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Problem-Solving Structure in Primary Science Textbooks: Question Placement Across Scenes

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Problem-solving lessons in science education structure the sequence through which learners identify problems, make predictions, consider methods, conduct observations or experiments, and draw conclusions. In such lessons, questions guide the learners' thinking about each scene of the problem-solving process. In addition, textbooks in many countries serve as key materials for shaping instruction. Therefore, examining the scene in which each textbook question is presented provides a means of understanding the problem-solving structure intended by the textbooks. This study aims to identify which scenes are associated with questions in Mongolian primary science textbooks and interpret these tendencies with reference to findings from research on Japanese textbooks. Science textbooks for Grades 4 and 5 in Mongolia were analysed, and all questions were extracted and classified into six scenes: Background, Problem, Hypothesis, Method, Result, and Discussion. The analysis showed that questions appear in the Problem and Discussion scenes, whereas questions associated with the Hypothesis and Method scenes were few. Reference to findings from Japanese textbooks suggests that the scenes emphasised in textbook questions differ according to national and educational contexts. These results indicate that analysing the placement of questions by scene offers a useful framework for understanding the structural characteristics of the problem-solving processes represented in science textbooks.

Keywords: Mongolia, primary school science, problem-solving, textbook, question

INTRODUCTION

Science education aims to cultivate learners' ability to identify problems in natural phenomena and solve them logically. In this context, problem-solving–based lessons are generally understood as opportunities for learners to deepen their understanding of natural events and develop evidence-based reasoning skills, and thus constitute a central

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component of science learning. Scientific literacy, as defined internationally, emphasises the ability to explain phenomena, design scientific inquiries, and make judgments based on evidence (OECD, 2017), making the cultivation of such competencies a shared challenge across countries.

Prior research has discussed various learning approaches related to scientific inquiry and problem solving. Inquiry learning has been conceptualised as a process involving multiple interrelated activities (Pedaste et al., 2015) and combining scaffolds to support inquiry has been shown to promote problem identification and planning (Gunawan et al., 2020). Linking inquiry with scientific literacy has been shown to enhance critical thinking skills such as interpretation, analysis, reasoning, and evaluation (Sutiani et al., 2021). These findings indicate that inquiry- and problem-solving-based learning substantially influence how learners construct scientific understanding.

Problem-solving lessons play an important role in science education as they provide a structured framework through which learners can identify a problem, make predictions, consider methods for solving it, and draw conclusions based on the results of observations or experiments. By organising this sequence of steps, problem-solving lessons support learners not only in acquiring scientific knowledge, but also in gradually developing the ability to reason and make judgments based on evidence. In this sense, problem-solving lessons function as an instructional structure that clarifies the flow of thinking—from recognising problems to interpreting results—and guides the development of learners' scientific reasoning. Given this educational role, examining which scene of the problem solving process each question corresponds to in the textbook is essential for clarifying how the intended structure of problem solving is represented in instructional materials.

In Japan, problem-solving-based science lessons are those in which learners identify a problem, conduct observations and experiments based on a prior prediction, and organise their ideas based on the results. This process has often been analysed by dividing it into several "scenes" representing shifts in learners' thinking during lessons or within instructional materials. Textbooks not only present scientific content, but also function as materials that structure the flow of problem solving. Questions in textbooks serve as cues that indicate the type of thinking learners are expected to engage in within each scene of the problem-solving process. Therefore, clarifying which scenes in the problem-solving process are associated with textbook questions is essential for understanding how textbooks shape the intended problem-solving structure.

Japan has accumulated substantial research analysing the relationship between textbook questions and problem-solving processes. Previous studies have categorised questions in lower secondary science textbooks according to problem-solving, revealing scene-specific tendencies (Mori et al., 2012; Watanabe et al., 2012). Nakayama and Saruta (2015) also demonstrated the trends in questions found in primary school science textbooks by focusing on scenes within the problem-solving process. These studies indicate that textbook questions help guide students' thinking, and analysing the correspondence between scenes and questions helps understand textbook design. This perspective is also consistent with classic views of problem-solving as a structured

process of reflective thinking, in which learners move from identifying a problem to generating hypotheses, testing ideas, and drawing conclusions (Dewey, 1910), as well as with more recent models of scientific reasoning.

In Mongolia, the national curriculum outlines the abilities associated with problem solving. Hikami (2020) reported that Mongolian primary science textbooks include different types of questions depending on the content domain, suggesting that the form of the intended problem-solving lessons may vary. However, insufficient attention has been paid to the question of which scenes in the problem-solving process are associated with textbook questions; that is, how textbooks structure the intended flow of problem solving.

This study aims to clarify which scenes in the problem-solving process are associated with textbook questions in Mongolian primary science textbooks. By referring to the distribution of questions reported in prior analyses of Japanese textbooks, this study examines how the structure of the problem-solving process represented in Mongolian textbooks can be interpreted in relation to these previous studies. It should be noted that this study does not conduct a direct comparative analysis but uses previously reported findings as a descriptive reference. By analysing the placement of questions across scenes in the problem-solving process, this study aims to visualise the relationship between the intended progression of scientific reasoning and the design of textbook questions. This perspective not only deepens the understanding of Mongolian science education, but also provides an analytical lens applicable to comparative studies of science textbooks in other countries.

To achieve this aim, the study addresses the following research questions: (1) What scenes of the problem-solving process are associated with questions in Mongolian primary science textbooks? (2) How can the distribution of these questions be interpreted in relation to findings from previous studies on Japanese textbooks?

METHOD

Research Materials

This study analyses the Grade 4 and Grade 5 science textbooks used in Mongolian primary schools (Altantsetseg et al., 2014a; Altantsetseg et al., 2014b). Science is taught only in these two grades at the primary level; therefore, the corresponding textbooks were selected as research materials. All questions explicitly presented in the textbooks, including those in the main text and those attached to the figures and tables, were extracted as units of analysis. No distinction was made between the different functions or cognitive levels of the questions; all statements in a questioning form that required learners to think, check, judge, or act were treated as questions.

The present study did not re-analyse Japanese primary school science textbooks. Instead, this study referred to the number and distribution of questions reported by Nakayama and Saruta (2015) as descriptive reference data for each scene in the problem-solving process.

Framework of the Problem-Solving Process

The Mongolian national science curriculum specifies the abilities required for problem solving, such as identifying problems, generating hypotheses, planning and carrying out activities, processing information, and drawing conclusions; however, it does not present in detail how the flow of the problem-solving process should be structured in textbooks or instructional materials.

To examine how the problem-solving process is positioned in Mongolian science education, this study adopted the scene names and definitions proposed by Nakayama and Saruta (2015), who analysed Japanese primary science textbooks. Six scenes—Background, Problem, Hypothesis, Method, Result, and Discussion—were used as an analytical lens through which the abilities indicated in the Mongolian curriculum were aligned and reorganised into a six-scene structure (Table 1).

Table 1
Scenes of the problem-solving process and corresponding abilities in the Mongolian curriculum

Scene	Description of the Scene	Abilities Specified in the Mongolian Curriculum
Background	Scene that provides the premise for setting up the problem	Investigating natural objects and phenomena
Problem	Scene in which the problem to be addressed is established	Asking questions (identifying the problem)
Hypothesis	Scene in which predictions are generated and prospects for solving the problem are formed	Formulating hypotheses
Method	Scene in which methods for solving the problem are examined	Planning activities
Result	Scene presenting and analyzing facts obtained from observations or experiments	Carrying out planned activities; processing information
Discussion	Scene in which facts are interpreted in relation to the initial problem and a conclusion is drawn	Drawing conclusions

Source: Created by the authors based on Nakayama and Saruta (2015) and the Mongolian Curriculum (MoES 2014).

These six scenes provide a way to organise the problem-solving processes that learners are expected to experience in science learning. While the author's previous study (Hikami, 2020) examined question types (e.g. "what", "why") to identify characteristics of intended problem-solving lessons, the present study retains the overall framework but shifts the analytical focus. Instead of analysing the linguistic form or type of question, this study focuses on which scene of the problem-solving process each question corresponds to.

Drawing on prior research and the abilities specified in the Mongolian curriculum, this study reorganised the problem-solving process into six scenes and analysed the

placement of questions in textbooks with reference to this framework. This approach was intended to ensure consistency with previous research while providing a structured basis for interpreting the distribution of questions across scenes.

Procedure for Extracting Questions

All questions were extracted through careful reading of the text and accompanying visual elements in the textbook. In addition to sentences containing interrogative words or question marks, statements written in the form of questions that required learners to think, judge, or act, despite lacking an explicit question mark, were also included. This extraction procedure followed the established criteria used in previous studies that analysed questions in science textbooks (Nakayama & Saruta, 2015; Mori et al., 2012; Watanabe et al., 2012). This ensured consistency with previous research and maintained the validity of the extraction criteria. The extraction and subsequent classification of questions were conducted by the author based on the criteria established in previous studies. While these criteria provided a structured basis for analysis, no inter-rater reliability measures were applied. Therefore, the classification may involve a degree of subjectivity, which should be considered when interpreting the results.

Criteria for Classifying Questions

Each extracted question was classified according to the scene in which it appeared during the six-scene problem solving process. Some questions did not correspond clearly to any of the six scenes. These questions—equivalent to those categorised as "utilization", "issue", or "other" in the author's previous study (Hikami, 2020)—were grouped into a single "other" category. To maintain the total number of questions, while focusing on the structure of the problem-solving process, the analysis used seven categories: Background, Problem, Hypothesis, Method, Result, Discussion, and Other.

The classification was conducted with reference to criteria proposed in earlier studies (Mori et al., 2012; Watanabe et al., 2012), which were selectively refined and reorganised to align with the purpose of the present analysis (Table 2). When a question corresponded to more than one scene, it was assigned to the scene that most directly reflected the primary intent of the question within the instructional context. This decision was based on the interpretation of the instructional intent of the question within the learning context.

Table 2
Criteria for classifying questions into problem-solving scenes

Scene	Description of Questions in Each Scene
Background	Questions that prompt awareness of phenomena or situations serving as the background for learning
Problem	Questions intended to set or clarify the problem to be solved
Hypothesis	Questions asking learners to predict or explain results (hypothesis generation)
Method	Questions prompting examination of methods or procedures for verification
Result	Questions requiring organization or confirmation of observational or experimental results
Discussion	Questions prompting interpretation of results as evidence for reasoning
Other	Questions that do not correspond to any of the above scenes

Source: Created by the authors based on Mori et al. (2012) and Watanabe et al. (2012).

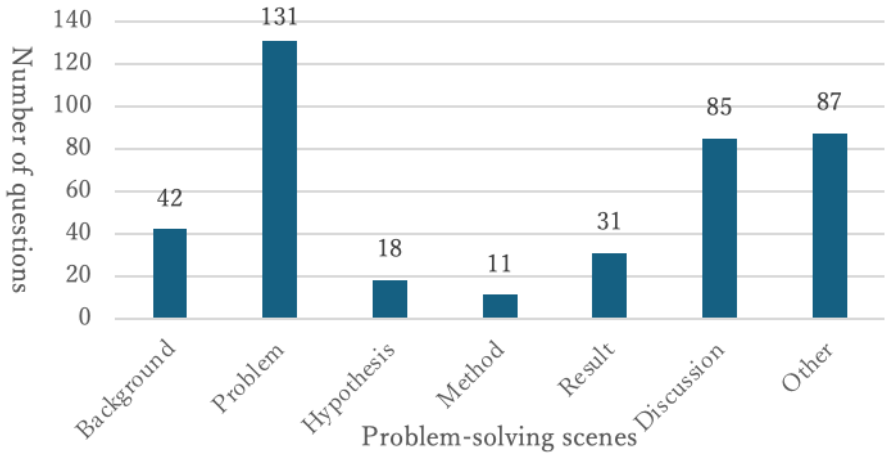
Some questions were reclassified differently from those in the author's previous study (Hikami, 2020) because the scene boundaries and classification criteria were refined for the present analysis. As a result, differences in the number of questions across scenes reflect this refined framework rather than any coding errors.

FINDINGS

Distribution of Questions in the Textbooks

Figure 1 presents the results of extracting all questions from the Grade 4 and Grade 5 Mongolian primary science textbooks and classifying them into the six scenes of the problem-solving process or into the "other" category.

Figure 1
Number of questions classified into each scene of the problem-solving process



As shown in Figure 1, the largest number of questions (131) were classified into the Problem scene, followed by the Discussion scene with 85 questions. In contrast, the Hypothesis scene contained 18 questions and the Method scene contained only 11 questions, both of which were considerably fewer than those in other scenes. The Background scene contained 42 questions and the Result scene contained 31 questions. These findings show that the number of questions included in the textbooks varies across different scenes of the problem-solving process.

DISCUSSION

This study aimed to clarify the structure of the problem-solving process in Mongolian primary science textbooks by examining the scene of the process in which each question was placed. In this section, the structural characteristics identified through the analysis are discussed. As questions are the central elements that guide learners' thinking in each scene of a problem-solving lesson, analysing the scene where each question is placed is helpful for interpreting the intended structure of the problem-solving process in the textbook.

Overall Characteristics

The results show that questions in Mongolian primary science textbooks are not evenly distributed across the problem-solving process. A large number of questions concentrated on the Problem and Discussion scenes, whereas relatively few questions were placed in the Hypothesis and Method scenes.

This pattern suggests that textbooks may emphasise presenting the problem clearly at the beginning of learning and supporting the formulation of ideas at the end of learning based on the results. This interpretation is based on the observed distribution of questions across the different scenes. In other words, Mongolian science textbooks appear to focus their support on scenes that clarify the direction of learning and the expected learning outcomes.

Questions in the Problem and Discussion Scenes

This section examines the implications of the relatively large number of questions in the Problem and Discussion scenes. The frequent placement of questions in the Problem scene likely serves to clarify the purpose of learning. When the goal of learning is clarified through questions, learners can gain a clearer overall view of the lesson, making it easier to understand the meaning of subsequent activities.

Similarly, the large number of questions in the Discussion scene suggests an emphasis on supporting learners' reasoning as they interpret results and draw conclusions. Such questions are likely to help learners articulate their understanding and consolidate what they learned at the end of the lesson.

Taken together, concentrating questions in the Problem and Discussion scenes can be interpreted as a textbook design feature that prioritises the presentation and reinforcement of the structural framework of learning.

Questions in the Hypothesis and Method Scenes

This section examines the implications of the relatively limited number of questions in the Hypothesis and Method scenes. In the Hypothesis scene is where learners make predictions or generate ideas about a problem, forming a prospect for solving it. In the Method scene, learners consider procedures or methods to test their hypotheses.

The scarcity of questions in these scenes implies that, although learners are guided to identify the problem and organise the results, they may have fewer opportunities to verbalise and construct reasoning processes that connect these scenes. This suggests that the structure of the problem-solving process in the analysed textbooks may place greater emphasis on identifying the problem and understanding or interpreting the results rather than formulating hypotheses or planning methods.

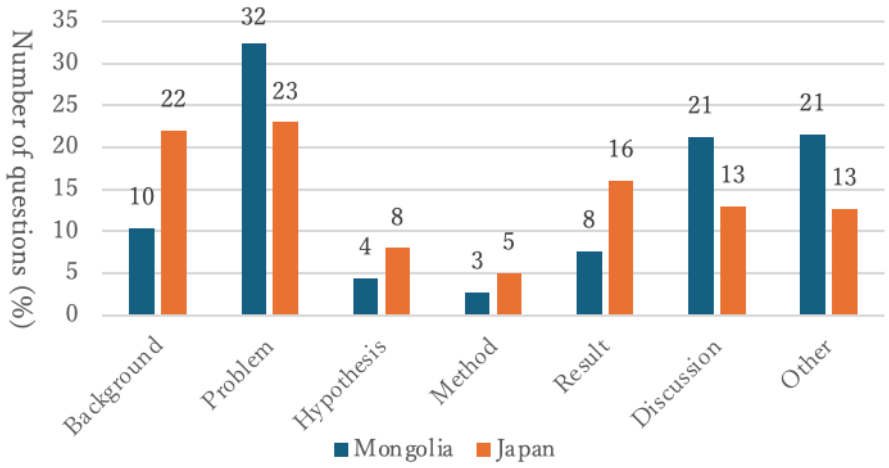
However, the limited number of questions in these scenes does not necessarily indicate a deficiency in the textbooks. It is possible that the processes of constructing hypotheses or planning methods may be supplemented by teacher questioning and instructional practice during lessons; however, this study does not include classroom observations, and this interpretation should therefore be treated with caution. In this sense, Mongolian science textbooks may primarily serve to present the framework of problem solving while leaving the detailed unfolding of learners' thinking processes to classroom instruction.

Comparison with Research on Japanese Science Textbooks

This section compares the question placement characteristics identified in this study with findings from previous research on Japanese primary science textbooks. It should be noted that the results for the Japanese textbooks cited here are not based on new analyses conducted in the present study, but rather on the findings reported by Nakayama and Saruta (2015). According to their analysis, questions tend to be frequently placed in the Background, Problem, Result, and Discussion scenes of the problem-solving process. Figure 2 presents a comparison between the results of the

present study and those reported by Nakayama and Saruta (2015), which were converted into proportions for each scene.

Figure 2
Comparison of the number of questions classified into each scene of the problem-solving process



As shown in Figure 2, questions in the Mongolian textbooks were concentrated in the Problem and Discussion scenes. Moreover, the number of questions in the Hypothesis and Method scenes was relatively small compared to that in Japanese textbooks.

These differences suggest that the scenes in which textbooks encourage learners to think through questions vary across countries. They also indicate the presence of structural differences in how textbooks construct the flow of problem solving depending on which scenes are emphasised.

Through such comparisons with existing research, examining textbook questions from the perspective of the scenes in which they are placed allows for a relative understanding of the structural characteristics of problem solving emphasised in the textbooks of the two countries.

Relationship Between the Structure of the Problem-Solving Process and Question Placement in Textbooks

Although the Mongolian science curriculum specifies the abilities required for learners to identify and solve problems based on natural phenomena, it does not define in detail how the anticipated flow of the problem-solving process should be structured and presented in textbooks. This study adopted the scene framework of the problem-solving process used in previous research as an analytical lens to examine where questions appear within the process.

The analysis revealed imbalances in the number and placement of questions across the scenes. Questions were frequently placed in the Problem and Discussion scenes, whereas the Hypothesis and Method scenes contained relatively few questions. This

may indicate that Mongolian textbooks tend to place questions primarily in scenes related to problem identification and the interpretation of results, while offering limited questioning support in scenes corresponding to prediction or method planning.

In other words, Mongolian science textbooks appear to be structured such that questions are concentrated in scenes that clarify the problem and guide the interpretation of results, whereas questions corresponding to intermediate processes, such as generating hypotheses or examining methods, are limited. These intermediate processes are expected to be supported by teacher questioning and instructional practice during lessons.

Summary

This study examines which scenes of the problem-solving process contain questions in Mongolian primary science textbooks. The findings revealed that the questions were not evenly distributed across the scenes; rather, they were concentrated in the Problem and Discussion scenes, whereas the Hypothesis and Method scenes contained fewer questions. This tendency may reflect a textbook structure that emphasises presenting the direction of learning and clarifying understanding at the end.

This analytical perspective is useful for identifying which scenes of the problem-solving process are explicitly supported in textbooks and which scenes are left relative to classroom practice. Furthermore, analysing the correspondence between scenes and questions offers a perspective for examining how the structure of problem solving differs across national, educational, and cultural contexts.

CONCLUSION

This study examined Mongolian primary science textbooks to identify the scenes of the problem-solving process in which the textbook questions are placed. The analysis revealed that questions were not evenly distributed across the scenes of the process; rather, they were concentrated in the Problem and Discussion scenes, whereas the Hypothesis and Method scenes contained fewer questions.

These findings suggest that the problem-solving process in the analysed Mongolian science textbooks is not treated in an evenly structured sequence, although this interpretation is limited to the materials examined in this study. Instead, textbooks appear to be organised in ways that emphasise scenes that clarify the problem and support the interpretation of results. In other words, textbooks place greater emphasis on guiding the direction of learning and clarifying expected outcomes, whereas scenes corresponding to intermediate processes, such as making predictions or examining methods, are presented less explicitly.

Furthermore, by referring to the questions reported in previous research on Japanese primary science textbooks, this study suggests that the characteristics of textbook design may differ across educational contexts. Although the present study did not directly analyse Japanese textbooks using the same criteria, the findings of earlier research were used as a reference frame to interpret the structural characteristics of problem-solving reflected in textbooks from both countries in relation to each other.

The significance of this study lies in its analytical focus on the relationship between problem-solving scenes and textbook questions, which provides a framework for examining how instructional structures are represented in educational materials. The academic contribution of this study lies in its focus on the scenes of the problem-solving process in which questions are placed rather than the content or form of questions. This approach made it possible to visualise which aspects of learners' thinking are explicitly supported in textbooks and which aspects remain relatively implicit. This analytical perspective enables a relative understanding of the intended structure of the problem-solving process represented in textbooks and provides a useful framework for examining how approaches to problem solving differ across national, educational, and cultural contexts.

However, this study has several limitations. First, the analysis targeted the 2014 edition of Mongolian primary science textbooks, and did not include revised editions or more recent curricula. Second, the comparison with Japanese textbooks relied on findings from previous studies rather than a direct analysis using identical criteria. Third, the classification of questions was conducted by a single researcher based on predefined criteria, and no inter-rater reliability measures were applied, which may limit the objectivity and reproducibility of the findings.

Future research should examine the revised editions of textbooks as well as classroom practices, and conduct international comparative studies to explore the diversity of textbook design related to the problem-solving process and its educational implications from a broader perspective.

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