Examining the role of STEM in Twelfth-grade Robot Subject Instruction using the UTAUT model

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Abstract. Since the rise of the waves toward artificial intelligence, more and more countries robot education has changed from Robot-Assisted Instruction (RAI) to Robot-Subject Instruction (RSI). This study mainly compares the differences between the two teaching methods of RSI using traditional single subject teaching and STEM cross-disciplinary teaching. Through the data of Unified Theory of Acceptance and Use of Technology (UTAUT) and Course Satisfaction, this study finds out the advantages and disadvantages of STEM integration into RSI. Therefore, schools that are ready to promote RSI in the future can consider whether to use STEM-based RSI based on the analysis of this study.

Keywords: Robot Subject Instruction, STEM education, Unified Theory of Acceptance and Use of Technology

1 Introduction

In the new 12-years basic education curricula in Taiwan, a new field of technology has been added, and a course called "Robotics Project" has been developed in this field. It means that Taiwan's robot education has changed from Robot-Assisted Instruction (RAI) to Robot-Subject Instruction (RSI). The course focuses on developing student competencies including programming, data access and computing, electromechanical integration, computational thinking and design thinking. This study conducted a two-year lead study before the start of the new RSI. The first year of RSI used traditional teaching, meaning that the course taught only the hardware and software operations of the robot, and then began using the STEM-based RSI in the second year. The research tools section of this study used a unified theory of acceptance and use of technology (UTAUT) and course satisfaction to compare the differences between the two teaching methods. Schools. The results of the study can be used as a reference for future RSI schools. The overarching research question for this study is “To find out the advantages and disadvantages of STEM integration into

RSI”. To focus the study, this overarching question is divided into the following three sub-questions:

RQ1. What is the difference in UTAUT Questionnaires between traditional RSI and STEM-based RSI?
RQ2. What is the difference between the pre-test and post-test of the UTAUT questionnaire for implementing STEM-based RSI?
RQ3. What is the difference in Course Satisfaction between traditional RSI and STEM-based RSI?

2 Literature Review

2.1 Robot Subject Instruction, RSI

With the advent of artificial intelligence, the application of robots in education has become more diverse. Qi, Dong, Chen, Qi, & Okawa proposed such as "Robot Subject Instruction (RSI)", "Robot-Assisted Instruction (RAI)” and “Robot-Managed Instruction (RMI)” [1]. Fridin suggests that robots are developmental and potential educational tools with broad appeal and learning relevance [2]. Chalmers proposed that the educational robot interface design has an intuitive visual effect, which helps students to learn programming at the teaching site [3], but the biggest bottleneck of the existing curriculum is the lack of specific teacher training [4]. The use of educational robots in both formal and informal learning can effectively build students' critical thinking and problem-solving skills and improve the study of mathematics and science. [5] [6] [7], Nag, Katz, & Saenz-Otero mentioned that robotics courses combined with competitions even helped students to cross-domain learning in STEM (science, technology, engineering, mathematics) [8].

2.2 Unified Theory of Acceptance and Use of Technology, UTAUT

The UTAUT model comes from the Technology Acceptance Model (TAM) proposed by Davis [9]. The TAM has two major determinants are "Perceived Usefulness" and "Perceived Ease of Use". Perceived Usefulness means that the user's operation of a specific application or system will improve the performance or learning of the individual, while another Perceived Ease of Use refers to the user's learning to use the operating application or the ease of the system. The UTAUT model through the past research on “users accepting behaviors in technology”, and this model found that predicting and interpreting users' access to information technology has more than 70% explanatory power [10]. Therefore, most of the follow-up studies will omit attitudes. The facets and Moderators of UTAUT as follows:

Performance Expectancy (PE), PE as the extent to which users believe that using the system will help improve or improve job performance. PE is affected by three moderators such as Gender, Age, and Experience, which affects male more obvious.

Effort Expectancy (EE), EE as the extent to which users can easily manipulate new technologies, systems, and applications. For example, the user interface of the IT device and the design of the operating system will affect the user's information technology acceptance. EE is affected by three moderators such as Gender, Age and Experience, which affects female more obvious, but EE will decrease with the growth of experience.

Social Influence (SI), SI as the extent to which the user feels that the existing organization believes that the user should use this new technology and system to what extent. SI is affected by four moderators such as Gender, Age, Experience and Voluntariness of Use, which affects female more obvious, but SI will decrease with the growth of experience. SI will directly affect the intent of the user to use the new technology, coupled with Ahmad & Love research indicates that lecture incentives can help them adapt to the new technology to learn [11]. So this study, SI was defined as the use of robots for students to be recommended by teachers. Students also believe that it is feasible to use robots to learn.

Facilitating Conditions (FC), FC as the extent to which users believe that existing organizations support users in using new technologies and systems. FC is affected by two moderators such as Age and Experience, which affects older workers more obvious and increasing as experience increases. Since the quality of RSI equipment provided by the school will affect the students' learning behavior and willingness, FC is defined in this study as the degree to which students assessed the school's support for the RSI by equipment quality.

Behavioral Intention (BI) was originally proposed by Fishbein and Ajen [12] and is defined as the degree of personal willingness of users to participate in certain behaviors. However, in this study, behavioral intentions were defined as students' willingness to continue to support RSI in the future or would like to further recommend RSI to others.

Since RSI is an open innovation course, users with a high degree of Personal Innovation are more likely to develop new technologies [11], and personal innovations in new information technologies will positively influence the adoption behavior [13] , so this study adds the “Personal Innovation” proposed by Agarwal & Prasad to investigate the willingness of users to accept and use new technologies [14].

Based on the above, this UTAUT model will explore the changes of the six items including Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Behavioral Intention, and Personal Innovation.

3 Methodology

In the first year of the study, RSI carried out traditional teaching (only teaching software and hardware operations). In the second year, STEM was integrated into RSI. After completing the six-unit course, Course Satisfaction and Traditional UTAUT questionnaire were performed, only in the second. The experiment of the year was added to the "UTAUT-based Expectation situation questionnaire" for pre- and post-test analysis (Fig. 1).

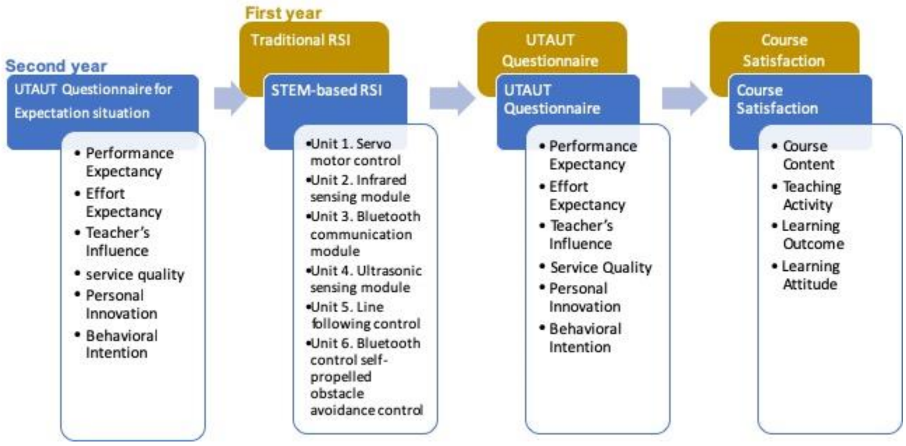

Fig. 1 Research architecture diagram

As shown in Fig. 1, the RSI course has six units including Servo motor control, Infrared sensing module, Bluetooth communication module, Ultrasonic sensing module, Line following control, and Bluetooth control self-propelled obstacle avoidance control. The Course Satisfaction has four dimensions including Course Content, Teaching Activity, Learning Outcome, and Learning Attitude. The UTAUT questionnaire and the UTAUT-based Expectation situation questionnaire have six items including Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Behavioral Intention, and Personal Innovation.

3.1 Participants

In this study, two consecutives 12th grade students in a high school in northern Taiwan were Participants. The experiment lasted for two years. In the first year, 41 students participated in the study and 49 students participated in the second year. The two-year class hours (three hours a week for a total of 18 weeks) and the instructors are the same, the difference is that the second year of the course has introduced STEM cross-disciplinary teaching.

3.2 Research Tools

In this study, the robot uses Explore Board as the main controller, control software for the InnoBASIC ™ Workshop (Fig. 2), this software platform provides students to write programs, functional testing, to download code to the robot.

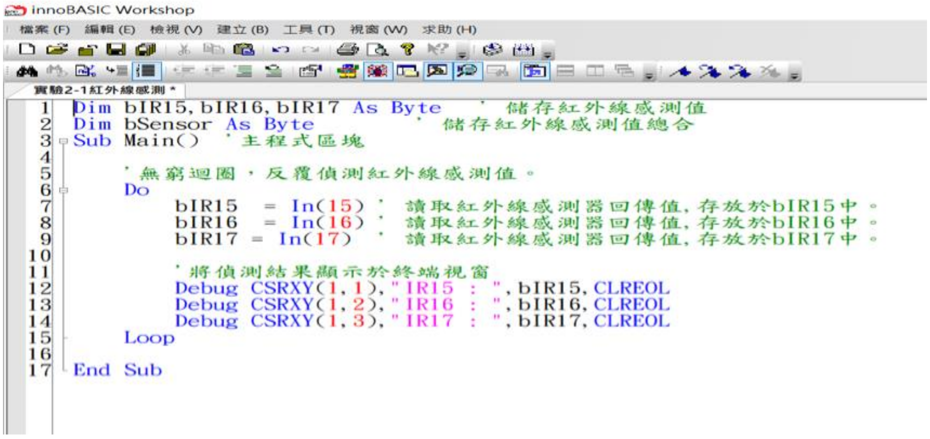

Fig. 2 The interface of InnoBASIC™ Workshop

3.3 Research framework

The RSI contains the following six units, as explained below:

Unit 1. Servo motor control: After explaining through the teacher's instructions, the student programmatically controls the robot to move forward, backward, turn left, and turn right.

Unit 2. Infrared sensing module: After the teacher explained the working principle of the infrared sensor, the student programmed to control the robot to walk along the black line.

Unit 3. Bluetooth communication module: After the teacher explained the working principle of the Bluetooth communication module, the student programmed to control the robot by the mobile APP.

Unit 4. Ultrasonic sensing module: After the teacher explained the working principle of the ultrasonic sensor, the student programmed to control the robot to detect the distance of the obstacle and return the data to the computer.

Unit 5. Line following control (Competition activities I): In this unit, students must use the Bluetooth device of the mobile phone to control the robot to follow the line from the starting point to the end point.

Unit 6. Bluetooth control self-propelled obstacle avoidance control (Competition activities II): In this unit, students must use the Bluetooth device of the mobile phone to control the robot to automatically avoid obstacles and get out of the maze with the ultrasonic sensor.

3.4 UTAUT Questionnaire

The questionnaire was revised to the original UTAUT and adopted a five-point Likert scale according to 5,4,3,2,1 score. The content of the questionnaire is divided into two parts. The first part is translated and modified [15] There are 4 questions for students to assess their current status, and The second part is a study modified from Milošević, Živković, Manasijević and Nikolić [16], including six facets, a total of 19 questions, including "Performance Expectancy" 4 questions, "Effort Expectancy" 3 questions, "Social Influence" 2 questions, "Facilitating Conditions 4 questions, "Behavioral Intention" 4 questions and "Personal Innovation" 2 questions, 19 high school students who did not participate in the experiment conducted a reliability test to obtain a high reliability of Cronbach's α value of .980, which proves the feasibility of the questionnaire.

3.5 UTAUT Questionnaire for Expectation situation

The main purpose of this questionnaire is to establish a pre-test of UTAUT Questionnaire, so change the beginning of all topics to "I expect" so that it can be tested before class.

3.6 Course Satisfaction

This questionnaire is mainly to explore the satisfaction of students after each PSI unit and adopted a five-point Likert scale according to 5, 4, 3, 2, and 1 score. The Course Satisfaction has four dimensions including Course Content, Teaching Activity, Learning Outcome, and Learning Attitude. The questionnaire was tested by the 19 high school students who did not participate in the experiment. The reliability test showed that Cronbach's α value was .979, which proved the feasibility of the questionnaire.

4 Experiment Results

4.1 UTAUT Questionnaire Results

As shown in Fig. 3 that the average curves of the UTAUT experiment results of Traditional RSI and STEM-based RSI are very similar. The similarities are that both scored low on both Effort Expectancy and Behavioral Intention, indicating that some students feel that RSI still has some difficulty and does not want to recommend it to others.

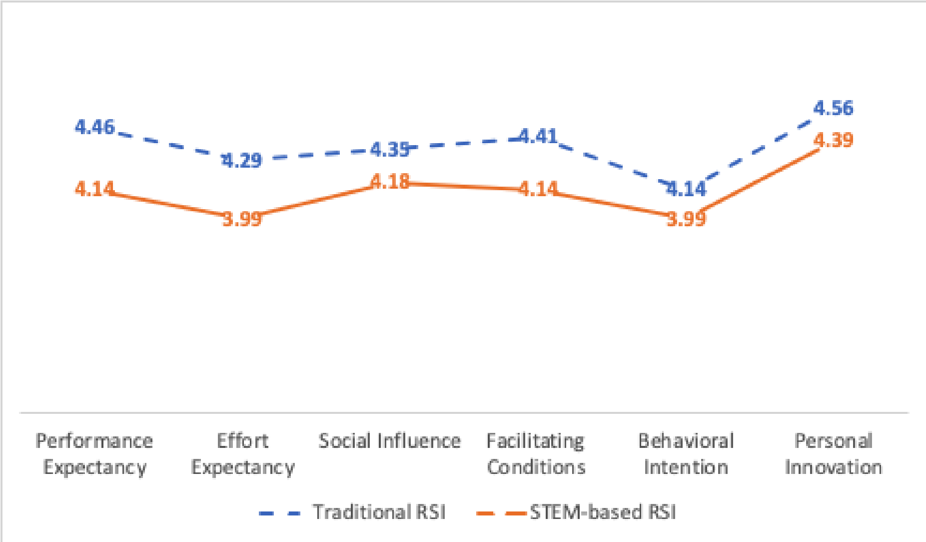

Fig. 3 The UTAUT experiment results of Traditional RSI and STEM-based RSI

4.2 The UTAUT pre-test and post-test of the STEM-based RSI

From Table 1, it can be found that the students have significant differences in the Performance Expectancy and Behavioral Intention (**p* <.05) through the paired samples *t*-test. However, the three sub-items Effort Expectancy, Social Influence, and Facilitating Conditions More significant difference (***p* <.01). This means that students feel better than expected for the "STEM-based RSI" arrangement, and there is no significant difference in their own "Personal Innovation" because it is always high.

Table 1. The paired samples t-test of STEM-based RSI

Item	pre-test		post-test		*t*
	M	SD	M	SD	
Performance Expectancy	3.81	0.769	4.14	0.584	2.691*
Effort Expectancy	3.61	0.716	3.99	0.567	3.481**

Social Influence	3.85	0.751	4.18	0.61	2.714**
Facilitating Conditions	3.85	0.694	4.14	0.508	2.783**
Behavioral Intention	3.76	0.735	3.99	0.555	2.200*
Personal Innovation	4.19	0.749	4.39	0.637	1.839

$^{*}p < .05$ $^{**}p < .01$

4.3 Course Satisfaction Results

It can be seen from the average curve of Figures 4 and 5 that although the first three units Course Satisfaction results of STEM-based RSI are not as high as that of the Traditional RSI, the satisfaction of the last two competition activities units has steadily increased, but the Traditional RSI has declined. This result shows that the students of Traditional RSI have high satisfaction in each of the above four units because they only need to complete the learning of software and hardware. However, when the last two units need to use cross-domain knowledge to solve problems, they have learning difficulties. In contrast, STEM-based RSI is students feel very burdensome because each unit is integrated into science, technology, engineering, and mathematics, but in the last two competition activities units, they can use what they have learned to achieve satisfactory results.

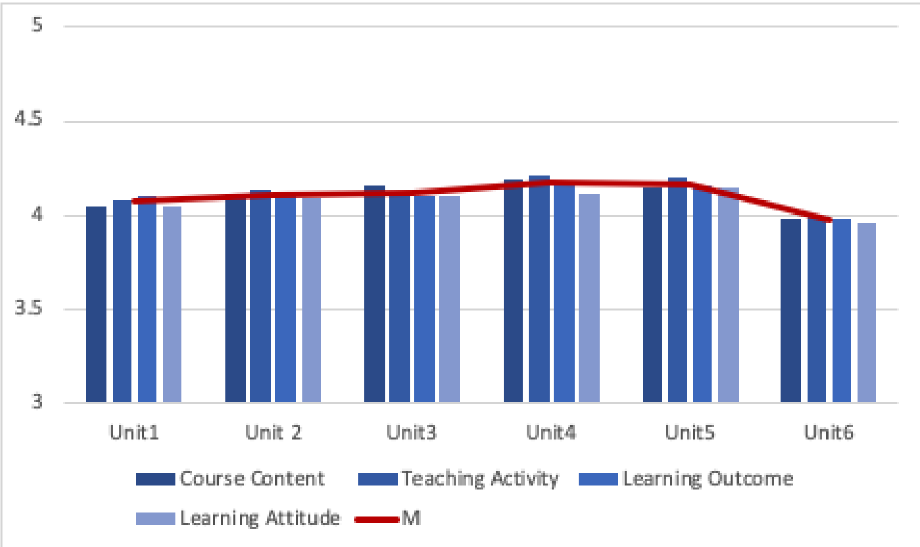

Figure 4. The Course Satisfaction results of Traditional RSI

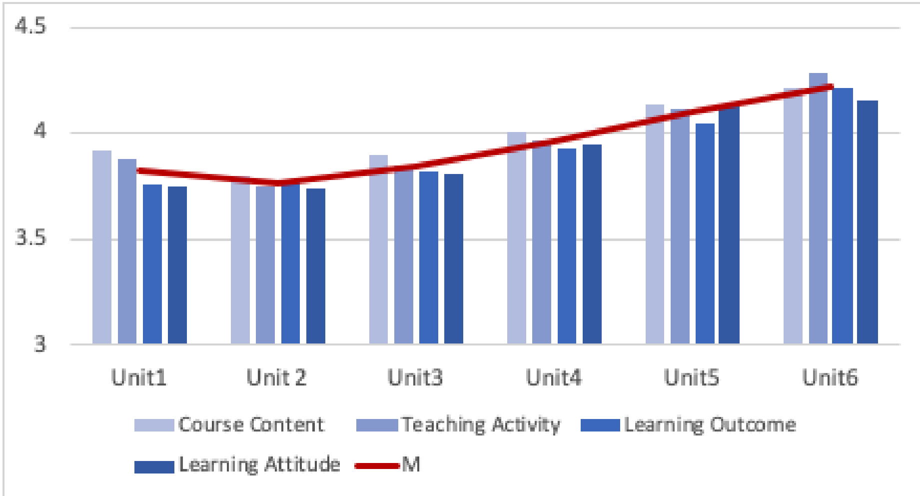

Figure 5. The Course Satisfaction results of STEM-based RSI

5 Discussion and Conclusions

This study mainly compares the differences between the two methods of Robot-Subject Instruction (RSI) using traditional single subject teaching and STEM cross-disciplinary teaching. Through the UTAUT Questionnaire data, the study found that the six sub-item curves of the Traditional RSI and STEM-based RSI UTAUT are close, indicating that students have similar views on the acceptance of the two RSIs. The students' scores of the five sub-items (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Behavioral Intention, Personal Innovation) of the STEM-based RSI UTAUT are significantly higher than the pre-tests, which means that the students' acceptance after class is significantly higher than the previous expectations of the course. Finally, in the Course Satisfaction questionnaire data after six units, we can find that the satisfaction of STEM-based RSI is low first and then high, and the traditional RSI is high first and then low. The key factor is that the Traditional RSI has a lower learning burden in the first four units, so the satisfaction is higher, but the Competition activities unit at the end of the period is prone to problems, causing a decline in satisfaction, while the STEM-based RSI students are the opposite. Therefore, schools that are ready to promote RSI in the future can consider whether to use STEM-based RSI based on the analysis of this study.

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