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Guidance on Finding Problems Systematically Based on Questions, Research Questions and Hypotheses —Research on Teaching Methods for Setting Assignments Connecting Junior High School and High School—

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Abstract

The purpose of this study is to improve students' ability to identify issues. In order to achieve this goal, we considered a science and mathematics curriculum. In connects junior high school and high school, and questions, research questions and hypotheses are systematically arranged for the inquiry-based research in secondary schools. We also developed a student textbook with which teachers instruct students in setting issues. We practiced it to students from the 1st year of junior high school to the 2nd year of high school for one year in the 2021 academic year. In Japanese high schools, inquiry-based activities have come to be emphasized due to the introduction of a new subject area "Science and Mathematics" and subjects such as "Basic Inquiry-Based Study of Science and Mathematics" and "Inquiry-Based Study of Science and Mathematics" in the new Course of Study [1] from 2022. On the other hand, guidance on setting research questions is left to the experience of each teacher [2]. If the research plan is made while the research questions or hypotheses are vague, the research may not be sufficiently deepened. There is also a previous study that high school students are inadequate to set hypothesis [3]. We will report the results and issues of the science and mathematics curriculum for secondary school and the textbook that specifically shows the teaching method in setting research questions.

Keywords: *Ability to identify issues, Science and Mathematics Curriculum, Scientific Inquiry*

1. Background of the study

In Japan, there is a need to improve the quality of learning, and in particular, the importance of incorporating inquiry-based activities is mentioned. Domestic surveys have revealed that there are problems in the implementation of inquiry-based activities in high schools. For example, in the teacher questionnaire survey on the basics of chemistry classes in the high school course of study implementation survey report conducted by the National Institute for Educational Policy Research [4], 36.9% of the respondents answered positively to the question, "Do you incorporate learning activities in which students make predictions based on their own ideas and then observe and experiment?" In addition, 13.6% of the respondents answered positively to the question, "Do students adopt a learning plan to plan observations and experiments based on their own ideas?"

In order for students to make plans for observations and experiments based on their own ideas, it is necessary for students to have a process of identifying issues on their own. However, previous studies have pointed out that high school students are inadequate in their ability to formulate hypotheses. Inagaki (2015) [3] reported that although research projects enable students to make positive efforts in experiments and presentations, they are insufficient in terms of students' issues with the discovery and hypothesis setting. Yamashina (2020) [2] points out that there are situations where the guidance of issue settings in high schools is left to the supervising teacher. Although, the guidance will be based on the experience of each teacher.

Therefore, the purpose of this study is to improve students' ability to identify issues by devising and practicing a science and mathematics curriculum for systematic issues-setting situations that connects junior high school and high school.

2. Purpose of the study

The purpose of this study is to improve students' ability to identify issues. In order to achieve this goal, we considered a science and mathematics curriculum.

3. Research Outline

3.1 Practice of classes and Implementation period

A total of 705 students were eligible, including 308 students in grades 1 to 2 at public high schools, which are super science high schools in Tokyo, and 397 students in grades 1 to 3 of the attached junior high school. We practiced it on students from the 1st year of junior high school to the 2nd year of high school for one year in the 2021 academic year.

3.2 The characteristics of the practice of this study

Previous studies on the conversion process from question to research questions include, for example, the study of Yoshida and Kawasaki (2020) [5], which pointed out that elementary school students lack knowledge about research questions formation and conversion into research questions. From this, we consider that the lack of knowledge to generate research questions from questions and to formulate hypotheses from research questions is a factor that makes it difficult to find problems even in high school students.

Based on these previous studies, we decided to examine a curriculum that systematically arranges questions, research questions, and hypotheses on guidance regarding issue settings in subject research at integrated junior and senior high schools. In addition to examining the curriculum, we developed a textbook for teaching students to set issues as a specific way to instruct students and used the developed textbook to practice it for students from the first grade of junior high school to the second year of high school for one year.

The characteristics of the practice of this study are as follows.

① The curriculum systematically arranged guidance on questions, research questions, and hypotheses for the inquiry-based research in secondary schools.

② Based on the annual plan, a course was established to learn specific methods for problem discovery, hypothesis, and verification plans necessary for issue setting situations.

③ In order to make the learning content of junior high school and high school more systematic, content on questions, research questions, and hypotheses of learning in the issues finding scene was arranged.

④ In order to enable teachers who have no experience in teaching subject research to teach in the course, we developed textbooks that specifically indicate the contents of instruction and conducted in-school training to share information on teaching methods.

Table 1. The Science and mathematics curriculum that systematically arranges questions, research questions, and hypotheses developed in this study

grade	course	questions	research questions	hypotheses	time	substance
1st grade of junior high school	Research questions Discovery Course Ⅰ	○			1	Mind Maps Quote from a book
		○			2	Mind Maps Quote from the web
		○	○		3	What is a question? What is a research questions? Converting questions into research questions
2nd grade of junior high school	Research questions Discovery Course Ⅱ				1	What is a thesis? Why write a thesis?
		○			2	When do I have questions? What does it mean to have questions?
			○	○	3	Flesh out questions with mind maps Flesh out questions and conversion process from question to research questions
3rd grade of junior high school	Basic Exploratory Course	○	○		1	What is inquiry? The difference between study and inquiry What is scientific? The process of exploration
		○			2	What is a mathematical view and way of thinking? What is a science view and way of thinking?
		○			3	About “Inquiry-Based Study of Science and Mathematics” in the new Course of Study Set up research questions
			○	○	4	Process of issues Solving Setting a hypothesis Hypothesis examine

			○	○	5	Make a plan to validate the hypothesis
				○	6	Scientific evidence Processing numerical values in experiments
					7	Experience the verification flow Quantitative experiments
					8	Make a table from experimental results Make a graph from experimental results
					9	Discuss from the results Discussion Conclusion
					11	Trial and error Self-improvement Value Creation
				○	12	Survey Comparison Issue Judgment Hypothesis explanation Planning Practice Analysis Interpretation Conclusion Communication
1st grade of high school	Research questions Discovery Course Ⅲ	○	○		1	Workshops for discovering research questions
		○	○		2	What does it mean to "think" inquiringly?
		○	○		3	How to investigate previous research Learn the perspective of problem discovery from previous papers
	Research Plan Course Ⅰ	○			1	Example of Poster Layout for Research Proposal Trial and error Self-improvement Value Creation
				○	2	Survey Comparison Issue Judgment Hypothesis explanation Planning Practice Analysis Interpretation Conclusion Communication
		○	○		3	What is a question? Flesh out questions and conversion process from question to research questions
		○	○		4	Cross-grade exchange Presentation of Research Projects Record comments from senior students
		○	○		5	Organizing and sharing information obtained through cross-grade exchanges Review and Improvement of Research Questions
			○		6	Explain the revised research questions and background to the faculty member in charge
			○		7	Investigating previous research to clarify the background
			○	○	8	Setting a hypothesis Case study Make a plan to validate the hypothesis
			○	○	9	From hypothesis setting to verification plan
			○	○	10	Explain the research plan to the faculty member in charge Preparation of a research proposal
				○	11	Cross-grade exchange Presentation of research proposal Record comments from senior students
				○	12	Organizing and sharing information obtained through cross-grade exchanges Review and Improvement of research proposal
2nd grade of high school	Research Plan Course Ⅱ	○	○	○	1	Presentation of research question in cross-grade exchange Improvement of research projects
		○	○	○	2	Presentation of research projects in cross-grade exchange Improvement of research projects

4. Result and discussion

After the course, students conducted a questionnaire survey to investigate whether they felt that their ability to identify issues had improved. The responses were based on the five-point method: 5: improved, 4: slightly improved, 3: neither improved nor decreased, 2: slightly decreased, and 1: decreased. Table 2 shows the aggregated results. The results suggest that there is a certain effect on issue settings.

Table 2. Answers to the question of whether you feel your ability to identify issues has improved

grade	course	Number	Mean	Standard deviation	The students felt their ability to identify issues had improved.
1st grade of junior high school	Research Questions Discovery Course Ⅰ	129	4.132	0.794	80.6%
2nd grade of junior high school	Research Questions Discovery Course Ⅱ	107	4.028	0.733	75.0%
3rd grade of junior high school	Basic Exploratory Course	109	3.872	0.721	69.1%
1st grade of high school	Research Questions Discovery Course Ⅲ	104	3.692	0.915	57.7%
	Research Plan Course Ⅰ	107	4.084	0.728	77.6%
2nd grade of high school	Research Plan Course Ⅱ	184	3.750	0.763	58.9%

5. Conclusion

The purpose of this study is to improve students' ability to identify issues. In order to achieve this goal, we considered a science and mathematics curriculum. In an awareness survey of students, more than a certain number of students felt that their ability to identify issues had improved after taking the course. In the future, we will continue to implement the science and mathematics curriculum developed in this research and it is a challenge to obtain objective data on whether the improvement of students' ability to identify issues can be seen in future survey questions.

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