SV_4VoMBRBX2RHW6Im

Appendix 1b Items and Subscales of the Revised Chinese Version of Motivated Strategies for Learning Questionnaire (MSLQ-RCV). (Lee, Yin, & Zhang, 2010)

Self-efficacy (7 items)
2. Compared to other students in this class I expected to do well. 我期望能比同班同學做得更好。
6. I am certain that I can understand the ideas taught in my classes. 我確認我能懂得課堂所教的內容。
8. Compared with others in this class, I think I am a good student. 與同班同學相比，我覺得我是一名好學生。
10. I am sure I can do an excellent job on the class assignments and homework. 我確認我能在堂課和功課上表現出色。
12. I think I will receive good grades in my exams.我認為我在考試中可以得到優異成績。
15. My study skills are excellent compared with others in this class. 與同班同學相比，我擁有良好的學習技巧。
17. I know that I will be able to learn the materials for the tests and exams. 我認為我將學會用於考試和測驗的課堂材料。

Intrinsic Value (9 items)
1. I prefer class work that is challenging so I can learn new things. 我更喜歡具有挑戰性的課業，因此我能學會新知識。
4. It is important for me to learn what is being taught in school. 學習學校所教授的東西對我來說是重要的。
5. I like what I am learning in school. 我喜歡我在學校所學習的。

7. I think I will be able to use what I learn in one subject in another. 我覺得我將能利用在課堂所學的，到其他不同的學科中。
9. I often do more than is required of me for homework assignments. 我常常完成老師要求以外的功課。
13. Even when I do poorly on a test or exam I try to learn from my mistakes. 即使我在考試或測驗中做得不好，我嘗試從錯誤中學習。
14. I think that what I am learning in school is useful for me to know. 我認為現時在課堂所學習的東西對我有用。
16. I think that what we are learning in school is interesting. 我認為我們在學校所學的很有趣。
19. Understanding the subject is important to me. 明白此學科對我來說是重要的。

Extrinsic Value (4 items)
40. Getting a good grade in this class is the most satisfying thing for me right now. 現在在班上得到好成績對於我來說是最滿意的。
42. The most important thing for me right now is improving my average score in exams, so my main concern in this class is getting a good grade. 我認為現在最重要的事情是提高我的考試平均分，因此我的主要關注點是在班上得到好成績。
46. If I can, I want to get better grades in this class than most of the other students. 如果我努力的話，我認為我能夠得到比大部分同學更好的成績。
48. I want to do well in this class because it is important to show my ability to my family, friends, or others. 我會想要表現得好一點，因為證明給家庭、朋友等其他人看我有這個能力是重要的。

Test Anxiety (4 items)
3. I have an uneasy, upset feeling when I take a test or exam. 當我考試或測驗時，我感覺不安、煩惱。
11. I worry a great deal about tests and exams. 我非常擔心考試和測驗。
18. When I take a test I think about how poorly I am doing. 考試時，我會擔心做得有多差。
20. When I take tests, I think of the consequences of failing. 考試時，我會想到失敗的後果。

Strategy Use (19 items)
21. When I study for a test, I try to put together the information from class and from the textbook. 當我為考試測驗溫書時，我嘗試把課堂所學到的東西和課本結合起來。
22. When I do homework, I try to remember what the teacher said in class so I can answer the question correctly. 當我做功課時，我嘗試回憶老師教了什麼，以便我能正確回答問題。
23. I ask myself questions to make sure I know the material I have been studying. 我會自己提出問題，自問自答，以確保我能明白學會了什麼。
24. It is not difficult for me to decide what the main ideas are when I study. 確定主要學習內容對於我來說是不困難的。
25. Although work is hard, I neither give up nor study the easy part. 當我覺得功課很困難，我不會放棄，也不會只溫習容易的部分。
26. When I study I put important ideas into my own words. 我會把所學到的重要知識，用自己的方式說給自己聽。
27. I always try to understand what the teacher is saying even if it doesn't make sense. 我經常嘗試去理解老師所說的內容，即使老師所說的難以理解。
28. When I study for a test I try to remember as many facts as I can. 當我為考試測驗溫書時，我會盡自己所能記憶內容。

29. Even when study materials are dull and uninteresting, I keep working until I finish. 即使功課很沉悶和不有趣，我也會繼續工作直至完成。
30. When I study for a test I practice saying the important facts over and over to myself. 當我為考試測驗溫書時，我會一遍又一遍地默讀重要的內容。
31. Before I begin studying I think about the things I will need to do to learn. 在我開始學習之前，我會考慮我需要學習的內容。
32. I use what I have learned from old homework assignments and the textbook to do new assignments. 我會使用以前所完成的功課和課本，來幫助我完成新的功課。
33. The materials I use for studying are not difficult to understand for me. 我所使用的學習材料對於我來說是不難明白的。
34. When I am studying a topic, I try to make everything fit together. 我嘗試把跟這一個課程有關的內容，全部貫通起來。
35. When I am studying I stop once in a while and go over what I have read. 當我學習時，我會暫停下來，多讀幾次已學部分。
36. When I read materials for my classes, I say the words over and over to myself to help me remember. 當我閱讀課堂材料時，我會重複默讀，來幫助記憶。
37. I outline the chapters in my book to help me study. 我會概述書本章節，來幫助學習。
38. I work hard to get a good grade even when I do not like a class. 即使我不喜歡某課堂，我也會努力以獲得好成績。
39. When I am studying I try to connect the things I am reading about with what I already know. 我嘗試把我已經知道，和現在所學的組合起來。

Peer Learning (7 items)
41. When I am reviewing the lessons, I often try to explain the material to a classmate or friend. 當我重溫課堂所學時，我經常嘗試將課堂資料向同學或朋友解釋。 43. I try to work with other students from this class to complete the assignments. 我嘗試與其他同班同學合作完成習作。 44. When I am reviewing the lessons, I often spare time to discuss with some classmates. 當我重溫課堂所學時，我常常抽時間和其他同學討論。 45. In classroom discussion, I cooperate with other students to complete the learning tasks. 在課堂討論時，我和其他同學一起討論和合作，以完成學習任務。 47. I consult other students when I have problems in review. 當我在溫習遇到問題時，我會請教其他同學。 49. I often work with other students to complete the tasks in project learning. 在專題研習中，我常常和其他同學一起完成學習任務。 50. I usually ask classmates for help when I meet difficulties in a quiz. 當我在小測遇到難題時，我經常向其他同學請教。

Appendix 2: Pretest-posttest Computer Programming Performance Test (CPPT)

Q1. 以下算法的輸出是什麼？

What is the output of the following algorithm?

```
LENGTH   ← 6
HEIGHT   ← 5
AREA     ← LENGTH * HEIGHT
LENGTH   ← 4
HEIGHT   ← 3
輸出 AREA
```

A. 12

B. 20

C. 24

D. 30

Q2. 在下列算法中，輸入什麼 B 值會產生運行錯誤？

In the following algorithm, what input value of B will generate a run-time error?

```
輸入 B
A ← 2
C ← 2
D ← (B × B − 4 × A × C) 的平方根
輸出 D
```

```
input B
A ← 2
C ← 2
D ← square root of (B × B − 4 × A × C)
output D
```

A. – 4

B. 2

C. 4

D. 5

Q3. 測試下列算法段的邊際個案是什麼？

What are the test cases of the following algorithm?

```
輸入 A
如果 A > 5
   則     B ← 10
   否則   B ← 20
輸出 A, B
```

```
input A
if   A > 5
   then B ← 10
   else B ← 20
output A, B
```

A. 5, 6

B. 10, 20

C. 6, 10, 20

D. 5, 6, 10, 20

Q4. 下列算法的輸出是什麼？

What is the output of the following algorithm?

```
S ← 5
C ← 0
當 S ≤ 10
   C ← C + 1
   S ← S + C
輸出 C
```

```
S ← 5
C ← 0
While S ≤ 10
   C ← C + 1
   S ← S + C
Output C
```

A. 11

B. 5

C. 4

D. 3

Q5. Y 是一個陣列。下列算法的輸出是什麼？

Y is an array. What is the output of the following algorithm?

```
Y[1] ← 4
設 k 由 1 至 5 執行
        Y[k+1] ← Y[k] + k
輸出 Y[6]
```

```
Y[1] ← 4
Execute k from 1 to 5
    Y[k+1] ← Y[k] + k
Output Y[6]
```

A. 10

B. 14

C. 15

D. 19

Q6. 空運行下列包含陣列 AR 的算法，AR[5] 的值是什麼？

Dry run the following algorithm on the array AR. What is the value of AR[5]?

```
cnt ← 1
ind ← 1
當 cnt < 100
      cnt ← cnt + 2
      AR[ind] ← cnt
      ind ← ind + 1
```

```
cnt ← 1
ind ← 1
while cnt < 100
   cnt ← cnt + 2
   AR[ind] ← cnt
   ind ← ind + 1
```

A. 1

B. 7

C. 9

D. 11

Q7. 某陣列 DAT 儲存了英文名，如下圖所示.

An array DAT stores English names as shown below.

Amy	Bob	Carol	Dave
DAT[1]	DAT[2]	DAT[3]	DAT[4]

在執行以下算法後，在 DAT 中哪個元素儲存「Carol」？

After executing the following algorithm, which element in DAT stores ‘Carol’?

```
P ← 4
當 P > 2
   DAT[P] ← DAT[P-1]
   P ← P - 1
```

```
P ← 4
While P > 2
   DAT[P] ← DAT[P-1]
   P ← P - 1
```

A. DAT[1]

B. DAT[2]

C. DAT[3]

D. DAT[4]

Q8. 下列哪些偽代碼得出的結果是相同的？________

Which of the following pseudocodes produce the same result? _______

```
(1) 如果 P < 3 與 Q > 25 則
        R ← R + 1

(2) 如果 Q > 25 則
        如果 P < 3 則
            R ← R + 1

(3) 如果 P < 3 則
        如果 Q > 25 則
            R ← R + 1
```

```
(1) IF P < 3 AND Q > 25 THEN
        R ← R + 1

(2) IF Q > 25 THEN
        IF P < 3 THEN
            R ← R + 1

(3) IF P < 3 THEN
        IF Q > 25 THEN
            R ← R + 1
```

Q9. 下列算法是用作計算 $(1^2 + 2^2 + 3^2 + 4^2 + \ldots + N^2)$ 的值。方格內應是什麼？

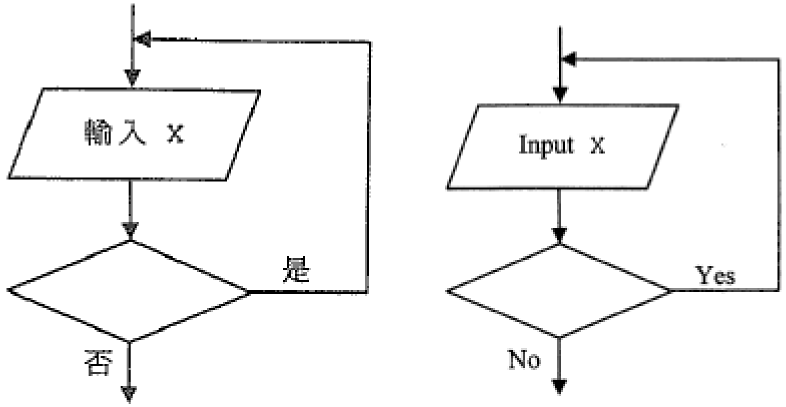
The following algorithm is used to find the value of $(1^2 + 2^2 + 3^2 + 4^2 + \ldots + N^2)$. What should be in the box?

```
輸入 N
S ← 0
當 [          ]
    S ← S + N × N
    N ← N - 1
輸出 S
```

```
INPUT N
S ← 0
WHILE [          ]
    S ← S + N × N
    N ← N - 1
OUTPUT S
```

Q10. 某流程圖的一部分如下展示。其算法要求用戶重複輸入一個數字，直至有正數輸入為止。判定框內應填上什麼？

Part of a flowchart is shown below. The algorithm requests the user to repeatedly enter a number until a positive number is entered. What should be filled in the decision box?



Appendix 3a: Semi-structured Interview Questions (for students received POI intervention)

Knowledge Recall 知識回顧

1. What have you learned in the programming courses? For example, which course is the most impressive to you? 請問你在編程課堂中學了什麼？對你來說，哪一節課的內容是最印象深刻的？請舉例說明。
2. Do you think you meet the learning objectives for understanding the programming concepts and algorithms design? Please explain with examples. 你認為你能夠達到明白編程概念和算法設計的學習目標嗎？請舉例說明。

Self-efficacy 自我效能感

3. Do you think you have improved your self-efficacy during the programming course? And why? (For example, you feel confident in your ability to do well in a tough programming challenge.) 在學習編程的過程中，你認為你提升了自我效能感嗎？(例如你解決編程難題時，對自己的能力更有信心。)

Intrinsic value 內在價值

4. Do you think you have improved your intrinsic value during the programming course? And why? 在學習編程的過程中，你認為你提升了內在價值嗎？為什麼？

Extrinsic value 外在價值

5. Do you think you have improved your extrinsic value during the programming course? And why? 在學習編程的過程中，你認為你提升了外在價值嗎？為什麼？

Test anxiety 考試焦慮

6. How do you feel about test anxiety during the programming course? And why? 在學習編程的過程中，你的考試焦慮感是如何的？為什麼？

Strategy use 學習策略使用

7. Do you think you have more learning strategies in the programming course than before? And why? 在學習編程的前後對比，你認為你學會了更多的學習技巧嗎？為什麼？

Peer learning 同儕學習

8. Have you learned with peers during the programming course? And why? 在學習編程的過程中，你是否與同伴一起學習？為什麼？

Appendix 3b: Semi-structured Interview Questions (for students NOT received POI intervention)

Knowledge Recall 知識回顧

1. What have you learned in the programming courses? For example, which course is the most impressive to you? 請問你在編程課堂中學了什麼？對你來說，哪一節課的內容是最印象深刻的？請舉例說明。
2. Do you think you meet the learning objectives for understanding the programming concepts and algorithms design? Please explain with examples. 你認為你能夠達到明白編程概念和算法設計的學習目標嗎？請舉例說明。

Self-efficacy 自我效能感

3. Do you think you have improved your self-efficacy during the programming course? And why? (For example, you feel confident in your ability to do well in a tough programming challenge.) 在學習編程的過程中，你認為你提升了自我效能感嗎？(例如你解決編程難題時，對自己的能力更有信心。)

Intrinsic value 內在價值

4. Do you think you have improved your intrinsic value during the programming course? And why? 在學習編程的過程中，你認為你提升了內在價值嗎？為什麼？

Extrinsic value 外在價值

5. Do you think you have improved your extrinsic value during the programming course? And why? 學習編程的過程中，你認為你提升了外在價值嗎？為什麼？

Test anxiety

6. How do you feel about test anxiety during the programming course? And why? 在學習編程的過程中，你的考試焦慮感是如何的？為什麼？

Strategy use

7. Do you think you have more learning strategies in the programming course than before? And why? 在學習編程的前後對比，你認為你學會了更多的學習技巧嗎？為什麼？

Peer learning

8. Have you learned with peers during the programming course? And why? 在學習編程的過程中，你是否與同伴一起學習？為什麼？

Appendix 3c Semi-structured Interview Questions (for class teachers)

Knowledge Recall 知識回顧

1. Do you think your students can meet the learning objectives for understanding the programming concepts and algorithms design? 您認為您的學生能夠達到明白編程概念和算法設計的學習目標嗎？

Self-efficacy 自我效能感

2. Do you think your students have improved their self-efficacy during the programming course? 在學習編程的過程中，您認為您的學生提升了自我效能感嗎？

Intrinsic value 內在價值

3. Do you think your students have improved their intrinsic value during the programming course? 在學習編程的過程中，您認為您的學生提升了內在價值嗎？

Extrinsic value 外在價值

4. Do you think your students have improved their extrinsic value during the programming course? 在學習編程的過程中，您認為您的學生提升了外在價值嗎？

Test anxiety 考試焦慮

5. Do you spot out your students' test anxiety during the programming course? 在學習編程的過程中，您是否發現了您的學生考試焦慮感？

Strategy use 學習策略使用

6. Do you think your students have more learning strategies in the programming course than before? 在學習編程的前後對比，您認為您的學生學會了更多的學習技巧嗎？

Peer learning 同儕學習

7. Do you spot out your students have learned with peers during the programming course? 在學習編程的過程中，您是否發現了您的學生與同伴們一起學習？

Appendix 4: Selected five patterns discussed in the POI Group

Pattern 1: Dose any item in the list satisfy a condition?

Pattern's name: *Dose any item in the list satisfy a condition?*

Initial state: a list of elements and a condition
Goal: return TRUE if an item was found, and FALSE otherwise
Algorithm:
initialize *Found* to FALSE
while (there are more items) AND (NOT *Found*) do
    assign the next element to *NextElement*
    if *NextElement* satisfies the condition, then
        assign TRUE to *Found*
return *Found*

Application: **Q1. Digits** Develop an algorithm that gets an input of a large integer number and checks and reports whether one of its digits equals 5. **Q2. Lottery** Develop an algorithm that generates 10 random numbers from 10 to 10,000 and checks whether any of the numbers has all identical digits.

Pattern 2: Do all items satisfy a condition?

Pattern's name: *Do all items satisfy a condition?*

Initial state: a list of elements and a condition
Goal: return FALSE if an item was found not satisfied, and TRUE otherwise
Algorithm:
initialize *AllSatisfy* to TRUE
while (there are more items) AND *AllSatisfy* do
    assign the next element to *NextElement*
    if *NextElement* NOT satisfies the condition then
        assign FALSE to *AllSatisfy*
return *AllSatisfy*

Application: **Q1. Gasoline prices** Develop an algorithm that gets as input the gasoline prices of the last seven years and checks whether the prices persistently went up during these years. **Q2. Signs** Develop an algorithm whose input is a sequence of t (plus) and 7 (minus) signs and returns the value 1 if all signs equal t or all equal 7 and returns 71 if the sequence consists of both signs.

Pattern 3: Maximum associated value

Pattern's name: *Maximum Value*

Initial state: collection of values
Goal: maximal value in the collection
Algorithm:
initialize *Max* to *FirstValue*
while there are more items do
    assign the next element to *NextElement*
    if *NextElement* > *Max*, then
        assign *NextElement* to *Max*
return *Max*

Application: **Q1. Election parties** In the elections to the students' union each candidate has an identifying code, which is a letter of the alphabet. Develop an algorithm that gets as its input the elections results, more specifically the identifying code and the number of votes for each candidate, and reports the code of the winning candidate. **Q2. Precipitation** The meteorological service collected data on the amount of precipitation (rain) measured in a town during each of 55 recent years. Develop an algorithm whose input is the amount of precipitation measured in those years and report the year with the highest amount of rain.

Pattern 4: Minimum associated value

Pattern's name: *Minimum Value*

Initial state: collection of values
Goal: minimal value in the collection
Algorithm:
initialize *Min* to *FirstValue*
while there are more items do
    assign the next element to *NextElement*
    if *NextElement* < *Min*, then
        assign *NextElement* to *Min*
return *Min*

Application: **Q1. Election parties** In the elections to the students' union each candidate has an identifying code, which is a letter of the alphabet. Develop an algorithm that gets as its input the elections results, more specifically the identifying code and the number of votes for each candidate, and reports the code of the winning candidate. **Q2. Precipitation** The meteorological service collected data on the amount of precipitation (rain) measured in a town during each of 55 recent years. Develop an algorithm whose input is the amount of precipitation measured in those years and report the year with the highest amount of rain.

Pattern 5: Conditional count

Pattern's name: *Conditional count*

Initial state: a list of elements and a condition
Goal: calculate *Count* if an item satisfies the condtion
Algorithm:
initialize *Count* to 0
while there are more items do
        assign the next element to *NextElement*
        if *NextElement* satisfies the condition, then
                assign *Count* to (*Count* + *NextElement*)
return *Count*

Application: **Q1. A school's outstanding achievement** A school in which most of (more than half) the students obtain math grades higher than the national average wins a prize from the Ministry of Education. Develop an algorithm whose input is the number of students in a certain school, a list of students' math grades and the national average grade, and check whether this school wins the outstanding achievements reward.

Appendix 5 Semi-structured Interview Transcript Analysis

	POI Group	Control Group	Class Teacher
Knowledge Recall	1. Most impressive content is the maximum and minimum value, because it will relate to our daily life such as online shopping in seeking best-buy. I think I have learnt more about the programming and found something useful in daily life. 2. Most impressive pattern is the maximum and minimum value because it is the easiest one and most useful one. I think I have the basic understanding on algorithms now. But I need to study harder. 3. I like the conditional count pattern because it is very useful when sorting games criteria. I think I know more about algorithms, maybe. 4. I like the maximum and minimum associated value part most. Because it is useful in school setting. I think I know more programming concepts like loops. 5. Most impressive course is the maximum and minimum value. Because I like the class activity. I think I understand more about algorithms design.	1. The most impressive content is the for-loop because I like calculating the Maths. There are too many programming concepts, but I think I understand more now. 2. Most impressive course is the Boolean because it is the easiest part. I think I understand more programming concepts such as input and output. 3. I like the for-loop most because it is very challenging. I think I can understand more control structures. Public exams will test on them. 4. I like flowchart most because it is easiest way to have input, process and output. I think I understand more algorithms design now. 5. I like Boolean most because the class activity is interesting. I think I understand more programming concepts which is on the syllabus.	Two groups of students can have very basic programming concepts and algorithms design so far. There are many life examples for them to comprehend. POI group is not focusing on the traditional programming concept's introduction. And together with the syntax introduction in text-based programming. They may feel confused later in the advanced programming. But so far, they can have basic idea on the algorithms design. More effort and input for them is needed to prepare for public exams.

Self-efficacy	1. Yes, I think I have improved my confidence and try to think about the patterns behind the problem. 2. The case studies were funny, but I am not sure whether I can do better in exams. 3. It was great I can understand the programming content! 4. I can finish the class activity quicker and I can follow your instruction. 5. These programming exercise seem different from the traditional one. I like this way so I believe I can do a better job in later coding class.	1. I can finish these tasks which my exams will test me. 2. These programming exercises are not too easy, but I overcome them now. 3. I believe I can do better in the later Java programming. 4. I am more confident to use these PowerPoint to review later for my quizzes and exams. 5. Programming is so hard but I learnt a little bit!	The performance of traditional group is similar to my pervious classes. They already tried their best to understand the difficult content. In the POI group, it is interesting to find out their learning motivation is increased than before. They are engaged in the daily examples and found out the algorithm patterns there.
Intrinsic value	1. I like the online shopping examples and the patterns, and it is very useful to relate to Maths class as well. 2. The examples are so related to me, and I think I will try to spot out the pattens in my video games. 3. If the quiz and exam was as funny as the patterns in the class, I think I would definitely love exams. 4. Programming is fun! 5. I think I am more in to computer course.	1. Although there are lots of challenging problems, sometimes I feel tired. 2. I know the ICT subject is important, because I have chosen it as my elective for public exam. 3. Not too much useful in what I learnt in the school. I won't use programming too often. 4. Please too much homework. I want more help in the class. 5. Maths class will share the similar	Students in two groups have tried their best, and it was their first or second time to use text-based programming. It was a good practice to let students to think about their daily life examples. It can motivate them and find something interesting to learn in the school. It seems POI group is much happier and more engaging.

		calculation, I think.	
Extrinsic value	1. Yes I think I want to do better in the class to show I am not lazy. 2. I want to improve my average score in final exam next two weeks, especially Maths and ICT. 3. There are lots of "straight-A students" in my class, but I think I have learnt more thinking ways to get good grade like them. 4. I hope I can receive good grade one day, and the pattens have given me some hope. 5. Although there is much peer pressure in my class, I think I have more knowledge than that "star students" now.	1. I think it was just fine, as everyone is trying to improve scores. 2. I hope I can study hard to get good grades in the exam later, but I am not sure. 3. Programming is difficult though, and "star students" always do better jobs than me. 4. I would like to study hard but "straight-A students" are too strong. 5. There are too many "good students" in my class, especially their programming codes have won prizes!	To be honest, the students selected into the experiments are not so "smart" as the "best students". But I can see their progress and willingness to be better in computer course. POI students seem to be braver than before in my classes.
Test anxiety	1. I wish I could have the pattens finding in the public exam! 2. I like the patterns and examples in class, but I know public exam would not test them. 3. I think I need more time to prepare the exam later, though I will try my best to think coding in patterns. 4. It is so sad why public exam doesn't test the patterns. Public exam is not funny. 5. I worry about my exam weeks later and I don't want to have a detention.	1. It was fine because that content will be tested next two weeks, right? 2. I worry about for-loop because I need to take more time to get things right in exam. 3. I hope there would be revision before the exams. 4. I don't like public exam, but we all need to go through it. Try hard. 5. The classes are useful to public exam.	Test anxiety is the most challenging element for them, no matter which group they are in. Patterns and examples are excellent, but public exams would not directly assess them in that way. They still need more time to comprehend. Maybe it would be better to let them think in pattern when they are in junior year not the

			senior year. It is truth that senior year students need to focus on the preparation of public exams.
Strategy use	1. I learnt the "self-talk" strategy and now I often use it. I will speak aloud to explain the pattern to myself. 2. I can learn from the previous patterns and use them to the new ones. 3. I have tried to link with the previous patterns and daily life examples to help me understand the new ones. 4. I like to create new goals and patterns and it is very funny! 5. I have tried to remember what you said in the class and to understand the new patterns as I can.	1. I have reviewed your lesson PowerPoint to do my exercises. 2. I will set up my goals in the programming. 3. What you said in classes is somehow difficult, but I often try to understand and ask you after the class. 4. For-loop is hard! I often "google" it to help me understand more. 5. Just try hard, not give up.	Programming exercise is flexible for students to apply learning strategies. They have many resources in websites, class materials and even human resource like you. They know how to seek help better. POI group is more "self-focus".
Peer learning	1. Previously I like to study the materials with my friends. But they need time to understand my new patterns. Sometimes they don't know what I mean. 2. I like to create new patterns with my friends. But sometimes they will judge me. 3. There are lots of funny discussion and creation of the patterns and examples. I like to work with friends.	1. I will discuss the exercises with my classmates. 2. I prefer to work with my friends to complete the tasks. 3. I know who the best to the homework in the class is, and I often seek help from him. 4. Before the quizzes and exams, I often review materials with my friends.	Peer discussion is good teaching strategy even in the programming learning, just like there is pair-programming time. Two class needs group discussion time.

	4. If there were group discussion in the ICT public exams, it would be great. 5. They will ask questions to me and discuss together.	5. I like the group discussion in the class, and it saved me.	

Appendix 6 Lesson Design in Two Groups and the Alignment with Learning Objectives from Curriculum Development Council

Lesson	POI Group	Control Group	CDC Learning objectives[1]
1	Pre-test (MSLQ-RCV, CPPT) Pattern 1: Dose any item in the list satisfies a condition?	Pre-test (MSLQ-RCV, CPPT) Introduction to algorithm design (flowchart and pseudocode) Introduction to variables and constants, simple data types (integer, real character and Boolean)	Students will learn about: ✓ the systematic approach to problem-solving; ✓ the application of concepts of systematic problem-solving to real-life problems; ✓ the use of pseudocode and/or a program flowchart to represent the algorithm; ✓ how to identify the objectives of an algorithm, trace the logical flow and examine values of variables during execution; and ✓ various ways of solving the same problem, and the differences between them.
2	Pattern 2: Do all items satisfy a condition?	Introduction to data structure (string and one-dimensional array) Introduction to Boolean logic (AND, OR, NOT)	
3	Pattern 3: Maximum associated value Pattern 4: Minimum associated value (Part 1)	Introduction to input, output and assignment statement Introduction to control structures (sequence, selection, iteration) (Part 1)	
4	Pattern 4: Minimum associated value (Part 2) Pattern 5: Conditional count (Part 1)	Introduction to control structures (sequence, selection, iteration) (Part 2)	
5	Pattern 5: Conditional count (Part 2) Post-test (MSLQ-RCV, CPPT) Treatment group interview	Introduction to control structures (sequence, selection, iteration) (Part 3) Post-test (MSLQ-RCV, CPPT) Control group interview	

[1] Curriculum Development Council, Hong Kong Examinations and Assessment Authority (2015). *Information and Communication Technology: Curriculum and assessment guide (Secondary 4-6)*. Retrieved December 23, 2021, from https://334.edb.hkedcity.net/doc/chi/curriculum2015/ICT_CAGuide_e_2015.pdf