A Framework to Develop the Tools and Methods for Supporting Self-Regulated Learning and Programming Strategies

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Abstract— **Programming has become one of the most in-demand professional skills of the 21st century. To study how learning programming occurs, most of studies have focused on the analysis of students' block-based coding behavior by analyzing the trace data captured in block-based programming environments. This research proposes the new methods based on the analysis of students' behavior to understand the relationship between their SRL and block-based programming strategies and automatically classify them into differentiated groups and supporting both students' and teachers in developing those SRL strategies that better relate with good performance in block-based programming.**

Keywords— technology enhanced learning, self-regulated learning, programming, design-based research, interactive learning design

I. INTRODUCTION

Conventional educational approaches cannot encounter the demands of 21st-century students. It is better to modify the principles of instructional design. However, these designs are an evolution of the existing instructional design models, consists of goal analyses, define learners, instructional strategy development, implementation, media selection, and student evaluation. A reasonable remark in responsive designing 21st-century learners requires to emphasis a learner-centered. The instructional design cooperates with both teacher and students in every step.

Programming has become a crucial professional skill of the 21st century. To face this need, several initiatives in both schools and universities have been proposed to integrate computer education in the main curriculum. However, these initiatives come hand in hand with several challenges that these institutions have to face. Not only practitioners lack of tools to support this type of learning, but also students lack of the self-regulatory learning (SRL) skills needed for facing block-based programming tasks; that is, they have difficulties on planning, setting goals, organizing and self-monitoring their learning to ensure they achieve their block-based programming tasks. To deal with these challenges there have been in the past years a growing interest in the technology-enhanced learning (TEL) research community to investigate how learning block-based programming occurs and how to support both, teachers and student of the industrial education field in developing the necessary self-regulated learning.

To study how learning programming occurs, most of studies have focused on the analysis of students' coding behavior by analyzing the trace data captured in programming environments [1]. Prior works on this line provide insights on the features and methods to detect behavioral patterns for classifying students in groups [2] [3] and students' behavioral-based models that correlate with students' performance [4]. These prior studies offer some insights on the most effective programming strategies, but they are limited for proposing systems to inform teachers' interventions in actual contexts because they are based on algorithms that require human interventions, hindering an automatic classification of students on real-time. Looking for more automatic processes is the way to go, and some researchers have started to investigate new methods to do so [5]. However, studies of this type are still scarce and need to be applied in other contexts to understand its applicability for informing teachers' interventions.

In addition to the study of programming behavior, some researchers have explored the relationship of students' self-regulated learning strategies and learning programming for improving students' performance in programming tasks. Self-regulated learning is defined as the ability to engage with cognitive, metacognitive, affective and motivational processes in order to achieve learning goals. Prior work provides empirical evidences on the relationship between students' self-regulatory skills and strategies and programming performance. Some researchers showed that students' self-regulation traits such as motivation and self-efficacy correlate positively with good performance in programming tasks [6]. Other researchers demonstrated that students who perform well in programming use more metacognitive and resource management strategies than lower performers [7], and that self-regulatory variables can be used to discriminate between high and low academic performers [8]. Based on these evidences, some researchers have developed e-learning tools that support computer science students in developing those SRL strategies to help them learn programming concepts and develop and debug programs. Most of existing approaches in this line are summarized in the systematic literature review by [9], which shows that strategies such a, monitoring, organization, goal setting, self-evaluation, and strategic planning are supported in some existing tools, showing good results

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on supporting students' in their programming tasks. However, these authors also highlight that aspects such as environmental structuring and seeking social assistance are not well covered in current literature, and that automated assessment for supporting students' metacognition and self-reflection should be further studied. In addition, they indicate that current research does not present students' growth in self-regulated skills, opening up an opportunity to propose new platforms for engaging students' in SRL strategies while block-based programming and studying what strategies lead to certain block-based programming behaviors for industrial education students.

Two main implications derive from this prior work that deserve further study and set the basis for this research. First, there is a need for new methods based on the analysis of students' behavior to understand the relationship between their SRL and block-based programming strategies for industrial education students and automatically classify them into differentiated groups. Second, there is a need for tools for supporting both students' and teachers in developing those SRL strategies that better relate with good performance and understanding in programming. These will address these two implications developing a technological tool for supporting SRL strategies that support the block-based programming learning.

II. Objectives

Previous work proposed Motion Graphic in concurrence with self-regulated learning [10] so that students can pursue through with a guided process. However, students cannot complete the issues after examining the details and choosing block-based programming. Accordingly, overall objective of this research is to design, implement and evaluate a technological solution for supporting students and teachers in the development of students' self-regulated learning skills that support block-based programming learning for industrial education students.

Objective 1: To study and adapt existing methods and instruments for detecting and analyzing the relationship between self-regulated and block-based programming strategies from students' trace data.

Objective 2: To propose models and methods to automatically classify student's into groups depending on their SRL and block-based programming strategies.

Objective 3: To design, implement and evaluate a tool for supporting both, teachers and students developing the SRL strategies that better related with good performance in block-based programming.

III. Methodology

This research will follow a Design Based Research (DBR) approach [13], a research approach whose interventions lie within a wide range of methodologies using mixed methods and blending educational research with theoretical background through experiments.

To resolve the issues mentioned above, we apply the DBR approach to follow the Interactive Learning Design (ILD) framework proposed by [1]. It organizes the research process into 4 phases:

(1) informed exploration phase, we found the limitations of students in constructing a technological tool for teaching and learning. Collecting data demonstrate the need for up-to-date technology to build the instrument. Therefore, block-based programming with Thunkable still was chosen to support their building. Thunkable empowers our student to build an application without having a coding background, and the creative freedom on here is unmatched with any other no-code platform. The ease of use, live testing, and support to see the changes instantly made application development possible for student's application." Ultimately, they will be able to develop applications on their own through a process of learning and self-regulated learning to obtain the complete instrument. The researcher proposed Thunkable as a tool to collect trace data and force our students. Moreover, the current version of Thunkable has supported completing more convenient applications with the Drag and Drop builder, shown in Fig 1.

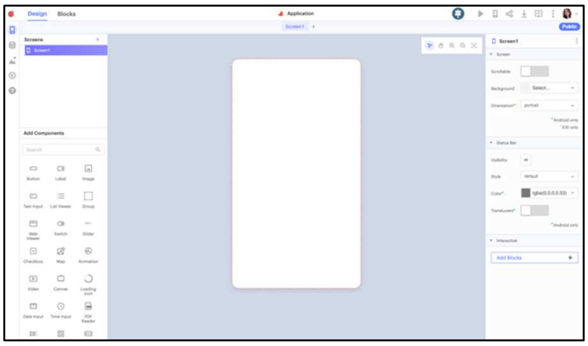

Fig. 1. Thunkable drag and drop screen builder

(2) enactment or implementation phase, we design educational management for students to understand programming. Educational design is a systematic process involving needs analysis and the development of systems to meet student needs and keep the learning process active and constructive. The educator designs an example content and prepares to create a Motion Graphic. By the way, the content is from Thunkable applications aimed at industrial education student. In particular, the educators used it as a new media. From the results of problem interest in this step and collecting summary data at the analysis phase, then bring it to make a design brief to create a storyboard for Motion Graphics. Different from earlier is collecting from placing blocks to match exactly where the students are using the blocks in Thunkable, shown in Fig 2 and Fig 3. Then improving and developing new motion graphics and tools to encourage self-regulated learning for students to build an application by themselves.

We suggested allowing students to customize content for the future. They must have a basic knowledge of designing an educational system and can be trained in pre-tests, lessons, exercises/workshops and it should be configured with post-tests.

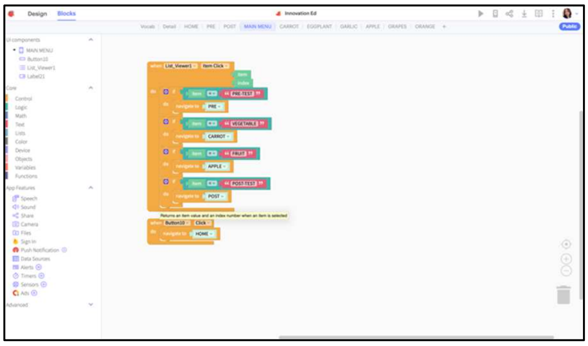

Fig. 2. Thunkable block-based programming

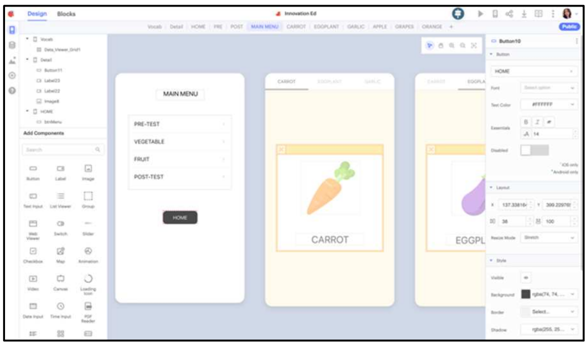

Fig. 3. Thunkable layout design

Educators suggest students follow the designed material like the materials used to create the application. It is part of the implementation tested by teachers' experiments throughout the course, which the students can access it anytime, anywhere. Approaches to creating innovative educational information technologies for industrial education students to promote higher learning outcomes and competencies were facilitated. In addition, the emphasis is on students applying their knowledge in practice. Next, we design guidelines for creating innovation for industrial education students, following the learning management process for proficiency in the SLR. The way learning activities are taught can improve learners' skills with the study concepts of the instructional design to develop educational innovation and information technology for industrial education.

(3) evaluation of local impact, firstly, is to start by creating the Motivation (M) for students. The teacher explained the course outline in the initial class to stimulate the learner's interest. The second is to provide the Information (I) as a Motion Graphics lesson to the learner through an online tool. Next is the Application (A) to practice including, the experiment. Finally, the teachers took action to measure the Progress (P) as the practice assessment results according to what they assign. The process is followed up periodically to ensure that the lessons can motivate the students to learn by self-regulation. It also indicates that the students can meet the requirements of the assignment or not. If there are constraints or additional suggestions from the students, the teacher will apply them to improve.

(4) evaluation of broader impact. The experiments will be carried out at the Rajamangala University of technology Srivijaya in Thunkable Blocks. We therefore focus and encourage students to study in accordance with the Self-Regulated Learning Framework, shown in Fig 4.

To address Obj 1, we will conduct a systematic literature review on the instruments and methods used for measuring SRL and programming strategies in computer-based systems. Prior work on learning aanalytics studying SRL and programming strategies from trace data will be taken as a reference [11][12][14].

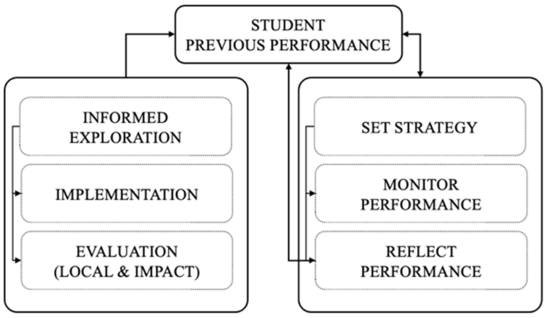

Fig. 4. Self-Regulated Learning Framework

This instruments and methods will be applied in the data collected in Educational Innovation and Information Technology courses of the Rajamangala University of technology Srivijaya. This course focuses on how the student use technology to build the instrument used in their pedagogy.

The results of these two tasks will be a set of instruments and methods for understanding the relationship between SRL and block-based programming strategies, as well as the SRL traits and strategies that better correlate with students' performance.

These tasks will be part of the Informed Exploration phase of the ILD methodological framework. To address Obj 2, we will take as a reference the results from Obj. 2 and experiment with different computational classification models for automatically classify students according to their SRL and programming strategies based on prior work [15][5]. This method will be tested in an actual programming course so as to validate and improve them. The expected results are a set of computational classification methods and models to automatically classify students in groups. All of tasks will be part of the Informed Exploration phase and Implementations and Enactment phase.

Finally, and with the results of Obj 1 and 2, to address Obj 3, we will design and implement a tool for supporting both students' and teachers in the development of SRL strategies that better relate with good programming practices. This tool will be evaluated in an actual experimental setting to analyze its impact on students' performance. The results of these tasks will be the tool and a case study analyzing its impact. These tasks correspond to the Local and

Broader evaluation phases of the methodological framework. The efficiency of using the principle of the Design-Based Research (DBR) approach and Self-regulated learning is a process in which students plan tasks, monitor performance, and reflect on consequences. This process repeats as students use reflection to adjust and prepare for their next task. The process is not unique. It is able to tailor to the individual student and specific learning task. Although, the major steps are performed by the student, the instructor plays vital role in coaching the student. The collaboration within this research, applying DBR with SRL, focuses on developing a design for the students to involve self-regulated learning skills in programming subjects. Initial with designing students' behaviors about their interest in programming courses and experiment with how students can code as well as obtain program results.

To assess all of the processes in teaching and learning, such as pre-lecture preparation, being active during lectures, then post-lecture review to lead to the analysis of students' abilities. The researcher expects how much student knowledge, change, and effective learning outcomes. To analyze and design learning management that encourages students to learn by themselves and to be able to regulate themselves during the course until success. During the teaching and learning process, the focus is on the students to set their own goals and learning objectives. The instructor will monitor the students as they reflect on their mistakes.

Programming in the students who do not have the skills, there may be mistakes in the same place. Therefore, this action focuses on taking the wrong data or collecting it as trace data from the students to develop an instrument that can introduce the correct programming during the student's learning process. If students make mistakes in programming, generated tools will suggest the proper syntax to get programming correctly. Obtained feedback during programming courses, but the information was limited. The problems and recommendations need to create tools to support self-regulated learning in the teaching and learning management of students.

IV. Discussions and Conclusion

The obtained results from Educational Innovation and Information Technology courses that record all constraints faced. Respondents are academic students and lecturers. The constraints faced by respondents also provide input components that are expected to support and design the tool, shown in Table I.

In short, the need to design the tool is indispensable to face any changes, Proposed changes, and design models required for the course requirement. This research will contribute with novel ways to address the study the relationship between SRL and programming strategies as well as with tools to support them. The expected outcomes will impact both the Learning Analytics and Learning sciences communities.

TABLE I. SELF SELF-REGULATED COMPONENT

Self-Regulated Component	Self-Regulated Goal	Student's Ability
Planning	Self-regulated students take time to plan. They consider whether the goals are relevant, valuable, attractive, and achievable. They are motivated to achieve the goal and act autonomously to programming.	✓
Problem-Solving	They choose strategies to accomplish their goals and monitor the extent to which their actions solve the program.	✓
Self-Evaluation	The academically self-regulated student performs self-evaluation. They assess whether they have performed following their goal by contrasting the outcomes of their efforts to program, giving meaning to the suitable output.	✓

The researchers can summarize the operating results according to the objectives as follows:

Objective 1: To study and adapt existing methods and instruments for detecting and analyzing the relationship between self-regulated and block-based programming strategies from students' trace data. The result shows that self-regulated students take time to plan. They consider whether the goals are relevant, valuable, attractive, and achievable. They are motivated to achieve the goal and act autonomously to programming.

Objective 2: To propose models and methods to automatically classify student's into groups depending on their SRL and block-based programming strategies. The result shows that the student chose strategies to accomplish their goals and monitor the extent to which their actions solve the program according to the updated model and tools.

Objective 3: To design, implement and evaluate a tool for supporting both, teachers and students developing the SRL strategies that better related with good performance in block-based programming. The result shows that academically self-regulated student performs self-evaluation. They assess whether they have performed following their goal by contrasting the outcomes of their efforts to program, giving meaning to the suitable output.

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