The Development of Practical Skills through Robot Experiment Training Activity for Undergraduate Students

Zhou Jiale[1*], Dr.Phenporn Thongkamsuk[2], and Prof. Dr. Supaporn Srihamee[3]

[1] Graduate student, Master of Education in Curriculum and Instruction, Bansomdejchaopraya Rajabhat University.

[2] Academic, Department of Education in Curriculum and Instruction, Faculty of Education, Bansomdejchaopraya Rajabhat University.

[3] Academic, Department of Education in Curriculum and Instruction, Faculty of Education, Bansomdejchaopraya Rajabhat University.

[*]**Corresponding author, E-mail:** 287656431@qq.com

Abstract

The objectives of this research were 1) to develop of robot experiment training activity to improve the practical skills of undergraduate students and 2) compare students' practical skills before and after the implementation of robot experiment training activity. The sample group includes 50 second-year students majoring in computer application technology who were selected as the sample group. The research instruments included 1) lesson plans robot experiment training activity, and 2) evaluation criteria for robot practical skills. Data was statistically analyzed by mean, standard deviation, and t-test for dependent samples. The results were found that 1) developing robot experiment training activity for undergraduate students, the course includes module1 problem-solving process using Triz theory, module 2 MSP430 microcontroller hardware basics, module 3 MSP430 microcontroller control software writing fundamentals, and module 4 adjusts MSP430 microcontroller control program parameters according to the actual scenario, 13 hours in total. And measure students' practical skills before and after the course, it was found that students' practical skills have been improved; 2) using the robot experiment training activity, the practical skills of the second-year students majoring in computer application technology of the Information Technology Branch of Zhejiang Yuying Vocational and Technical College were higher after class than before class, with a significance level of .01.

Keywords: Robot Experiment Training Activity, Practical Skills, Undergraduate Student Students

Introduction

Since the 21st century, the competition among countries is mainly the competition of science and technology, and the competition of science and technology is essentially the competition of innovation. As the new industrial and technological revolution continues to evolve, the spillover effect of innovation is gradually emerging, becoming an important engine for economic and social development and a strong weapon for national security (State Council 2017). In the report of the 20th National Congress of the Communist Party of China, President Xi Jinping stressed that "we must insist that science and technology is the first productive force, talent is the first resource and innovation is the first driving force, implement the strategy of developing the country through science and education, the strategy of strengthening the country through talent and the strategy of innovation-driven development, open up new fields and tracks for development, and constantly shape new momentum and advantages for development" (State Council 2022).

Therefore, promoting the deep integration of innovation and entrepreneurship education with professional education, infiltrating innovative and entrepreneurial ideas, 2 cultivating students' creative thinking, and inspiring innovation and entrepreneurship have gradually become the new trend of professional curriculum education in major universities. In order to further guide the students of colleges and universities to actively participate in the trend of "mass entrepreneurship and innovation", combined with the national development strategy and economic and social demand for talent training, to enhance the innovation and practical ability of college students as the core, to improve the quality of college training as the goal. Adhering to the operation mode of "taking students as the main body, oriented by national strategic needs, and supported by the participation of industry enterprises", the Department of Education has created a number of competition platforms with college students' robotics practice as the carrier. The participating schools support the use of competition to promote education and integrate the content of the competition into the curriculum to better improve the innovation and practice of students. The robotics experimental course is a practical course that goes along with the basic course "Microcontroller Principles and Applications" of the College's electronic information engineering major. The microcontroller is equivalent to the brain of an intelligent robot.

The problem of learning and application is that students find it difficult to find innovative ideas and methods for solving problems in robotics experiments, and group 3 experiments are mostly simple repetitions of previous cases, lacking the application of innovative thinking. In general, the original robotics laboratory course does not integrate teaching, learning, and application, and is not very effective in improving students' innovation and practical skills. Since its inception in 1946, TRIZ theory has gone through different stages of development. It has gradually evolved from classical TRIZ theory to modern TRIZ theory, and has developed many powerful tools for problem analysis, such as functional analysis, causal analysis, and tailoring, which have basically overcome the shortcomings of classical TRIZ theory (Altshuller 1999). The typical process of solving practical problems in modern TRIZ theory is "problem identification", "problem-solving" and "concept verification". In the "Problem Identification" stage, the focus is on a comprehensive analysis of the problem; in the "Problem-Solving" stage, the key problems analyzed in the previous stage are first transformed into problem models in TRIZ theory, then TRIZ tools are used to find strategies and models for solving the problem, and finally into concrete solutions. In the "proof of concept" phase, the main objective is to evaluate the feasibility of the specific solutions obtained in the previous phase (Livotov, 2008). The integration of TRIZ theory into the implementation of robotics experimental courses helps students to improve their sense of independent innovation, find problems and seek solutions on their own initiative, and gain a better and deeper understanding of what they have learned in the classroom, which can only be applied if they master the knowledge themselves.

Compared with other innovation methods, TRIZ theory has a well-developed theoretical system and problem-solving process, which is an efficient problem-solving methodology with strong regularity and easy to promote. The students will learn TRIZ theory systematically and applying it to robotics experimental courses will help them improve their practical skills, realize the transformation from "being able to manipulate like this" to "willing to manipulate like this", and grow into excellent talents with the ability to improvise. Kyle Wagner believes that practical skills are the ability to solve practical problems, and the definition of practical skills is not the same in different fields (Kyle Wagner 2018). Schachterle in the field of engineering, engineering practice ability is considered to be the comprehensive ability to solve practical engineering problems. Based on the understanding of the engineering practice process, engineering design ability, and engineering operation ability are generally regarded as important aspects of engineering practical skills, and other more frequently mentioned abilities include communication ability, teamwork ability, organization and management ability, etc., and a few scholars have included systematic thinking ability in the scope of engineering practical skills (Schachterle 1996). Kolmos Engineering’s practical skills are the ability to consider all aspects of the social factors to design according to the needs of the client (Kolmos 2018).

Overall, although different scholars have different understandings of practical skills, they still highlight the key 4 competencies necessary for the engineering practical. With the changes in the elements and their connections within the modern engineering system as well as the internal and external relationships, the traditional connotation and extension of engineering practice competence need to be deepened and expanded, highlighting the modern features of interdisciplinary characteristics and social dependence that engineering practice has. Taking into account the global trend of engineering education reform, engineering practical skills can be defined as "a comprehensive ability including engineering design ability, engineering operation ability, engineering communication ability, teamwork ability and organizational management ability necessary for solving practical engineering problems.

Objectives

1. To develop robot experiment training activity to improve the practical skills of undergraduate students.
2. To compare students' practical skills, before and after the implementation is robot experiment training activity.

Research Framework

The development of practical skills through robot experiment training activity for undergraduate students. The research concept framework is as follows.

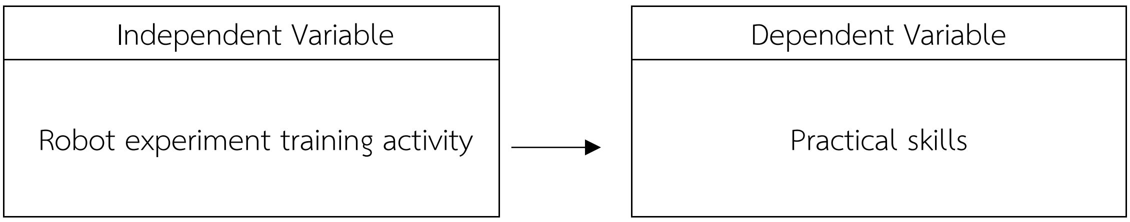

Figure 1: Research Framework

Materials and Methods

The development of practical skills through robot experiment training activity for undergraduate students. The research Instruments are as follows.

Creating and checking the quality of research instruments is shown as follow.

1. Robot experiment training activity and Practical skills test.

1) Studied the concept of Robot experiment training activity and development process of checklist form.

2) Drafted the checklist form. At the end of each section, there is a space for experts to write suggestions that can be helpful in improving the Robot experiment training activity.

3) Experts verified the validity of the checklist concept and development process. Taking the instrument to 3 experts to consider. The test consistency index of congruency is between 0.60-1.00, the level of consideration is as follows:

Rating is +1. There is an opinion that "Corresponds to definition/ measurement objectives.

Rating is 0. There is an opinion that "Not sure it corresponds to definition/measurement objectives."

Rating is -1. There is an opinion that "Inconsistent with definition/ measurement objectives."

4) Modify the checklist form according to suggestions.

Here's a simplified summary of each teaching content and steps:

Teaching Content 1: Problem-solving process using TRIZ theory

1. Analysis of the Problem: Initial student engagement was low; few students completed pre-class readings or participated actively in initial discussions.

2. Identify the Conflict: Students showed limited initiative in constructing and analyzing system diagrams, with little interactive discussion.

3. Principle Resolution: Some groups managed to develop conceptual solutions using TRIZ tools, though overall student engagement was moderate.

4. Comparative Evaluation: A few groups completed solution evaluation within the time limit; overall student participation in this step was not high.

5. Implementation: Limited student teams described the final solution completely; hands-on participation remained weak.

Teaching Content 2: MSP430 microcontroller hardware basics

1. Analysis of the Problem: There was a noticeable improvement in student preparation and engagement compared to the first content.

2. Identify the Conflict: More active discussions and better understanding in drawing and analyzing the system's functional structure.

3. Principle Resolution: Increased number of groups obtaining multiple conceptual solutions; students showed better grasp and use of TRIZ tools.

4. Comparative Evaluation: More groups engaged in the solution marking process, showing improved discussion and interaction.

5. Implementation: All teams completed the textual description of the final solution; student-initiated participation increased notably.

Teaching Content 3: MSP430 microcontroller control software writing fundamentals

1. Analysis of the Problem: A significant improvement in student initiative and readiness; high engagement in pre-class activities.

2. Identify the Conflict: Improved analysis and understanding of system problems with lively discussions among most groups.

3. Principle Resolution: All groups achieved multiple conceptual solutions, indicating a better understanding and application of TRIZ.

4. Comparative Evaluation: Enhanced group discussions during solution evaluations, indicating deeper student involvement.

5. Implementation: Complete solutions from all teams with increased student-led hands-on practice; classroom dynamics shifted towards student-centered learning.

Teaching Content 4: Adjust MSP430 microcontroller control program parameters according to the actual scenario

1. Analysis of the Problem: Total engagement from students in pre-class materials; high levels of active participation in discussions.

2. Identify the Conflict: Comprehensive analysis and discussion on system problems, exceeding expectations in diagramming and critical thinking.

3. Principle Resolution: All groups demonstrated the ability to generate multiple solutions, showing significant improvement in the TRIZ application.

4. Comparative Evaluation: Detailed and professional evaluation of solutions by all groups, indicating a deepened understanding and critical assessment skills.

5. Implementation: Complete and practical final solutions from all teams; enhanced display and operational capabilities, with some groups utilizing advanced technologies.

Symbol and Abbreviations

Represent data analysis results based on symbols and semantics. The details are as follows:

$\bar{X}$	means	average value
SD.	means	standard deviation
n	means	number of students
D	means	scores of differences between pre- and post-test
df	means	degree of freedom
t	means	statistical data for t-test value
**	means	statistical significance at level .01

Results

To explore the positive impact of a robotics lab course developed based on TRIZ theory on enhancing the practical skills of college students, the researchers conducted the following two studies:

Part 1: The results of the impact of a laboratory course based on TRIZ theory on students' learning behavior and learning emotion.

Learning behavior refers to a series of behavioral activities that students perform in a specific environment in order to acquire certain knowledge or skills. These behavioral activities usually include observation, imitation, practice, feedback, etc., which is the process of individuals actively acquiring knowledge and skills. Learning behavior is characterized by initiative, practice, interaction, etc. It not only includes the acceptance and processing of external information by individuals, but also includes the regulation and integration of internal psychological activities of individuals. Learning emotions, on the other hand, refer to a variety of emotional experiences produced in the learning process. These emotional experiences may come from the learning behavior itself, or from the learning environment, learning content, and other factors. Learning emotions have diversity and complexity, which include not only positive emotional experiences, such as interest, curiosity, and satisfaction, etc. but also negative emotional experiences, such as anxiety, stress, boredom, and so on. Learning emotions have an important impact on learning behaviors and learning effects. Positive emotional experiences can promote the occurrence and continuation of learning behaviors and improve learning effects, while negative emotional experiences may lead to inhibition or interruption of learning behaviors and reduce learning effects.

By analyzing students' learning behaviors and learning emotions it is possible to assess the subjective willingness to learn and motivation shown by students in a course, thus effectively evaluating the teaching effectiveness of the course. In the traditional classroom, the data collection of students' learning behaviors and learning emotions mainly relies on teachers' observation in the classroom and teaching reflection records after class, which is limited by teachers' own attention and energy, and it is difficult to analyze and record the learning behaviors and learning emotions of all students in the class in a more complete way. Therefore, in this study, the researcher used the hardware conditions of the school's smart classroom to record the whole process of the robotics experimental course with 44 high-definition cameras, and made use of the accompanying learning situation collection and analysis software to record and visualize the learning behavior and learning emotions of the students in the classroom, which is an important supplement to the teacher's own learning situation recording and analysis.

The learning condition collection and analysis software has four main functions:

1. Data collection. The learning situation collection system collects data on students' learning situations through various data sources, such as class attendance, classroom interaction, classroom feedback, etc.

2. data processing. The learning situation collection system analyzes multi-dimensional student learning situations through big data processing technology, obtains accurate learning behavior characteristics, and constructs learning behavior models.3. Data analysis. Through machine learning and deep learning technology, the system analyzes students' learning situations in depth and analyzes student's learning characteristics.4. Data visualization. Through charts, reports, and other means, the learning situation data is visualized, which makes it easy for teachers to understand the students' learning situation more intuitively. The learning situation collection system applies big data processing, machine learning, deep learning, and other technologies, which can collect students' learning situations in real time, extract students' learning behavior data, and accurately analyze students' learning situations.

In this study, a total of 50 students from the Computer Application Technology 1 class of the Information Technology Branch of Zhejiang Yuying Vocational College were selected for teaching practice. Among the 50 students in this class, there were 27 male students (54% of the total number) and 23 female students (46% of the total number). The content of the teaching is divided into four modules in total, the first part is the introduction to the application of TRIZ theory; the second part is the hardware system of the MSP430 microcontroller; the third part is the software system of the MSP430 microcontroller; and the fourth part is the comprehensive debugging of the robot based on MSP430 microcontroller. Through the collection of data on the learning behavior and learning emotions of the students participating in the teaching of this experimental course in the classroom and the teacher's teaching feedback, it can be clearly found that the positive learning behavior and positive learning emotions of the students show an upward trend as the course continues to deepen, 45 and the observation of the learning behavior and learning emotions of the specific course modules are as follows

Part 2: The results of The Comparison of Students' Practical Skills Before and After Taking the Robotics Lab Course.

In this study, a total of 50 students from the Computer Application Technology 1 class of the Information Technology Branch of Zhejiang Yuying Vocational College were selected for teaching practice. Among the 50 students in this class, there were 27 male students (54% of the total number) and 23 female students (46% of the total number). The researcher organized the students in the sample group to take the pre-test and post-test, and the results of the quizzes were compiled and calculated as shown in Table 1.

Table 1: Pre-test and Post-test Scores of the Sample

Student ID	Before class scores Pre-test	After class scores Post-test	Different scores (D)	SD
1	10.00	11.00	1.00	0.647
2	15.00	25.00	10.00	0.369
3	17.50	22.50	5.00	0.875
4	16.00	21.00	5.00	0.426
5	17.00	24.00	7.00	0.221
6	10.00	16.50	6.50	0.356
7	22.00	29.00	7.00	0.325
8	17.00	25.00	8.00	0.759
9	11.00	17.00	6.00	0.687
10	13.00	18.00	5.00	0.667
11	16.00	22.00	6.00	0.542
12	14.00	19.00	5.00	0.687
13	12.00	15.00	3.00	0.571
14	11.00	20.00	9.00	0.547
15	10.00	17.00	7.00	0.896
16	13.00	19.50	6.50	0.647
17	10.00	15.00	5.00	0.567
18	13.00	18.00	5.00	0.258
19	11.00	19.00	8.00	0.479
20	12.00	18.00	6.00	0.674
21	14.00	22.00	8.00	0.647
22	15.00	24.00	9.00	0.675
23	11.00	21.00	10.00	0.356
24	17.00	24.00	7.00	0.875
25	12.00	21.00	9.00	0.896
26	12.00	22.50	10.50	0.356

27	14.00	20.50	6.50	0.896
28	11.00	16.00	5.00	0.258
29	16.00	24.00	8.00	0.647
30	12.00	16.00	4.00	0.356
31	16.00	23.00	7.00	0.675
32	10.00	15.00	5.00	0.875
33	16.00	24.00	8.00	0.647
34	14.00	18.00	4.00	0.567
35	10.50	14.50	4.00	0.647
36	10.00	17.00	7.00	0.675
37	10.00	17.00	7.00	0.896
38	10.00	15.00	5.00	0.356
39	11.00	18.00	7.00	0.412
40	13.00	20.00	7.00	0.357
41	12.00	17.00	5.00	0.356
42	11.00	21.00	10.00	0.458
43	17.00	19.00	2.00	0.794
44	14.00	22.00	8.00	0.745
45	12.00	21.00	9.00	0.647
46	14.00	20.00	6.00	0.896
47	16.00	23.00	7.00	0.357
48	11.00	20.00	9.00	0.794
49	13.00	20.00	7.00	0.458
50	10.00	19.50	9.50	0.356
Average scores (X)	13.26	19.93	6.67	0.845

From Table 1, Practical skill level scores of undergraduate students in the ample group participating in the teaching experiment before and after taking a laboratory course on robotics based on TRIZ theory, the average score for the pre-test was 13.26, while the average score for the post-test after learning was 19.93, and the mean difference was 6.67. The after-learning score was found to be higher than the before-learning score.

The researcher conducted a paired-sample t-test on the sample data using SPSS software, which showed that the sample difference was significant, indicating that the student's performance improvement was very obvious after the robotics laboratory course developed based on TRIZ theory, as shown in the results of the specific data analysis

Table 2: Data analysis table of pre-test and post

Practical Skills	n	Full Score	x	sd	df	P	T
Pre-test	50	30	13.26	2.64	50	0.000**	22.88
Post-test	50	30	19.93	3.42			

**Statistically significant at the level .01 ($p < .01$)

From Table 2, the practical skill level scores of undergraduate students in the sample group participating in the teaching experiment before and after taking a laboratory course on robotics based on TRIZ theory, the average score before learning was 13.26, and the average score after learning was 19.93. The standard deviation before learning was 2.64, and the standard deviation after learning was 3.42. The results were found that the practical skills of students after learning higher than before learning statistically significant at the level .01.

Conclusions and Discussion

Conclusion

In this research of developing a robotics laboratory course with TRIZ-based theory to enhance the practical ability of college students, after the process of theoretical research, classroom practice, and data analysis, the conclusions of the specific research are as follows:

1. Applying TRIZ theory to build a robotics laboratory course can enhance students' desire to explore knowledge, cultivate a problem-oriented way of thinking, and significantly improve students' learning behaviors. Through classroom observation, it was found that as the course progressed, the learning behaviors of the participating students, such as teamwork, communication, pre-study before class, review after class, and questioning and speaking, were positively changed.

2. The robotics experimental course constructed by using Triz theory can obviously improve the students' performance of practical robotics skills. The T-test shows that there

is a very significant difference between the pre-test and post-test scores, and the enhancement effect is very significant.

Discussion

In this study of developing a robotics laboratory course for enhancing the practical skills of college students, all of the pre-set research objectives have been achieved, the research hypotheses have been positively justified, and the findings are specifically discussed as follows:

1. The robotics experimental course developed based on TRIZ theory allows students to be problem-oriented, fully stimulates their desire to explore, discovers the root causes of problems, clarifies the contradictory keys to solving problems, and through structured tools allows students to quickly gain inspiration for solving contradictory conflict and obtaining innovative solutions, and in this way of learning, allows students to continuously accumulate solutions that This enables students to continuously obtain positive feedback, thus improving students' learning behavior. From the viewpoint of the whole teaching experiment process, as students become more and more adapted to the teaching process based on the TRIZ theory, their learning performance in the areas of pre-course preparation, cooperative learning, self-driven, communication learning, etc., has a very big improvement, which is helpful for promoting the development of the student's practical ability in the operation of robots. There is an obvious role in promoting the development of students' practical skills in robot operation.

2. In this study, a teaching framework divided into five steps was constructed based on the TRIZ theory and applied in the robotics experimental teaching course to theorize and standardize the teaching process. In the problem discovery and analysis link, the key points and difficulties of the teaching content are skillfully embedded, and students are guided to recognize and discover the key points of learning by themselves and visualize them. In the conflict definition and solution comparison session, the TRIZ invention problem-solving tool is introduced to help students quickly form structured solutions, and students' learning confidence is enhanced through continuous positive feedback. Finally, in the implementation session, through teamwork, communication, and mutual assistance, students' comprehensive practical skills are all greatly practiced. By comparing the students' scores in the pre-test and post-test, there is a significant improvement in the student's level of practical robotics skills before and after the course.

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