Development of a self-reflection scale for observers of mathematics lesson during lesson study

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Abstract

Purpose – This study aims to develop a self-reflection scale useful for teachers to improve their skills and to clarify the Japanese teachers' characteristics during mathematics lesson observation (MLO). In MLO, it is important to understand the lesson plan in advance to clarify observation points, and we aim to develop a scale including these points.

Design/methodology/approach – Based on the pre-questionnaire survey, nine perspectives and two situations for MLO were extracted. From these, a questionnaire for MLO was created. The results obtained from 161 teachers were examined, and exploratory factor analysis was conducted. ANOVA was conducted to analyze the effect of differences across the duration of teaching experience on the identified factors.

Findings – We developed a self-reflection scale consisting of 14 items with three factors: [B1] focus on instructional techniques and evaluation, [B2] focus on proactive problem-solving lesson development and [B3] focus on the mathematical background of the learning content. While duration of teaching experience showed no effect, three factors of the self-reflection scale for MLO showed a significant effect. Further multiple comparisons revealed the degree of focus was [B2]>[B1]>[B3].

Originality/value – Teachers who use this developed scale may grasp the strengths and weaknesses of their own MLO, which leads to self-improvement. The perspectives emphasized in lesson observation are the same when creating lesson plans and implementing lessons, leading to lesson improvement. Furthermore, based on the characteristics of teachers revealed, new training programs regarding MLO can lead to higher-quality lesson studies.

Keywords Mathematical lesson observation, Mathematics education, Self-reflection scale

Paper type Research paper

1. Introduction

1.1 Background and purpose of this research

Lesson study is a collaborative, practice-based inquiry cycle that centers on the study of teaching materials, as well as planning, observation and analysis of actual classroom lessons (Takahashi *et al.*, 2013). Currently, most studies focus on approaches taken before the

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research lesson, including lesson planning and on post-lesson discussion after the research lesson (Murata, 2011; Estrella *et al.*, 2018; Lim *et al.*, 2018; Archer, 2021). However, not many studies focus on observation itself during the research lesson, and there is insufficient work in characterizing and analyzing the implementation of lesson observations (Lewis and Hurd, 2011; Larssen *et al.*, 2018). Since learnings from lesson observations are important for improving lesson practice, there is a recent movement toward a greater focus of research on methods of lesson observations in mathematics education (Lee and Choy, 2017).

According to Takahashi and Yoshida (2004), to understand what a teacher intends to teach, observers need to collect data with the lesson goals in mind and use the lesson plan, seating chart and worksheet to record observations in a lesson study. However, the dearth of a common since there is no common self-reflection scale for observers of mathematics lesson has resulted in, teachers are just participating in lesson studies with their own reflection standards. In addition, we believe it is important for teachers to capture the characteristics of their Mathematics Lesson Observation (MLO, please refer §2.2 for definition) for reflection. Therefore, we develop a framework for to support teachers in better understanding their strengths and weaknesses during MLO, which can lead to higher quality lesson study programs.

In this study, we focus only on mathematics education and set the following two research questions.

(1) What are the different perspectives or foci that should be included in a self-reflection scale for MLO?

(2) Are there differences in responses to the MLO survey depending on duration of teaching experience?

To respond to these questions, this study aims to clarify the perspectives—what points to focus on—in lesson observations (please see §2.3 for details), to develop a self-reflection scale for the MLO survey and to characterize degree to which Japanese elementary school teachers focus on each item of self-reflection scale for MLO.

1.2 Literature review

Lesson observation is an important component of lesson study (Saito *et al.*, 2007), and appropriate observation skills are necessary for teachers to learn from instructional practices of other teachers and to reflect on their own teaching (Fitriati *et al.*, 2022). Danielson (2012) indicated that observers need to acquire certain skills to conduct fair and reliable observations of teaching, in order to evaluate quality of teaching and learning. This may be based on two domains of the Danielson Framework for Teaching: the classroom environment and instruction. The Mathematical Quality of Instruction (MQI)—developed by the University of Michigan and Harvard University—is also a widely known observation framework to measure the quality of mathematics lesson and can furthermore be applied for teacher professional development (Hill *et al.*, 2008). Hierbert *et al.* (2007) claimed that empirical observation of teaching and learning is a necessary component for analyzing teaching during teacher preparation programs. They also mention that following "Knowing" about (1) evidence about student's learning (effectiveness of teaching), (2) achievement of learning goals and (3) key moments to achieve the evidence are required.

However, most studies focus on an observation framework for improving the quality of teaching, and a number of them lack a framework for judging the effective implementation of observation itself (Larssen *et al.*, 2018; Fitriati *et al.*, 2022). The ability to properly evaluate a lesson depends on each teacher's perspective. Therefore, it is important to understand one's own tendencies and characteristics regarding lesson observation, to develop one's strengths and to improve one's weaknesses. Since teachers participate in lesson study far more often as observers than as lesson practitioners, the significance of teacher development as observers becomes apparent.

While the focus of observation is usually on teacher's activities, students' activities and students' learning, etc., self-reflection standards vary greatly from person to person (Lewis and Hurd, 2011; Larssen *et al.*, 2018; Baldry and Foster, 2019). It has also been reported that some teachers (e.g. beginning teachers) lacking observation skills find it difficult to improve their own lessons because their observations and analyses are superficial.

Regarding what teachers pay attention to when reflecting on their observations for mathematics lessons, Fitriati *et al.* (2022) qualitatively analyzed results of self-reflection of MLO in a lesson study of pre- and in-service teachers to extract four frameworks of "Student's Learning," "Students' Behavior," "Students' Disposition," and "Teacher Performance".

Ingram *et al.* (2018) reviewed some of observation frameworks developed to examine the possibility of developing an internationally common observation framework regarding mathematics education. For example, the Mathematics Education Traditions of Europe project (Török, 2006) listed four categories of frames: "mathematical focus (the objectives of a teacher's actions and decision making)," "mathematical context (the conception of mathematics based on the real world and the genuineness of the data)," "didactics" and "used materials". This is a tool for studying the extent to which quality of teaching increases student achievement (value-added assessment scores). However, Ingram *et al.* (2018) conducted that common international use of a framework is limited and depends on the country's culture, curriculum and aspects it seeks to measure.

Thus, according to Ingram *et al.* (2018), the aspects that observers should look at vary on the culture and curriculum content of the country. Considering this, the self-reflection framework for observers presented by Fitriati *et al.* (2022) alone is not enough since it does not consider the culture, curriculum content and other factors. With further literature review, we found no research on frameworks to reflect on observers' own perspectives while taking national cultures, curricula and other factors into account.

In actual lesson studies, observations are conducted without necessarily using an observation framework described above. Although this allows for a greater degree of freedom and variety of discussion for observers, the breadth and depth of observation may be limited because each observer potentially focuses attention only on those aspects that each one is interested in. Therefore, the development of a common framework in a country or a same cultural group to self-reflect on perspectives of lesson observation is highly significant.

Another important factor to consider is "trends" in the subject matter or content of mathematics education. Newton and Alexander (2013) explicitly mention the importance of "trends": while the nature of mathematics does not change, its "trends" and contents of coursework can change significantly. Therefore, there is a need for a specific self-reflection scale as framework for teachers to reflect on their own lesson observations following the "trends" of the country/region, which formed the purpose of this study.

2. Setting up survey items related to MLO

2.1 Overview of methodological approach

First, the definition of MLO is established with the importance of understanding lesson plan in advance (§2.2.1) and trends in particular country/region (§2.2.2). Since this study is conducted in Japan, we reviewed the content of Japanese lesson plan and current "trends" in Japanese mathematics education (§2.2.3). Interviews were conducted with three teachers, and the results were consolidated to identify perspectives for self-reflection scale for MLO to be investigated (§2.3). Then, based on those perspectives, specific survey items were developed (§2.4). The developed items were then administered to approximately 200 teachers in a questionnaire survey (§2.5), and the results were analyzed (§3).

2.2 Definition of mathematical lesson observation

We claim that a self-reflection scale for MLO needs to be set up across following two situations:

(1) Understanding the content of a lesson plan before the research lesson and

(2) Observation of teaching and learning activities during a lesson.

2.2.1 Necessity for understanding the lesson plan in advance. As stated above, it is necessary to understand the "intention of the lesson" before a lesson observation. The lesson plan can serve as a tool for this purpose. "Understanding of lesson plan," therefore, refers to obtaining preliminary information from various descriptions of the unit and lesson such as what points and situations to focus on during the lesson observation. Other aspects may include the research teacher's views and the actions and behavior of students in relation to the goals of the lesson. In the section below (§2.2.3) we describe more about the specific case of Japanese lesson studies. However, we describe a little more about "trends" in next section.

2.2.2 Trends in mathematics. When observing a mathematics lesson, it is important to capture the essence of mathematics as an instructional content while making observations. The essence of mathematics—commonly understood worldwide regardless of social changes and needs—refers to the content, meaning, nature and structure of mathematical objects. However, methods of instruction vary with culture and time, which we call "trends" following Newton and Alexander (2013).

Hence, in this study, Mathematical Lesson Observation (MLO) is defined as a procedure of "understanding of lesson plans before lesson observations and then observing mathematics research lesson based on the essence of mathematics and trends in mathematics education". In the next section, we will describe more concretely for the case of Japan.

2.2.3 Case in Japanese lesson study. Each country/region has its own structure of a "lesson plan" A typical Japanese lesson plan includes the following sections:

(1) Goals of the unit (how students' learning will look like at the end).

(2) Criteria for student evaluation of the unit.

(3) View on children: The situation of students in relation to the contents and activities.

(4) View on teaching materials: Significance and aim of the teaching material (what is to be learned) and its relationship with other learning contents.

(5) View on teaching: What to pay attention to when teaching.

(6) Teaching plan for the entire unit (including learning activities and evaluation for each period).

(7) Goals of the particular lesson.

(8) Development of the particular lesson.

(9) Blackboard plan (what and how a teacher writes on blackboard/whiteboard).

By reading these descriptions in advance, lesson observers can obtain preliminary information such as aspects of contents and pedagogy to focus on during the lesson and how to evaluate the statements and actions of the lesson practitioner and students in terms of the goals of the lesson. The extent of such advance preparation, although outside of actual lesson time, is thought to have a significant impact on the quality of MLO.

As we described in §2.2.2, in lesson observation, it is also necessary to consider about educational trends. Since this study focuses on Japanese elementary school teachers, we summarize the aims of Mathematics, as indicated in Japanese Courses of Study, as trends:

(1) Required qualities and abilities (knowledge and skills in mathematics, ability to think, judge and express mathematically and attitude to engage in independent study of mathematics);

(2) Organizing a systematic and developmental mathematics curriculum;

(3) Deep learning that approaches the essence of mathematics through proactive and interactive learning;

(4) Integrated and developed consideration using mathematical viewpoints and ideas;

(5) Perspective and reflection in problem-solving process using mathematics;

(6) Awareness of the goodness of mathematics through development of acquisition, utilization and exploration;

(7) Solid learning in mathematics by supporting children according to their actual conditions and

(8) Improvement of mathematics lessons through integration of instruction and evaluation.

2.3 Perspectives for self-reflection scale for MLO

As mentioned above, there are two situations involved in MLO—understanding contents of lesson plan and observing research lesson. And understanding of lesson plan in advance will significantly influence the quality of lesson observations. Therefore, in this study, we interviewed three teachers—Teachers A and C along with an instructional supervisor (Teacher B) who specializes in Mathematics—about what points to focus on in their lesson observations along with their intentions and reasons.

Responses are expressed focusing on children's learning activities and level of understanding. Therefore, based on the intentions and reasons for focusing on them, we reinterpreted and analyzed the responses with a focus on teaching activities that lead to lesson improvement.

As a result, we find in each situation, teachers are judging whether the instruction is appropriate and capturing the essence of mathematics from the perspectives of goal, content, method and evaluation. Among these four, the perspective of method included following focused perspectives: lesson development, instructional methods, individual support, devising questions, devising blackboard writing and using teaching materials and teaching tools. As a result, following nine instructional aspects were established as necessary perspectives in the self-reflection scale for MLO:

(1) Objectives;

(2) Learning content;

(3) Lesson development;

(4) Instruction method;

(5) Individual support;

(6) Questioning;

(7) Blackboard writing;

(8) Teaching materials and teaching tools and;

(9) Learning evaluation.

We found that these perspectives were present in teachers' responses: [A, C, D, E, F, G, I] in Teacher A's, [B, C, D, E, F, G, H] in Teacher B's and [A, C, D, E, F, I] in Teacher C's responses. Sample answers to the interview survey are shown in Table 1.

2.4 Survey items to develop self-reflection scale for MLO

Based on the two situations and nine perspectives on MLO, specific survey items were formulated from the results of interviews and trends in mathematics education. As a result, a total of 31 survey items were derived: 15 for pre-lesson and 16 for during-lesson situations. To confirm the validity of these items, one public elementary school principal, one supervisor of school instruction, and three teachers were selected to examine the items. As a result, all items are confirmed valid.

In the survey, these responses were to be answered from 1: Doesn't agree, 2: Agree a little, 3: Half agree, 4: Quite agree, or 5: Very much agree, to measure the depth of an observer's awareness from each perspective. To indicate the correspondence between survey items and nine perspectives of MLO, symbols [A] to [I] are appended. Also, to indicate the correspondence between survey items and trends, numbers (1) through (8) are appended as well.

The final set of items are shown below:

<<Before Lesson>>

When observing mathematics lessons, do you understand the lesson plans and unit plan from the following perspectives?

(1) Objectives of today's lesson based on the goals of the unit [A]-(1).

(2) Lesson plan of the entire unit is designed from perspectives of "acquisition, utilization, and exploration" [B]-(6).

(3) Lesson plan captures the essence of learning content of the unit [B]-(3).

(4) Lesson plan captures the relationship of learning content of the unit [B]-(2).

(5) Lesson plan captures the learning process through mathematical activities [B]-(1).

(6) Learning contents of the unit are interrelated, and the unit as a whole is viewed in a structured manner [B]-(2).

(7) Learning contents are structured in such a way that students can use mathematical perspectives and ways of thinking [B]-(4).

(8) Learning contents are structured in a way that leads to integrated and developed learning activities [B]-(4).

(9) Meaning and intent of the contents in the textbook are correctly understood [B]-(1).

(10) Lesson development is organized from the perspective of "integration and development" of previously studied content [C]-(4).

(11) Pair or group activities are set up as needed [D]-(3).

(12) Student's reactions are anticipated in accordance with the learning activity [E]-(7).

(13) Assistance is prepared according to expected students' reactions [E]-(7).

(14) Scenes are set up to provide a sense of mathematical goodness [C]-(6).

(15) Evaluation is prepared for students' learning activities [I]-(8).

1) Point	2) Intent	3) Reason	Perspective found	Teacher
Do the teachers *keep the "questions" that most children have at the center of learning in their lessons?*	To check whether the children's "questions" have been elicited and whether a satisfactory solution has been obtained	Without *making the "questions" of each child apparent*, the content of the class will be overblown and result in a conventional understanding	A objectives	Teacher A
Setting assignments in the lessons	To check if the assignment is appropriate for the lesson in question to achieve the goals of the unit	*Appropriate task setting is essential to motivate* students *to learn and to deepen their understanding of learning*	B learning content	Teacher B
Achievement of self-solving by each child	Because the *development of the subsequent lessons will depend on* the actual situation of self-solving	Plan to set a time for self-solving, and *prepare how and how deep students should interact with each other afterward*	C lesson development	Teacher C
Teachers' assistance in developing problem-solving prospects	To check *what steps are being taken to enable children to have a prospective solution based on what they have already learned*	Because it is important how to apply the mathematical viewpoints and thinking that have already been learned and cultivated up to this point	D instruction method	Teacher B
Individualized support of teachers in lessons	To check *if the teacher's assistance is tied to the cause of the children's difficulties*	Because *appropriate teaching methods* must be based on the children's understandings	E individual support	Teacher B
Was the teacher's questioning back effective in deepening learning?	To check whether children's thinking is directed toward what the teacher wants them to think about at this lesson by *asking questions precisely where necessary*	If the teacher jumps to the correct answer, the discussion may end with one student's comment. It is necessary to relate figures, equations, and words	F questioning	Teacher A
Structured and well-planned blackboard writing in lessons	To check *whether intentional blackboard writing is used* to focus the learning in the lesson	Teachers' blackboard writing has a significant role *to play in* visualizing and structuring students' thinking	G blackboard writing	Teacher B
Preparation of teaching and learning materials for lessons	To check *whether appropriate teaching and learning materials and equipment are prepared* to enable the students to approach the objectives through mathematical activities	Because an *appropriate learning environment setting* is necessary to deepen students' understanding	H teaching materials and teaching tools	Teacher B

(*continued*)

Table 1.
Sample answers to the interview survey

1) Point	2) Intent	3) Reason	Perspective found	Teacher
Does the reflection on the learning of the period *correspond to the objectives and relate to the essence of the period?*	The content of the children's reflections will give us an idea of *the level of their understanding of the content of the study and the essence of mathematics*	It is to see if the students have been exposed to connections with previous studies, and if *they have been enriched with mathematical activities such as developmental thinking, changing conditions, and extending the scope*	I learning evaluation	Teacher A

Table 1.

Source(s): Created by authors

<<During Lesson>>

During your mathematical lesson observations, do you observe teacher and students from the following perspectives?

(1) Lesson development is designed so that students can solve problems by using the content they have already learned [C]-(6);

(2) Lesson development is designed to deepen learning through problem-solving [C]-(3);

(3) Lesson development is adjusted according to students' understanding [C]-(7);

(4) Introduction of the lesson is well designed so that students can identify problems on their own [D]-(4);

(5) Problem-solving learning activities in which students proactively work on their own are incorporated [D]-(3);

(6) Learning activities are well designed to make learning interactive [D]-(3);

(7) Instructional methods are well designed based on the actual conditions of students [D]-(7);

(8) Questions are well-thought so that students can have a prospect on problem-solving [F]-(5);

(9) Questions are designed for deep learning [F]-(3);

(10) Specific measures are contrived to cope with students' difficulties [E]-(7);

(11) Individualized instruction is provided in a flexible manner according to the actual conditions of students [E]-(7);

(12) Blackboard writing is designed to help students understand the learning process [G]-(5);

(13) Supplementary materials and handouts are used according to the learning contents [H]-(7);

(14) Teaching tools are utilized according to the learning content [H]-(7);

(15) Understanding of students is checked through evaluations during instruction [I]-(8)

(16) Evaluation criteria for the objectives of this lesson have been met [I]-(8).

2.5 Survey participants

First, the interview participants for the pre-survey were selected from the head mathematics teachers at elementary schools and from the supervisors in charge of the mathematics department of Board of Education, with whom one of the authors has been working with. Potential participants were briefed on the interview procedures and assured about the implications of their informed consent. In particular, we highlighted that they had the choice to participate in or withdraw from the study without being disadvantaged in any way relating to their career progression. Data were processed and managed anonymously. Three participants volunteered and were asked to type their answers to the questions in a Word file prior to the interview. Based on these responses, interviews were conducted by the authors to understand and probe the participants' thinking and intent behind their responses.

For the main survey, we sent the developed questionnaire to approximately 200 Japanese teachers. The participants for this questionnaire were recruited from the elementary schools we had worked with in mathematics lesson studies. The same ethical considerations were conveyed as in the pre-survey. The survey was conducted by distributing and collecting pre-printed survey forms. These participants are teachers who are usually involved in mathematics lesson studies, observing several research lessons a year as in-school training. Therefore, in their responses, it is assumed that they envisioned the observation of research lessons in an in-school training program. At the end, we obtained 161 responses.

Among 161 teachers, 42 have 5 years or less (beginning teachers), 29 have 6–15 years (young teachers), 52 have 16–25 years (mid-career teachers) and 38 have 26 years or more (veteran teachers) of teaching experience. In Japan, the first five years of teaching are considered a period for developing the fundamentals skills through various training programs.

3. Analysis of results

3.1 Overview of analysis

First, we conduct factor analysis while determining preliminary effects. We then determined factors of self-reflection scale for MLO. With the results of the questionnaire survey, the average score of each individual teacher for items belonging to each factor was calculated. And finally, two-way analysis of variables (ANOVA) was conducted to control the duration of teaching experience and factors of self-reflection scale for MLO.

3.2 Ceiling and floor effects

Means (M) and standard deviations (SD) were obtained for each item to determine the ceiling and floor effects. Since a 5-point scale is used, a score is considered appropriate when the M ± SD is within a range of 1–5. Since we did not observe any ceiling or floor effects, no survey items were deleted.

3.3 Exploratory and validating factor analysis models

An exploratory factor analysis with maximum likelihood promax rotation was conducted on all 31 items. Survey items with factor loadings of 0.45 or greater were selected to increase the influence of the relevant factor and decrease the influence of other factors. Table 2 shows a factor matrix with items of factor loadings ≥ 0.45 and rearranged from larger to smaller factor loadings for each factor.

To examine the validity of item content belonging to sub-items of each factor, calculated goodness-of-fit index (GFI), comparative goodness of fit index (CFI) and root mean square error of approximation (RMSEA) values (Arbuckle and Wothke, 1999; Asano *et al.*, 2005) were used to examine the goodness of fit of the validating factor analysis model. In general, GFI

Item	Factor 1	Factor 2	Factor 3	Factor 4
29	0.936	–0.039	–0.042	0.030
28	0.924	0.014	–0.070	–0.083
27	0.785	–0.081	0.146	–0.023
24	0.779	0.089	–0.006	0.040
21	0.608	0.133	0.046	–0.044
31	0.516	–0.046	0.030	0.271
16	–0.038	0.887	0.002	–0.010
17	–0.010	0.784	–0.006	0.063
19	–0.045	0.783	0.091	–0.179
20	0.070	0.664	–0.103	0.164
23	0.152	0.632	0.002	0.077
4	–0.013	0.076	0.960	–0.140
6	0.068	–0.084	0.610	0.138
3	0.003	0.009	0.596	0.167
10	–0.029	0.012	–0.048	0.828
2	–0.050	0.017	0.197	0.587

Note(s): The highlighted values indicate which factor is a valid factor for each item
Source(s): Created by authors

Table 2.
Factor Matrix (4 factors and 16 items)

and CFI are considered good fits for ≥0.9 (Toyoda, 1998). In general, RMSEA is considered a good fit if for ≤0.08 (Arbuckle and Wothke, 1999). The GFI, CFI and RMSEA values for survey items related to were calculated: GFI = 0.887, CFI = 0.947 and RMSEA = 0.068, indicating only two criteria were met. Therefore, we modified the model using a modification index (Arbuckle and Wothke, 1999) to improve the GFI. The modification index provides a lower bound on how much the value of χ^2 is reduced from the value of χ^2 in the current model by adding one more parameter each to the current model that estimates such as the covariance among the error variables. As a result, item 10 with high modification index was deleted. This resulted in a smaller χ^2 value for the entire model. An exploratory factor analysis of survey items, which consisted of 15 items, was conducted again and item 2 (factor loading ≤0.45) was deleted. Final factor matrix is shown in Table 3.

Cronbach's α coefficient was calculated to examine the internal consistency of the 14 items. Value of α coefficient was 0.911, indicating the 14 items were reliable. To examine the validity of the content of items of each factor's sub-item, a validation factor analysis was conducted and GFI (0.904), CFI (0.961) and RMSEA (0.064) were calculated. Since all three criteria were met, the validity of the confirmatory factor analysis model shown in Figure 1 was deemed warranted. In Figure 1, for example "e29" indicates the error of item 29 explained

Item	Factor 1	Factor 2	Factor 3
29	0.940	–0.036	–0.046
28	0.908	0.005	–0.095
27	0.778	–0.087	0.147
24	0.768	0.080	–0.005
21	0.589	0.125	0.052
31	0.557	0.015	0.080
16	–0.048	0.888	0.003
17	–0.001	0.815	–0.016
19	–0.086	0.731	0.082
20	0.096	0.690	–0.074
23	0.166	0.647	0.011
4	–0.026	0.061	0.867
6	0.075	–0.074	0.673
3	0.013	0.025	0.668

Note(s): The highlighted values indicate which factor is a valid factor for each item
Source(s): Created by authors

Table 3. Factor Matrix (3 factors and 14 items)

above and “VAR0029” indicates the highlighted factor loading for each item (0.940 in Table 3).

From Table 3, three factors were identified. Factor 1 consists of items related to instructional techniques—teaching materials, teaching tools, questioning, blackboard writing and interactive learning—and items for evaluation of children’s achievement, which are essential to focus on during lesson observation. Factor 2 consists of items related to proactive thinking in terms of self-solving and perspective and items related to lesson development that leads to problem finding and problem-solving. Factor 3 consists of items related to understanding the mathematical background of the learning contents in terms of the nature, relationship and relevance of the learning content. In terms of the two situations of understanding lesson plan and observing lesson, Factor 3 is related to the understanding of the lesson plan before lesson and Factors 1 and 2 are related to observation of teaching activities.

Items of Factor 1: Focus on instructional techniques and evaluation.

(1) Teaching tools are utilized according to the learning content [H]-(7);

(2) Supplementary materials and handouts are used according to the learning contents [H]-(7);

(3) Blackboard writing is designed to help students understand the learning process [G]-(5);

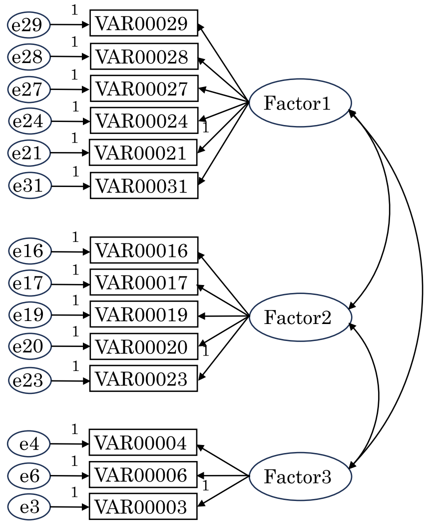

Figure 1.
Confirmatory factor analysis model

Source(s): Recreated by authors from the original image created by IBM® SPSS® Amos through analysis

(4) Questions are designed for deep learning [F]-(3);

(5) Learning activities are well designed to make learning interactive [D]-(3);

(6) Evaluation criteria for the objectives of the lesson have been met [I]-(8).

Items of Factor 2: Focus on proactive problem-solving lesson development.

(1) Lesson development is designed so that students can solve problems by using contents they have already learned [C]-(6);

(2) Lesson development is designed to deepen learning through problem-solving [C]-(3);

(3) Introduction of the lesson is well designed so that students can identify problems on their own [D]-(4);

(4) Problem-solving learning activities in which students proactively work on their own are incorporated [D]-(3);

(5) Questions are well thought so that students can have a prospect on problem-solving [F]-(5);

Items of Factor 3: Focus on the mathematical background of learning content.

(1) Lesson plan captures the relationship of learning content [B]-(2);

(2) Learning contents of the unit are interrelated, and the unit as a whole is viewed in a structured manner [B]-(2) and

(3) Lesson plan captures the essence of learning content [B]-(3);

3.4 Analysis of variance and multiple comparison

For the four groups of teachers by experience, a two-way ANOVA was conducted using a 4×3 mixed design. The first variable is duration of teaching experience:

(1) 5 years or less (beginning);
(2) 6–15 years (young);
(3) 16–25 years (mid-career) and
(4) 26 years or more (veteran).

The second variable is related to the three factors of self-reflection scale for MLO:

(1) Focus on instructional techniques and evaluation;
(2) Focus on proactive problem-solving lesson development and
(3) Focus on the mathematical background of the learning content.

In Table 4, the left two columns show the groupings of teachers based on the first variable. The right three columns show M and SD for second variables within each group of teachers. For each individual teacher, the average score for items belonging to each of the three factors of the second variable was calculated and used as an individual score. The M and SD of that score for teachers in each of the four groups by duration of teaching experience (the first variable) were then calculated. Results of ANOVA are shown in Table 5.

ANOVA revealed the main effect of the first variable ($F_{(3, 157)} = 2.02$) was not significant at 5% level, and the main effect of the second variable ($F_{(2, 314)} = 30.30$) was significant at 1% level. The interaction effect was not significant. Multiple comparisons using the Bonferroni method showed that the mean of 4.002 for B2 was significantly greater than the means of 3.798 for B1 and 3.571 for B3. And finally, there was a significant difference (Mean Squared error: *MSe*) between means of B1 and B3 ($MSe = 0.237, p < 0.05$).

4. Discussion

In developing a self-reflection scale for MLO in Japan, input from 161 local elementary school teachers was used to develop a wide range of candidate content items, which were categorized into nine perspectives and eight trends. Through factor analysis, a scale consisting of 14 items in three categories was developed. That covered seven perspectives except for [A] and [E] out of nine perspectives and seven trends except for (1) out of eight trends in mathematics education. The items developed, covering many perspectives and trends, are therefore

Variable 1 (Years of teaching experience)	Number of teachers	Variable 2	Mean	Standard deviation
A1 (≦5 years)	42	B1	3.568	0.647
		B2	3.900	0.584
		B3	3.437	0.859
A2 (6–15 years)	29	B1	3.799	0.667
		B2	3.972	0.690
		B3	3.448	0.744
A3 (16–25 years)	52	B1	3.955	0.686
		B2	4.100	0.675
		B3	3.635	0.556
A4 (25 or more years)	38	B1	3.868	0.757
		B2	4.037	0.663
		B3	3.763	0.495

Note(s): "B1" = Focus on instructional techniques and evaluation
"B2" = Focus on proactive problem-solving lesson development
"B3" = Focus on the mathematical background of the learning content
Source(s): Created by authors

Table 4. Number of teachers at each level, mean, and standard deviation for each year range of teaching experience

Table 5.
Results of ANOVA

Source of variance	Sum of sequence	Degree of freedom	Mean square	*F*-value
A	5.536	3	1.845	2.02 n.s
subj	143.281	157	0.913	
B	14.369	2	7.184	30.30 **
A × B	1.360	6	0.227	0.96 n.s
s × B	74.441	314	0.237	
Total	238.986	482	–	–

Note(s): "**" indicates that the *F*-value is significant at 1% level
"n.s." indicates that the *F*-value is not significant
Source(s): Created by authors

expected to function as a multifaceted self-evaluation scale. Repeated self-assessment by teachers using this scale will help them to understand their own strengths and weaknesses regarding their MLOs, helping them improve the quality of their MLOs.

Next, we used the developed scale to determine the characteristics of Japanese teachers.

Regarding the first variable, years of teaching experience (A1-to-A4), there was no difference in average self-reflection score for foci on instructional techniques and evaluation, proactive problem-solving lesson development and the mathematical background of the learning content (B1-to-B3). Yet, this does not mean the points and qualities of those foci are the same based on teaching experience.

For the second variable, there were significant differences between the means for B3 (mathematical background) and B1 (instructional techniques and evaluation) and between the means for B1 and B2 (proactive problem-solving lesson development). These suggest the degree of focus based on each item of self-reflection scale for MLO became lower in the order of focus on lesson development (B2), instructional techniques (B1) and mathematical background (B3). Moreover, this might be following the flow of focus from the whole to the part and from the visible (concrete) to the invisible (abstract).

Furthermore, since there was no interactive effect between the two variables, there might be the same tendency for all groups of teachers (A1-A4) to pay less attention to mathematical background in understanding lesson plans. However, understanding of lesson plans—reflecting the lesson practitioner's understanding of the mathematical background and his/her intention to teach mathematics based on it—is important as a requirement for considering how the lesson can be improved through lesson observation. Therefore, it is necessary to review lesson plans focusing on the mathematical background and to train teachers so they can realize the necessity of such plans.

5. Conclusion

In this study, we developed a self-reflection scale through an extensive questionnaire survey of Japanese elementary school teachers and used the developed self-reflection scale to understand their characteristics. Through the study, the following four points were identified: (1) and (2) are the answers to research question 1 and (3) and (4) are the answers to research question 2.

(1) We analyzed the results of interviews with teachers and derived nine perspectives of mathematical lesson observation: [A] Objectives, [B] Learning content, [C] Lesson development, [D] Instruction method, [E] Individual support, [F] Questioning, [G] Blackboard writing, [H] Teaching materials and teaching tools and, [I] Learning evaluation.

(2) We developed a 31-item survey and conducted a factor analysis of the data from Japanese teachers. As a result, we developed a self-reflection scale for MLO consisting

of 14 items in three categories: [B1] focus on instructional techniques and evaluation, [B2] focus on proactive problem-solving lesson development and [B3] focus on the mathematical background of the learning content.

(3) There was no difference in the degree of understanding of lesson plans and observation from various perspectives with respect to duration of teaching experience.

(4) The degree of focus based on each item of self-reflection scale for MLO is the strongest for [B2] and the weakest for [B3].

The self-reflection scale for MLO developed in this study is a framework for to think from what perspective teachers may understand mathematics lesson plans and observations. Teachers, with this scale, can grasp strengths and weaknesses of their own MLO, which leads to self-improvement. However, the content and depth of lesson observation that leads to the improvement of mathematics lessons found through self-reflections are also important elements in lesson observation in mathematics education. Therefore, it is necessary to conduct a further survey on what kind of contents were found to improve MLO from the perspective indicated in the items of self-reflection scale for MLO and to analyze the qualitative differences depending on duration of teaching experience.

In addition, although this study was limited to Japanese teachers, the characteristics of teachers regarding MLO may differ depending on the cultural backgrounds and changes in mathematics education in different countries/regions. Therefore, it is also important to develop a similar self-reflection scale for MLO in other countries/regions using the same method. We believe it is useful for planning new training programs on lesson observation and lead to higher quality lesson studies.

References

Arbuckle, J.L. and Wothke, W. (1999), *Amos 4.0 User's Guide*, Smallwaters Corporation, Chicago, IL.

Archer, R., Morgan, S. and Swanson, D. (2021), *Understanding Lesson Study for Mathematics: A Practical Guide for Improving Teaching and Learning*, Routledge, New York.

Asano, H., Suzuki, T. and Kojima, T. (2005), *Introduction to Practical Covariance Structure Analysis (Nyumon Kyobunsan Kouzou Bunseki No Jissai)*, Kodansha, Tokyo.

Baldry, F. and Foster, C. (2019), "Lesson study partnerships in initial teacher education", in Wood, P., Larssen, D.L.S., Helgevold, N. and Cajkler, W. (Eds), *Lesson Study in Initial Teacher Education: Principles and Practices*, Emerald, Bingley, pp. 147-160, doi: 10.1108/978-1-78756-797-920191011.

Danielson, C. (2012), "Teacher evaluation: what's fair? What's effective?", *Educational Leadership*, Vol. 70 No. 3, pp. 32-37.

Estrella, S., Mena-Lorca, A. and Olfos, R. (2018), "Lesson study in Chile: a Very promising but still uncertain path", in Quaresma, M., Winsløw, C., Clivaz, S., da Ponte, J.P., Ní Shúilleabháin, A. and Takahashi, A. (Eds), *Mathematics Lesson Study Around the World: Theoretical and Methodological Issues*, Springer, Cham, pp. 105-122.

Fitriati, F., Rosli, F. and Iksan, Z.H. (2022), "Lesson observation practice of mathematics teachers through school university partnership mediated by lesson study", *Creative Education*, Vol. 13 No. 02, pp. 675-690, doi: 10.4236/ce.2022.132042.

Hiebert, J., Morris, A.K., Berk, D. and Jansen, A. (2007), "Preparing teachers to learn from teaching", *Journal of Teacher Education*, Vol. 58 No. 1, pp. 47-61, doi: 10.1177/0022487106295726.

Hill, H.C., Blunk, M.L., Charalambous, C.Y., Lewis, J.M., Phelps, G.C., Sleep, L. and Ball, D.L. (2008), "Mathematical knowledge for teaching and the mathematical quality of instruction: an exploratory study", *Cognition and Instruction*, Vol. 26 No. 4, pp. 430-511, doi: 10.1080/07370000802177235.

Ingram, J., Sammons, P. and Lindorff, A. (2018), *Observing Effective Mathematics Teaching; Review of the Literature*, Education Development Trust, Reading.

Larssen, D.L.S., Cajkler, W., Mosvold, R., Bjuland, R., Helgevold, N., Fauskanger, J., Wood, P., Baldry, F., Jakobsen, A., Bugge, H.E., Næsheim-Bjørkvik, G. and Norton, J. (2018), "A literature review of lesson study in initial teacher education: perspectives about learning and observation", *International Journal for Lesson and Learning Studies*, Vol. 7 No. 1, pp. 8-22, doi: 10.1108/IJLLS-06-2017-0030.

Lee, M.Y. and Choy, B.H. (2017), "Mathematical teacher noticing: the key to learning from Lesson Study", in Schack, E.O., Fisher, M.H. and Wilhelm, J.A. (Eds), *Teacher Noticing: Bridging and Broadening Perspectives, Contexts, and Frameworks*, Springer, pp. 121-140, doi: 10.1007/978-3-319-46753-5_8.

Lewis, C. and Hurd, J. (2011), *Lesson Study Step by Step: How Teacher Learning Communities Improve Instruction*, Heinemann, Portsmouth.

Lim, C.S., The, K.H. and Chiew, C.M. (2018), "Promoting and implementing lesson study in Malaysia: issue of sustainability", in Quaresma, M., Winsløw, C., Clivaz, S., da Ponte, J.P., Ní Shúilleabháin, A. and Takahashi, A. (Eds), *Mathematics Lesson Study Around the World: Theoretical and Methodological Issues*, Springer, Cham, pp. 47-64.

Murata, A. (2011), "Introduction: conceptual overview of lesson study", in Hart, L.C., Alston, A. and Murata, A. (Eds), *Lesson Study Research and Practice in Mathematics Education*, Springer, New York, pp. 1-12.

Newton, K.J. and Alexander, P.A. (2013), "Early mathematics learning in perspective: eras and forces of change", in English, L.D. and Mulligan, J.T. (Eds), *Reconceptualizing Early Mathematics Learning*, Springer, London, pp. 5-28.

Saito, E., Imansyah, H., Kubok, I. and Hendayana, S. (2007), "A study of the partnership between schools and universities to improve science and mathematics education in Indonesia", *International Journal of Educational Development*, Vol. 27 No. 2, pp. 194-204, doi: 10.1016/j.ijedudev.2006.07.012.

Takahashi, A. and Yoshida, M. (2004), "Ideas for establishing lesson-study community", *Teaching Children Mathematics*, Vol. 10 No. 9, pp. 436-443, doi: 10.5951/TCM.10.9.0436.

Takahashi, A., Lewis, C. and Perry, R. (2013), "A US lesson study network to spread teaching through problem solving", *International Journal for Lesson and Learning Studies*, Vol. 2 No. 3, pp. 237-255, doi: 10.1108/IJLLS-05-2013-0029.

Török, J. (2006), "The mathematics education Traditions of Europe (METE) project", *Teaching Mathematics and Computer Science*, Vol. 4 No. 2, pp. 353-364, doi: 10.5485/tmcs.2006.0131.

Toyoda, H. (1998), *Covariance Structure Analysis [Introduction]: Structural Equation Modeling (Kyobunsan Kouzou Bunseki [Introduction]: Kouzou Houteishiki Modeling)*, Asakura Shoten, Tokyo.

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