Asian Journal of Education and Social Studies

Volume 50, Issue 11, Page 185-197, 2024; Article no.AJESS.126799
ISSN: 2581-6268

A Survey and Analysis of Implementation Status of Science and Technology Mini Projects Course in Middle School

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ajess/2024/v50i111646

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/126799

Original Research Article

Received: 15/09/2024
Accepted: 17/11/2024
Published: 22/11/2024

ABSTRACT

Cultivating students' inquiry ability, hands-on ability and innovation ability is the top priority of quality education nowadays. Science and technology mini projects contain a lot of scientific knowledge which are related to science teaching in middle school. Incorporating these handcraft projects into science practical teaching activities will no doubt provide students with more practice opportunities to "learn by doing" and enhances their engagement with scientific knowledge. This study was conducted through a questionnaire survey of middle school students to understand the status quo of the implementation of science and technology mini projects course. It was found that students expressed a strong passion about the course, and they believed that such course could improve their core science literacy. However, in the actual teaching arrangement, the implementation of

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Cite as: *Xu, Lintong, and Yiping Zhang. 2024. "A Survey and Analysis of Implementation Status of Science and Technology Mini Projects Course in Middle School". Asian Journal of Education and Social Studies 50 (11):185-97. https://doi.org/10.9734/ajess/2024/v50i111646.*

science and technology mini projects course was not satisfactory. The main reasons for this were the tight schedule of class time due to the influence of general education environment, and the lack of concepts and development ability of teachers to carry out relevant courses. Based on the results of the survey, this study puts forward suggestions combined with the current education situation. Teachers should dig deeper into the science and technology mini projects course' topics that are compatible with textbook teaching, and while pushing students to complete the tasks of the course, they should provide timely and effective feedback on the production process and outcomes to the students. This will help establish a positive learning cycle and ultimately promote the successful implementation of science and technology mini projects course.

Keywords: Science and technology mini projects course; questionnaire survey; middle school science; inquiry practice.

1. INTRODUCTION

Developing and designing a colorful science and technology mini projects extended course is of great significance to cultivate students' ability of inquiry and practice. Science and technology mini projects are full of sense of science and technology, with practicality, simplicity and can be completed, suitable for middle school students. At the same time, science and technology mini projects closely links the teaching materials with life, and has the function of guidance and motivation. Science and technology mini projects course can not only greatly enrich students' study life, understand the objective world scientifically and rigorously under the drive of curiosity, promote students' cognitive ability of the world, but also in the course of completing the exploration of handcraft, students unconsciously develop the hands-on practical ability and enhance the creative ability. It can play an important role in improving teaching quality and students' scientific literacy (Jin 2018)

In addition, some scholars believe that the course of science and technology mini projects not only provides a stage for students to study deeply and display their creativity fully, it also provides a space for teachers to guide students to carry out inquiry-based learning (Liu and Wu 2006). As for how to design science and technology mini projects course, Cao Fengjuan et al. think that teachers should use educational theory to explore the science and technology mini projects needed in teaching (Cao 2012). Zhou Fenglin reports that teachers should create a hands-on practice environment for students, stimulate students' curiosity and arouse students' imagination and insight, teachers' innovation is the source of cultivating students' innovative thinking (Zhou 2010). Dai Chunying et al. think that teachers should drill into the curriculum standard, the objectives of scientific design activity should closely linked to the characteristics, carry out the activity close to students' actuality, organize carefully and refine the process of handcraft activity (Dai and Fu 2015).

In the selection of the content of science and technology mini projects course, Ren Weiwei et al. believe that the selected topics should not only have practical significance, but also take into account the actual situation of the students, and the handcraft should be scientific and practical, the work should be artistic (Ren and Yuan 2019). In the process of science knowledge learning, the application of science and technology mini projects can be a science small experiment with a certain degree of interest, so that students' interest in learning can be fully stimulated, while enhancing the desire for knowledge (Su 2017).

In the implementation of science and technology mini projects course, Xing Haigen believes that teachers should establish the concept of liberal education, and that teachers should permeate the significance of science and technology production and small-scale invention activities to students, teachers should focus on penetrating the methods of science and technology production and small inventions to students, teachers should try to promote and guide the development of science and technology production and small invention activities, and sublimate the achievements of science and technology production and innovation (Xing 2013). Liu Lihua believes that it is necessary to carefully select the tools and materials suitable for students, boldly let students go, give students space for activities and thinking, skillfully questioned, give students the confidence to overcome difficulties and exchange mutual appreciation, give students the stage for display (Liu and Li 2019).

Roni Berger believes that efforts to make science and technology mini projects course more accessible to middle school students will focus on making research courses more experiential, and developing “user-friendly” courses (Berger 2002). Allsopp David H argues that by linking the course with field experience to bridge the gap between theory and practice, the course itself will be more acceptable to middle school students and teachers (Allsopp et al. 2006).

In the book of “Interesting physics experiments”, Takao Sawamaki et al. record a large number of interesting physics experiments, and these experimental teaching cases provide valuable reference value for the topic selection for the science and technology mini projects course (Takao and Yoji 2005). In addition, other scholars have studied specific teaching cases of science and technology mini projects courses, which also provide references for the design of course contents (Wu et al. 2019, Wang and Dai 2023).

The researchers also discussed the application and practice of science and technology mini projects in various educational hotspots, such as creative education (Tian and Liu 2019), environmental education (Li 2024), ideological and political education (Li 2022), school-based elective courses (Li 2022, Zhang 2022) and India's new education (Godbole et al. 2024).

This article hopes that through the survey of middle school students to understand the current situation of the development of science and technology mini projects course in middle school, the attitude of teachers and students on the course and the problems in the implementation of the course, so as to provide reference and suggestions for the design of middle school science and technology mini projects course cases from the source.

2. METHODS

2.1 Questionnaire Survey Method

This study was conducted to find out the implementation status of science and technology mini projects course in middle school through a student questionnaire survey. The main contents of the questionnaire include: students' attitudes towards the implementation of science and technology mini projects course, students' attitudes towards learning and task completion in such classes, and teachers' current situation of organizing students to implement science and technology mini projects course and their attitudes towards the implementation. The statistical methods were used to process and analyze the questionnaire data. By investigating the above content, this study seeks to understand the implementation status of science and technology mini projects course in middle schools, providing a reference for the design of related classroom teaching cases in future research.

2.2 Preparation of the Questionnaire

Under the educational concept of “student-oriented”, teachers should pay full attention to students' thoughts and learning experience when choosing teaching contents. Therefore, in the questionnaire, we focused on investigating the attitude of middle school students towards the development of science and technology mini projects course, and their experience and ideas about the current status of the implementation of the course.

The questionnaire was developed from four dimensions: the current teaching status of science and technology mini projects course, the students' attitude towards the course, the teachers' implementation of the science and technology mini projects activity, and the students' ideal model of the course. The questionnaire consists of 15 questions, and the corresponding relationships between the four dimensions and the questions is shown in Table 1.

2.3 Distribution of the Questionnaire

The respondents were students from three public middle schools in Taizhou, Zhejiang province. A total of 252 student questionnaires were distributed and 249 valid questionnaires were returned.

3. RESULTS AND DISCUSSION

The implementation status of science and technology mini projects course in middle school is analyzed through the findings of the questionnaire according to four dimensions respectively.

3.1 Survey Results and Analysis of the Current Teaching Status of Science and Technology Mini Projects Course

Figs. 1-3 shows the results of the first dimension - the current teaching status of science and technology mini projects course, corresponding to the questions 1-3 of the questionnaire.

Table 1. Correspondence between the four dimensions of the questionnaire content and the questions

No.	Dimensions of the questionnaire content	Questions No.
1	The current teaching status of science and technology mini projects course	1、2、3
2	The students' attitude towards science and technology mini projects course	4、5、6、7
3	The teachers' implementation of the science and technology mini projects activity	8、9、10、11
4	The students' ideal model of science and technology mini projects course	12、13、14、15

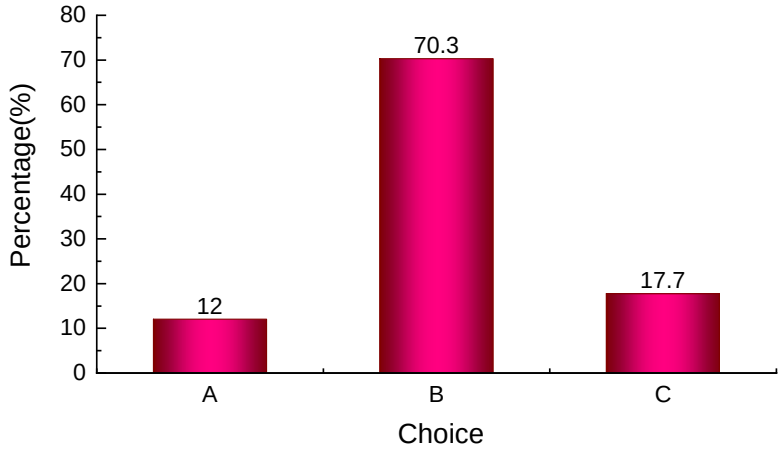

Fig. 1. Statistical results of the survey "Does your school offer a regular course on science and technology production?"

**A. At regular intervals during each semester*
B. Once or twice a semester
C. There is almost no

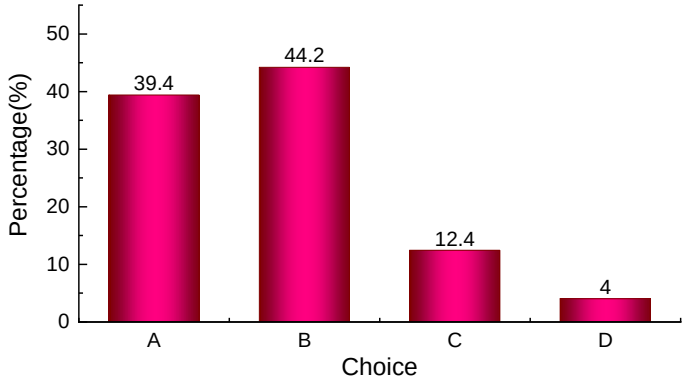

Fig. 2. Statistical results of the survey "What do you think is the biggest problem with the course content?"

**A. Lack of technological innovation in the process of science and technology production*
B. Lack of technical content in the process of science and technology production
C. Insufficient equipment and limited time
D. Others

Question 1 is “Does your school offer a regular course on science and technology production?”, question 2 is “What do you think is the biggest problem with the course content?”, question 3 is “What do you think is the biggest problem with teacher demonstration of making?”. This dimension covers whether science and technology courses are carried out regularly, the

main problems of course contents and the problems of teachers in the course of making demonstrations. It provides a comprehensive picture of the implementation and effectiveness of the science and technology course.

The results of the survey show that the current status of the teaching and development of the middle school science and technology mini projects course is not satisfactory. From the analysis of the data, it can be seen that most of the respondents (70.3%) believed that the school mainly focused on fulfilling the educational task indicators issued by the higher level, and such activity courses were only carried out once or twice in each semester occasionally. The lack of technological innovation (39.4%) and the lack of technical content (44.2%) in the process of making science and technology products were the main reasons for the gradual decrease of students' interest in this course. Teachers could not express the process clearly when demonstrating the production (32.9%), and the making process was complicated with many steps (48.2%), which reduced the sense of participation of each student.

3.2 Survey Results and Analysis of the Students' Attitude Towards Science and Technology Mini Projects Course

Figs. 4-7 shows the results of the second dimension - the students' attitude towards science and technology mini projects course, corresponding to the questions 4-7 of the questionnaire. Question 4 is “Do you think it is necessary to do hands-on work in science learning?”, question 5 is “Do you think it is worthwhile to do the scientific and technological inventions and productions covered in the science textbooks?”, question 6 is “Do you think that the science and technology mini projects course can enhance one's understanding of science knowledge?”, question 7 is “How do you think that the science and technology mini projects course affects one’s science achievement?”. This dimension covers the students' views on hands-on practice, value judgments on textbook science and technology projects, the impact of science and technology projects on their understanding of science knowledge, and its potential impact on their academic performance in science. It fully reflects the students' cognition and attitude towards science and technology mini projects course.

The results of the survey show that most of the students believe that the science and technology mini projects course is important for their own development. From the analysis of the data, we can conclude that the majority of the students think that carrying out the course can bring benefits, and they believe that by carrying out the course they can enhance their hands-on abilities, improve their understanding of science knowledge, and improve their performance in science. and improve scientific achievements to a certain extent.

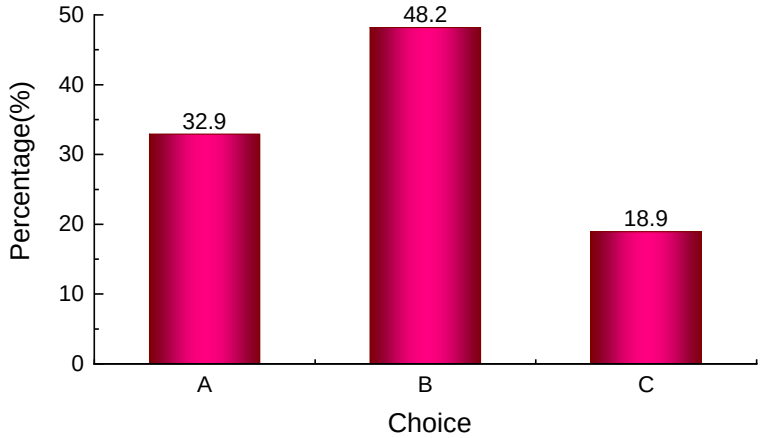

Fig. 3. Statistical results of the survey "What do you think is the biggest problem with teacher demonstration the production?"

**A. The making process cannot be clearly expressed in the demonstration*
B. The making process is complicated and has many steps
C. The demonstration is not meaningful

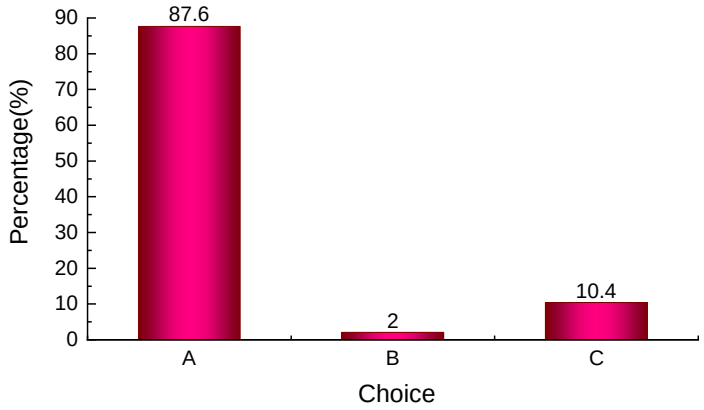

Fig. 4. Statistical results of the survey "Do you think it is necessary to do hands-on work in science learning?"

**A. Needed*
B. No need
C. dispensable

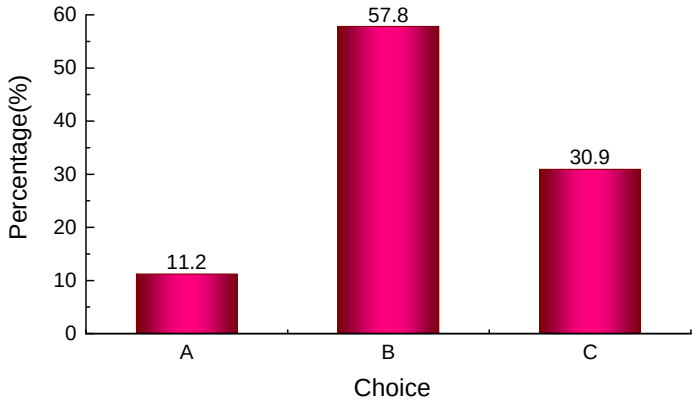

Fig. 5. Statistical results of the survey "Do you think it is worthwhile to do the scientific and technological inventions and productions covered in the science textbooks?"

**A. All of them*
B. Individually
C. Not at all

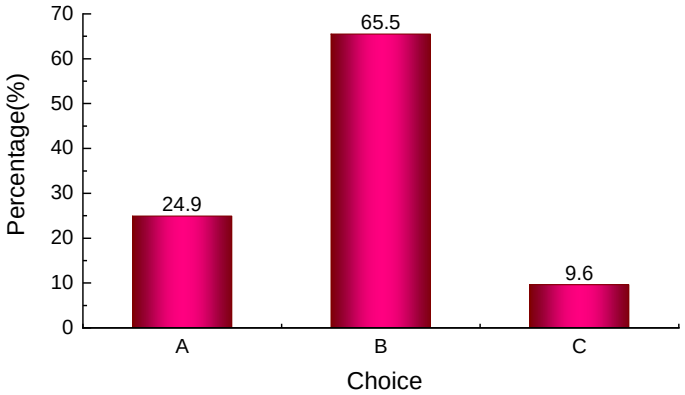

Fig. 6. Statistical results of the survey "Do you think that the science and technology mini projects course can enhance one's understanding of science knowledge?"

**A. It can improve the understanding of knowledge*
B. It can improve some understanding of knowledge
C. No help to the understanding of knowledge

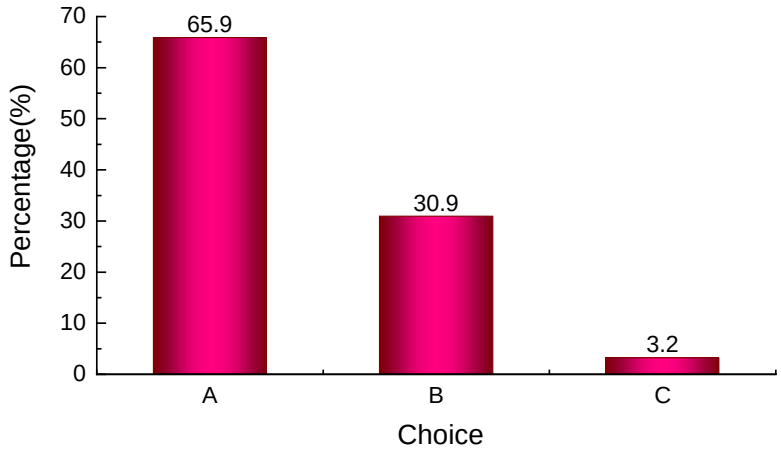

Fig. 7. Statistical results of the survey "How do you think that the science and technology mini projects course affects one's science achievement?"

**A. Getting a more systematic learning, more conducive to improving performance*
B. No effect
C. Spending unnecessary time, not conducive to performance

3.3 Survey Results and Analysis of the Teachers' Implementation of the Science and Technology Mini Projects Activity

Figs. 8-11 shows the results of the third dimension - the teachers' implementation of the science and technology mini projects activity, corresponding to the questions 8-11 of the questionnaire. Question 8 is "Does your science teacher assign science and technology mini projects tasks?", question 9 is "Can you complete the science and technology mini projects tasks assigned by your science teacher?", question 10 is "What difficulties have you encountered in completing your science and technology project?", question 11 is "Does your science teacher give you feedback on your project?". This dimension covers the student's feelings about the science and technology mini projects assignment, the difficulties they encountered in the course, and the teachers' feedback on the projects. It comprehensively reflects the situation of teachers' implementation of the science and technology mini projects activities and students' participation in the science and technology mini projects course.

The survey results show that the role of science and technology mini projects course has a weakened position in the teaching and learning process. From the analysis of the data, more than half (70.3%) of the science teachers in the surveyed classes only occasionally assigned students to carry out a few particularly important science and technology project tasks. In accomplishing the tasks in the course, although students possess certain hands-on abilities, they encountered a lack of production tools (49.8%) and a lack of thorough understanding of production principles, 38.6% of the participants did not know the steps of production. It is also because most of the science teachers assigned the tasks of science and technology projects less frequently, the classroom teaching feedback with the production results became less frequent, only 16.1%.

3.4 Survey Results and Analysis of the Students' Ideal Model of Science and Technology Mini Projects Course

Figs. 12-15 shows the results of the fourth dimension - the students' ideal model of science and technology mini projects course, corresponding to the questions 12-15 of the questionnaire. Question 12 is "How often do you think it would be appropriate to do a science and technology mini project?", question 13 is "Where do you want the content of your science and technology mini projects tasks to come from?", question 14 is "How would you like to see the science and technology projects course developed in your future study?", question 15 is "What kind of help would you like to receive from your teacher when completing your science and technology mini project?". This dimension covers the students' preferences for appropriate frequency of science and technology mini projects course, the source of the task content, the learning style, and the support they would like the teacher to provide. It comprehensively

reflects the students' perceptions of the form of learning and the role of teacher in the science and technology mini projects course, their needs and expectations in the course.

According to the results of the survey, students are full of expectations for science and technology mini projects course, nearly 85% of students want to complete every two weeks or even once or twice a week science and technology projects activities. However, the analysis of the data shows that most of the students still hope that they can carry out the science and technology mini projects course under the guidance of teachers. At the same time, students also hoped that science teachers could explain the corresponding principles in time during the production process and recommend more practical production equipment, so that the results of science and technology mini projects could be introduced into the classroom teaching.

3.5 The Implementation Status and Existing Problems of Science and Technology Mini Projects Course

Based on the analysis questionnaire survey of 15 questions from the above four dimensions, we can see that the students are full of enthusiasm and expectation for the science and technology mini projects course, and they hope to learn science knowledge, enhance science literacy

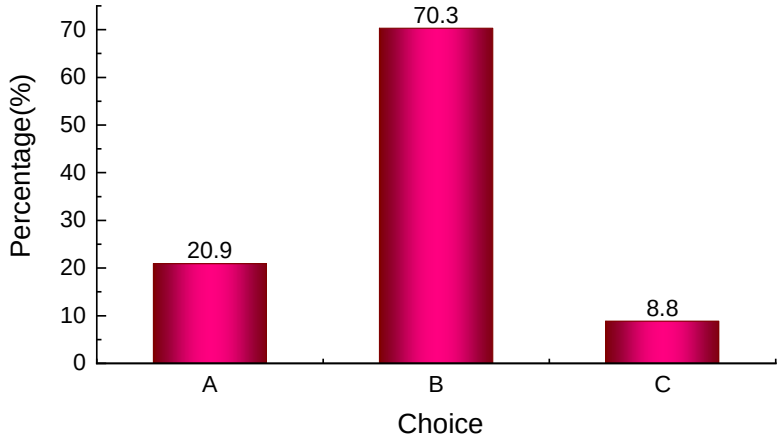

Fig. 8. Statistical results of the survey "Does your science teacher assign science and technology mini projects tasks?"

**A. Often assigns tasks for us to do*
B. There are occasional project tasks of particular importance
C. Never assigns hands-on tasks

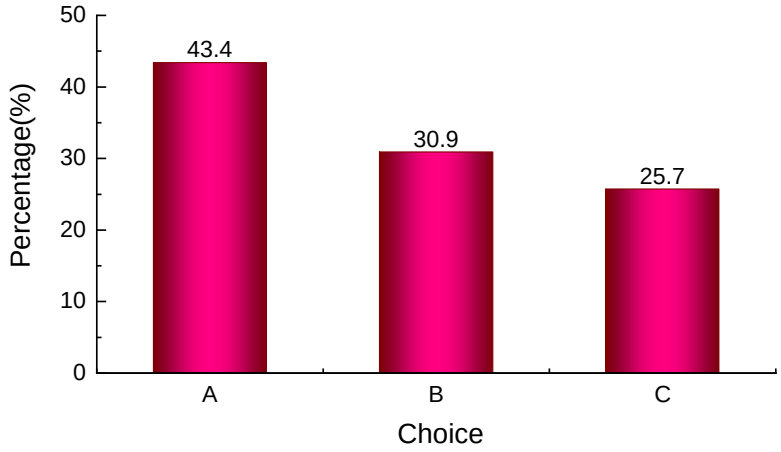

Fig. 9. Statistical results of the survey "Can you complete the science and technology mini projects tasks assigned by your science teacher?"

**A. All tasks are completed accurately and in a timely manner*
B. Most of them can be completed well
C. Only a few of the simple tasks can be completed

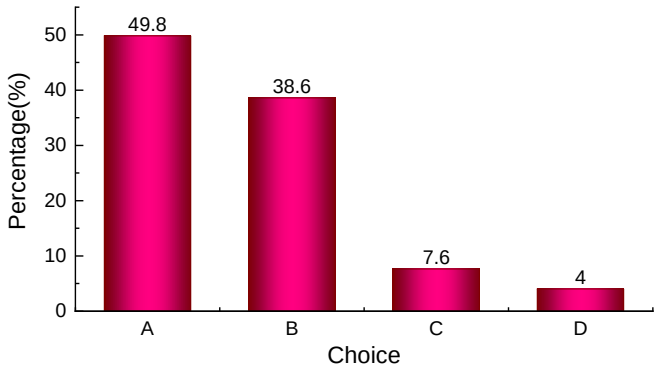

Fig. 10. Statistical results of the survey "What difficulties have you encountered in completing your science and technology project?"

**A. Lack of tools to complete the task*
B. Lack of understanding of the principles and steps of the project
C. The finished project could not meet the teacher's requirement
D. Others

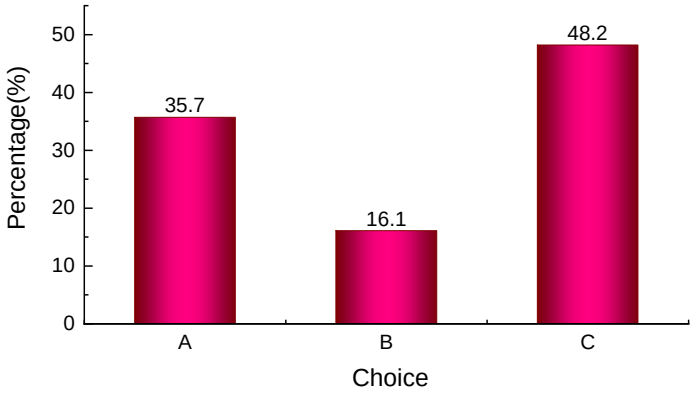

Fig. 11. Statistical results of the survey "Does your science teacher give you feedback on your project?"

**A. Yes, and they will recognize good projects in the classroom*
B. Yes, and they will integrate the projects with classroom teaching contents
C. No feedback is given

and improve science performance through hands-on practice. However, due to the driving force of the general environment of exam-oriented education and the limitation of class time, their classrooms are more inclined to book-based teaching, and students are less likely to participate in hands-on courses.

Students perceive the positive effects of the science and technology mini projects course. The course allows students to do hands-on production through task assignments, thus it can make up for the shortcomings of middle schools in having fewer science experiments. In hands-on practice, they can study more systematically, deepen their understanding of science knowledge in books, and improve their science performance and discipline literacy.

We can also see that at present, the science and technology mini projects course is not taken seriously in middle schools. Most science teachers fail to consciously assign tasks for science and technology production based on the teaching content, resulting in such kind of course often being carried out independently of classroom teaching. Although middle school students have a certain degree of hands-on ability, they often have difficulty in completing the production due to the lack of complete production tools, insufficient understanding of the production principles, or unclear production steps. In addition, teachers seldom show students' projects in class or combine the production results with the teaching content in class, which leads to the neglect of the importance of science and technology mini projects course in knowledge learning.

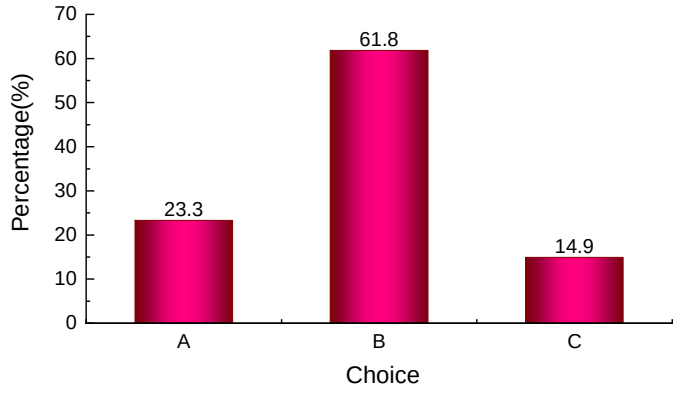

Fig. 12. Statistical results of the survey "How often do you think it would be appropriate to do a science and technology mini project?"

**A. Once or twice a week*
B. Once or twice a fortnight
C. Once or twice a month

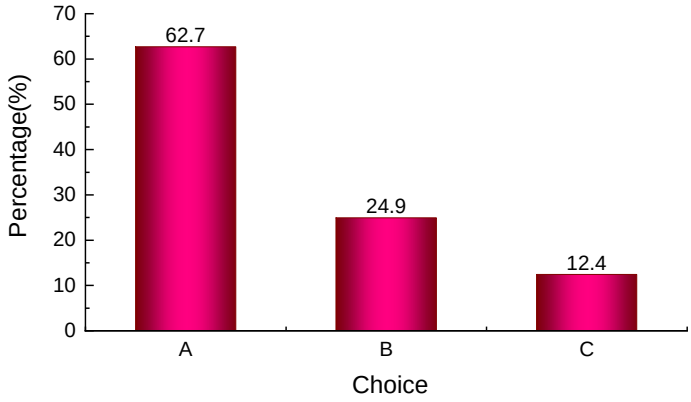

Fig. 13. Statistical results of the survey "Where do you want the content of your science and technology mini projects tasks to come from?"

**A. The teacher chooses the layout and provides the plan*
B. Choosing according to the student' own interests
C. Coming from some important contents in textbooks

3.6 Suggestions on the Teaching of Science and Technology Mini Projects Course

Based on the results and analysis of the above questionnaire survey of students, we put forward the following teaching suggestions for the middle school science and technology mini projects course:

(1) Teachers should dig deeper into the topics of science and technology mini projects that are suitable for the teaching of textbooks.

In modern education, the role of teachers is not only to teach knowledge, but also to guide students' learning and organize practical activities. Science teachers should fully realize the importance of hands-on practice in teaching, and try to combine science and technology production with classroom teaching to help students consolidate their knowledge in practice. Through the reasonable topic design, teachers can enable students to understand and apply book knowledge naturally in the production process.

For example, when teaching the principles of electric motors and generators, teachers can guide students to carry out related electronic component project tasks. This kind of activity can not only enhance students' understanding of theoretical knowledge, but also cultivate their hands-on ability and innovative thinking. In the process of hands-on production, students need to consider every aspect of the project, from the selection of materials to the assembly of circuits, and to the final function test, this series of

operations in practice make them deepen their understanding of what they have learned.

In addition, teachers can encourage students to innovate in the process of making, for example, letting them try to design small devices with different functions on the basis of an electric motor. This kind of creative task can not only stimulate students' imagination, but also develop their problem-solving ability. In this way, students can not only internalize their knowledge, but also exercise their hands-on ability and creativity, so that they can benefit a lot from the science and technology mini projects course.

(2) Teachers should provide timely feedback on students' projects in conjunction with the class.

Feedback from teachers is crucial after students have finished their science and technology projects. Effective feedback can not only help students recognize their shortcomings, but also motivate them to improve in future practice. In the science class, teachers should make reasonable use of students' projects and give specific comments and improvement suggestions to each project. For example, teachers can point out the strengths and weaknesses in the design of a particular project and encourage students to put forward their own views and ideas.

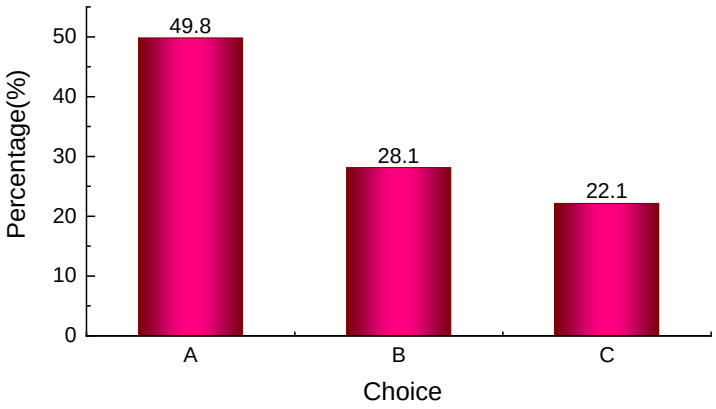

Fig. 14. Statistical results of the survey "How would you like to see the science and technology projects course developed in your future study?"

**A. With the help of teachers' guidance*
B. Group discussion to conduct cooperative investigation
C. Collecting information on the Internet for research

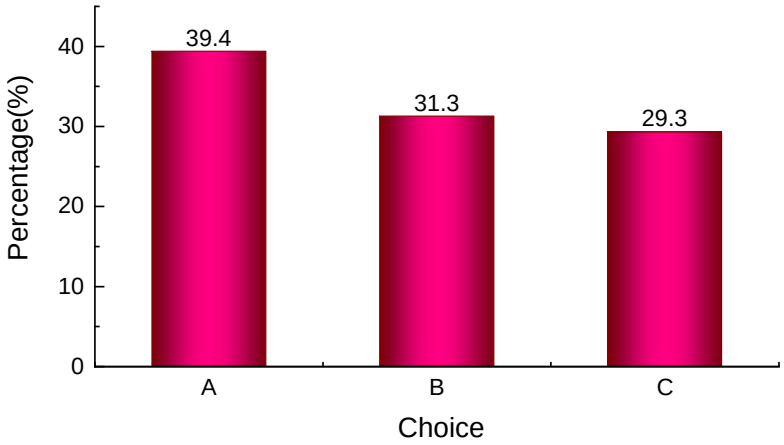

Fig. 15. Statistical results of the survey "What kind of help would you like to receive from your teacher when completing your science and technology mini project?"

**A. Explain the relevant scientific principles in a timely manner*
B. Recommend and provide more practical equipment
C. Provide a platform for the exchange and display of project results

In addition, teachers can also choose some characteristic and representative projects to present and explain. In this way, not only can more students understand the innovative ideas of other students, but also can stimulate their creativity and sense of competition.

To further enhance students' sense of participation, teachers can also evaluate students' projects in a variety of ways, such as scoring, commenting and setting up an exhibition area for their works. This diversified feedback mechanism not only helps students recognize their strengths and weaknesses in the production process, but also promotes communication and cooperation among them, forming a good learning cycle.

4. CONCLUSION

We investigated the current implementation status of the middle school science and technology mini projects course and analyzed the results of the corresponding questionnaires, with a view to providing suggestions for designing or improving the science and technology mini projects course.

The survey shows that students generally look forward to more opportunities for hands-on practice and believe that the science and technology mini projects course can effectively promote their understanding and consolidation of science knowledge. However, the current status of the implementation of the course is not optimistic. Although it is generally recognized by teachers that science and technology mini projects course plays an important role in consolidating students' science knowledge and exploring the science world, due to the influence of exam-oriented education, this kind of hands-on practice-oriented course has not been given due attention. In addition, the lack of rich teaching cases and relevant teaching experience of front-line teachers further constrains the effective implementation of science and technology mini projects course.

The value of science and technology mini projects course should not be overlooked. In order to make this course play a more important role in education and teaching, teachers and students need to work together to overcome the current difficulties. Based on the above findings, we suggest that teachers should dig deeper into the relevant contents of textbooks, actively promote students to complete the tasks of science and technology projects, and give full play to students' subjective initiative. At the same time, teachers should provide timely and effective feedback on the results of students' science and technology projects, and promote the virtuous cycle of students in completing the mini projects tasks. This not only helps to improve students' hands-on ability, but also enhances their understanding of science knowledge, and ultimately promotes the smooth development of the science and technology projects course.

In the future, we will also study the case design and diverse functions of science and technology mini projects course. Through thus in-depth study, we expect to be able to provide richer teaching references for front-line teachers and to promote the effective implementation of the course.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

CONSENT

All the interviewees consent the use of their views for analysis and publication purpose of the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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