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Identification of Cognitive Activities That Underlie Variations in Lecture Note-Taking: An Exploration of Japanese and Chinese High School Students' Strategies in Mathematics Class

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Lecture note-taking has been proven beneficial for learning at different educational levels. Previous studies have largely focused on the relationship between the outcomes of note-taking on a blank paper (e.g., measurements of the quantity and/or quality of notes taken) and student learning performance. However, there is no consensus as to what makes good notes. It is difficult to judge whether lecture note-taking is effective based only on the measurements of the notes. Past explorations have not adequately considered the cognitive activities that accompany such a process. Thus, using the interview method, the present study aimed to identify how lecture note-taking is used as a cognitive activity, and what factors influence it. To increase the possible range of note-taking approaches that could be observed, data from different cultural environments in Japan and China were sampled. Semi-structured interviews were conducted with 20 high school students from both countries (10 in each) to explore the cognitive activities in which students engage when taking lecture notes in mathematics class. Based on learning strategy models and studies, as well as using a thematic analysis, a new hierarchical framework of lecture note-taking, comprising shallow and deep lecture note-taking, was proposed. Deep lecture note-taking uses cognitive, metacognitive, and resource management functions. Furthermore, a comparison of students from the two countries revealed that their beliefs and teachers' instructions were potential factors influencing their lecture note-taking. Utilizing interview as the research method allowed us to obtain new insights into the cognitive activities that accompany lecture note-taking, such as the metacognitive function, which has rarely been explored in previous research. Future work is expected to commence on new measures based on this theoretical framework that gauges the cognitive activity of lecture note-taking. This study also calls for the exploration of effective note-taking instruction that considers the cognitive activity of note-taking.

Keywords: lecture note-taking, cognitive activities, interview, deep note-taking, information processing

INTRODUCTION

Lecture note-taking is a ubiquitous student activity from the elementary to the university level. It is defined as an activity that includes writing on learning materials, underlining, highlighting, and marking important points in class. Lecture note-taking is an essential activity that promotes learning (Peper and Mayer, 1986; Christopoulos et al., 1987; Peverly et al., 2003). Theories on note-taking propose two reasons why note-taking is beneficial for learning (Di Vesta and Gray, 1972). On one hand, according to the encoding perspective, note-taking is the act of recording information from a lecture, which benefits students through their engagement at a deeper processing level. On the other hand, according to the external storage perspective, the process of note-taking allows students to review, process, and commit information to memory. In this study, we were interested in how students' note-taking affected their understanding of lectures while receiving knowledge in the classroom. Hence, this study focused on the encoding function of note-taking.

Studies have pointed out that the encoding function of note-taking is effective because it encourages the processing of information (e.g., Kiewra, 1985). To evaluate the effectiveness of this encoding function, studies have generally compared the test performance of a note-taking group that could not review their notes with a listening-only group that did not take notes. Kiewra (1985) qualitatively analyzed 56 studies on the efficacy of encoding, from which there were 33 studies that displayed effects in favor of note-taking. Moreover, a meta-analysis of the encoding effect by Kobayashi (2006) found that, compared to listening only, note-taking without review had a small effect on test performance ($d = 0.22$).

However, taking notes does not necessarily lead to understanding. For example, Mueller and Oppenheimer (2014) reported that students who simply transcribed the presented content verbatim had inhibited learning. In addition, compared with university students, secondary students may act in a less self-regulated manner, as they rely on the teacher's instructions and supplement their notes on their own only minimally (Yokoi, 1999). Moreover, in Shiba's (2018) tutoring, the student being instructed always focused on the formality of the notes; for instance, "taking neat notes is studying," rather than the content to be written down. Thus, although lecture note-taking is vital in the classroom, the effect on promoting learning may depend on how it is used. Furthermore, considering that the process of note-taking affects understanding of information, it would be appropriate to also consider that there are shallow and deep levels in lecture note-taking. For example, repeated transcribing might be a shallow level of note-taking as it does not contribute to understanding or classroom learning.

Lecture note-taking is also a critical learning strategy for developing self-regulated learning at the secondary level (Zimmerman et al., 1996). From the perspective of self-regulated learning, in addition to deep and shallow levels in lecture note-taking, metacognitive aspects such as monitoring might also be important. Self-regulated learning is considered a proactive process through which students acquire academic skills—setting goals, selecting and deploying strategies, and self-monitoring their effectiveness (Zimmerman, 2008)—which are regarded as valuable skills learned during school years and beyond (cf. lifelong learning; OECD iLibrary, 2015). The basic process of self-regulated learning is viewed as a three-stage cycle: forethought, performance, and self-reflection (Zimmerman and Schunk, 2011). To complete the cycle, students need to monitor their own cognitive processes and then adjust/control them. For example, while taking lecture notes, it might be vital to monitor their comprehension, mark what they do not understand during class, and use the notes taken by them to adjust learning activities after class. Notably, previous studies concerning effective note-taking have only focused on what is written, that is, the results of note-taking. Thus, the cognitive and metacognitive aspects of lecture note-taking have not been examined. The present study focuses on the encoding function of note-taking, which is regarded as promoting students' understanding. In addition, we examined lecture note-taking on the axes of cognitive aspects, which consist of deep and shallow levels, and metacognitive aspects to grasp the whole figure of lecture note-taking from the viewpoint of cognition and metacognition.

Previous studies have measured the effects of lecture note-taking on learning by simply measuring the note quantity. Many studies have shown that the more notes students write in class, the better they perform on tests like fact recall and concept application tests (e.g., Kiewra and Benton, 1988; Peverly et al., 2007; Mueller and Oppenheimer, 2014). However, from this point of view, these studies could not explain why taking more notes verbatim had a negative relationship with the test performance of participants (Mueller and Oppenheimer, 2014).

Further, lecture note-taking is measured in terms of the quality of the notes; however, its criteria are varied. Numerous studies have examined the impact of note quality on memory of lecture content (Peverly et al., 2007, 2013; Peverly and Sumowski, 2012; Nakayama et al., 2017). Previous studies have shown that high-quality note-taking positively affects memory tests; however, the criteria for note quality vary across studies (e.g., Peverly and Sumowski, 2012).

Nevertheless, the critical issue is that cognitive processes of lecture note-taking are not considered. Both quantity and quality of notes are examined only in terms of the results of lecture note-taking; however, what the learner was thinking at the time is ignored, even though it is essential. For instance, even if the students write the same note, it is difficult to determine whether they just copied it verbatim or took it because they thought it was important. That is, there is a possibility that even if the same note contents are written, the learning effect would be different because of the different cognitive processes involved. However, without considering this, the true quality of lecture note-taking cannot be examined.

For example, in the study of learning strategies, the axes of shallow and deep strategies have been proposed and discussed (e.g., Marton and Säaljö, 1976; Murayama, 2007). We consider that lecture note-taking should exist these deep and shallow level use axes. Previous studies have assessed the quality of cognitive activity along these axes. For instance, Marton and Säaljö (1976) interviewed university students to understand their learning processes and discovered two learning strategies: surface-level

and deep-level processing. In addition, learners who use deep-level processing strategies performed better than those who use surface-level processing strategies (e.g., Ramsden, 1988). However, these aspects of lecture note-taking have not been examined thus far. For example, copying down might be shallow processing of note-taking, while understanding the meaning or clarifying what is not understood might be deep processing. Nevertheless, it is unknown what the specifics are.

This study aimed to investigate cognitive activities that underlie variations in lecture note-taking. This study sampled data from different cultural environments in Japan and China to increase the possible range of note-taking approaches that could be observed. For example, on the one hand, in Japan, there is a strong cultural emphasis on the teachers' practices regarding writing on the blackboard and note-taking instructions (e.g., Ohtsubo and Higashibata, 2012). In addition, the Japanese national curriculum refers to using lecture notes as an assessment of "independent attitude toward learning (Ministry of Education, Culture Sports Science and Technology, 2020)." On the other hand, note-taking tends not to be emphasized in China (Wang, 2014). Furthermore, the Chinese national curriculum makes no specific mention of lecture note-taking. Thus, in these different contexts regarding note-taking, we considered that Japanese and Chinese students might engage in different note-taking activities.

To investigate cognitive activities that underlie variations in lecture note-taking, this study focuses on lecture note-taking during mathematics classes. First, mathematics has been considered a critical area for self-regulation because many students face difficulty with it, and effective use of learning strategies can enhance their learning and achievement (Patricia et al., 2017). However, even university students might not be able to take notes efficiently in their mathematics class (Fukawa-Connelly et al., 2017). We consider that identifying how students take notes in math class is vital for subsequent educational practice. Further, in this study, we will also examine the factors influencing students' lecture note-taking use, such as deep-level note-taking. Our results could lead to fostering students' use of deep note-taking.

Students' behavior can be greatly influenced by their beliefs (Dunlosky et al., 2015). It was noted that their note-taking beliefs affected the actual use of the notes (e.g., Bonner and Holliday, 2006; Witherby and Tauber, 2019). For example, previous studies have reported that students take notes as they believe that it helps them understand the lesson (Van Meter et al., 1994). This is consistent with the perspective of the encoding function of note-taking. However, beliefs about the other storage functions—such as taking notes for later reviews—have not been addressed. Based on previous findings, we can predict that the beliefs students hold will influence whether they take notes, while its explicit effects remain unknown.

Furthermore, students' use of note-taking also appears to be influenced by external factors, such as teachers' instruction. For instance, Titsworth (2001, 2004) and Titsworth and Kiewra (2004) found that inserting organizational cues and providing explicit statements that a theory or sub-theme of the theory was about to be discussed in a lecture can lead to an increase in the quality and quantity of information in notes as well as better test performance. Moreover, it was reported that inserting pauses in a lecture allows students time to consult with their peers or instructors (Ruhl, 1996), and preparing copies of PowerPoint slides for students (e.g., Marsh and Sink, 2010; Williams et al., 2012) can enhance their learning. From these studies, we can infer that the instructions provided by teachers affect students' note-taking or directly affect their learning. However, the specifics are unknown; few studies have investigated the effects of the different types of note-taking instruction and their effect on students' actual use of note-taking.

To better explore how different types of note-taking instruction influence note-taking, we believed it would be informative to collect data from both Japan and China. Although both Japan and China are considered to have high academic achievement among students in East Asia, the instruction style for note-taking may differ between them. For example, most teachers in China did not emphasize how to take notes in class (e.g., Chen, 2000; Wang, 2014). However, teachers' blackboard instructions and note-taking are stressed in Japan (Ohtsubo and Higashibata, 2012). For example, Uosaki (2017) conducted a questionnaire survey of university students and reported that students had received teachers' instruction on items such as "writing in a way that allows for easy note review," "writing important words," and "writing a large amount of text" before. From these studies, we assumed that collecting data from both Japan and China would allow for a better exploration of the effects of different note-taking instructions.

The primary purpose of this study was to explore how lecture note-taking is used as a cognitive activity, as well as which attributes of students and what instructions from teachers would affect the use of note-taking. We conducted interviews with Japanese and Chinese high school students about their lecture note-taking uses in class. Thus, sampling data from different cultural environments was carried out to increase the possible range of note-taking approaches that could be observed. Furthermore, it allows for a better exploration of the underlying factors of students' note-taking. An investigation of these issues can give us valuable insights into why learners use note-taking less effectively and the crucial facet that lecture note-taking functions. In addition, strategies for note-taking instructions can be suggested to develop self-regulated learners in educational practice.

MATERIALS AND METHODS

A qualitative research design was used to explore the cognitive activities underlying students' various lecture note-taking, and the background factors that might influence it. We used semi-structured qualitative interviews and then applied thematic analysis, as proposed by Boyatzis (1998).

Ethics Approval

The study was approved by the Research Ethics Committee of the university to which the authors are affiliated. Its purpose, nature, and assurances on the confidentiality and anonymity of published data have been clearly stated. All participants were

verbally briefed on the interview day about the kinds of questions they would be asked, and they signed appropriate consent forms.

Participants

Twenty high school students from five high schools in Japan and seven high schools in China participated in this study. The participants were from 10th to 12th grade (approximately 15–18 years old), who were selected using snowball sampling. **Table 1** provides an overview of the gender, grade, and school status of each of the 20 participants.

Procedure: Semi-Structured Interviews

In autumn 2019, semi-structured qualitative interviews, intended to investigate students' actual lecture note-taking use and their perceptions of it, were conducted with 10 participants from each country. The interviewees were asked to bring the notebooks or other materials that they used during their actual math class. A semi-structured interview guideline and a series of questions in a conversational style was designed and used; for example, "Could you tell me how you take notes in your regular math class?" and "Why did you take notes in that way?" All sessions were audiotaped and lasted for approximately 30 min.

Data Analysis

The first author immediately transcribed verbatim all the audiotapes after each session. An inductive thematic analysis was applied to the primary transcripts using the coding method proposed by Boyatzis (1998). All labels, categories and their definitions were recorded in Excel as a codebook. The interviews were analyzed in Japanese, and the excerpts that were used to illustrate our results in the current paper were translated into English.

First, the transcripts of each group—Japanese and Chinese—were coded. The transcript of Student 1 in the Japanese group was coded, and the derived codes were given labels. Next, Student 2's transcript was coded using these labels, and new labels were derived and defined. Then, the remaining transcripts were coded based on the accumulated labels. Similarities among the labels were sought. The Chinese group underwent the same procedures.

Next, the two groups were compared and contrasted. Within the subsample, we developed categories and subcategories, based on which the subgroups were compared. We also sequenced the categories and detailed the activities used by the participants during their lectures.

Subsequently, after the initial coding, an external researcher—a native Chinese graduate student fluent in Japanese—who was unfamiliar with the study's aims independently analyzed 20% of the data. Her coding was compared with the authors' coding; this showed an inter-rater agreement of 79% (Gwet's AC1 was used). The disagreements were discussed, and codes were revised for inclusion in the analysis.

TABLE 2 | Primary materials for note-taking in the Japanese and Chinese groups.

	Notebook	Textbook	Total
Japanese students	9	1	10
Chinese students	4	6	10

RESULTS

Typical Lecture Note-Taking Style of Japanese and Chinese High School Students

First, we confirmed the overall differences between the two groups' typical note-taking styles before conducting a more specific analysis. The lecture notes of nine out of the ten Japanese students were observed to be consistently taken in their notebooks (see **Table 2**). They seem to have been noted down exhaustively (see **Figure 1**). By contrast, more than half of the Chinese students' lecture notes were seen to be taken directly on their textbooks (see **Table 2**) rather than their notebooks, and the contents of the notes were inferred to have been jotted down selectively (see **Figure 2**). Next, a thematic analysis was adopted for coding and comparison to discuss the differences more specifically.

Categories Identified in the Current Study

As mentioned above, based on studies of learning strategies (e.g., Murayama, 2007) and the thematic analysis, students

TABLE 1 | Participants' gender, grade, and school characteristics.

Japanese group					Chinese group				
ID	**Gender**	**Grade**	**Area**	**School status**	**ID**	**Gender**	**Grade**	**Area**	**School status**
J1	Female	11th	Tokyo	Private	C1	Female	10th	Hunan	Private
J2	Female	11th	Tokyo	Private	C2	Male	10th	Jiangsu	Public
J3	Female	11th	Kanagawa	Public	C3	Female	10th	Hunan	Private
J4	Male	11th	Kanagawa	Public	C4	Male	11th	Hunan	Private
J5	Female	11th	Kanagawa	Public	C5	Male	11th	Hunan	Private
J6	Female	10th	Tokyo	Public	C6	Male	11th	Tianjin	Public
J7	Female	10th	Tokyo	Private	C7	Male	11th	Hunan	Public
J8	Female	10th	Tokyo	Private	C8	Male	12th	Hunan	Public
J9	Female	10th	Tokyo	Private	C9	Female	11th	Hunan	Public
J10	Female	10th	Tokyo	Private	C10	Female	11th	Hunan	Public

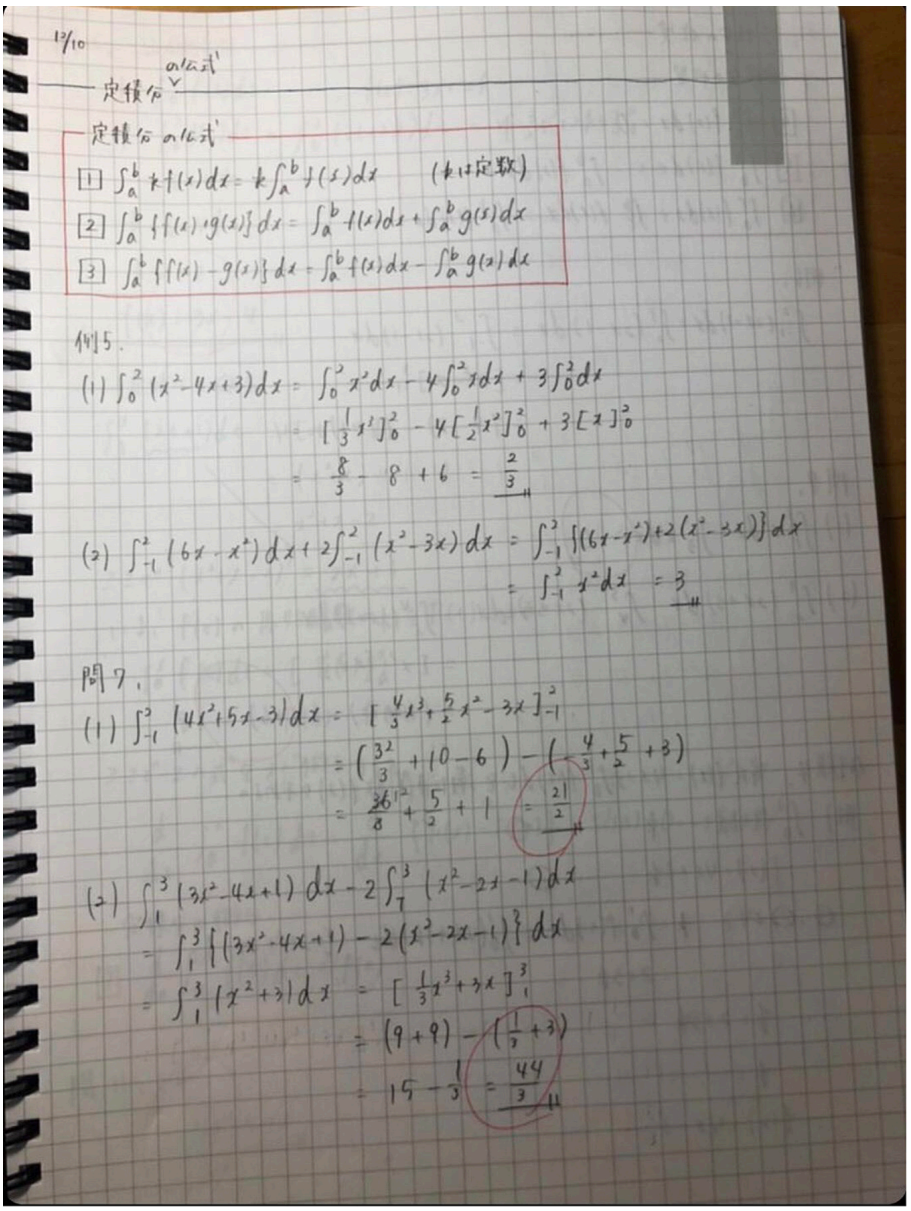

FIGURE 1 | Lecture notes in the Japanese group.

from both Japan and China identified two categories of lecture note-taking—shallow lecture note-taking and deep lecture note-taking. Deep lecture note-taking was further divided into three subcategories: cognitive, metacognitive, and resource management functions (see **Figure 3**).

Shallow Lecture Note-Taking

Based on previous studies (e.g., Murayama, 2007), lecture note-taking that relied on passive activities to help in the recall of information, as reported by the students, was categorized as shallow lecture note-taking: (a) copying the board, (b) acting as per instructions, (c) unconscious use of color, and (d) copying the textbook. Regarding copying from the board, students reported that they copied what the teacher wrote on the board during math class. For example, a student said, "The board: first, I definitely would copy the teacher's notes on the board. In the case of a formula, it usually has a detailed description of the calculation process and so on; I would copy all of them down." Acting as per instructions was coded by students, mentioning that they wrote down as the teachers told them to. About the unconscious use of color, students explained that they take notes as colorfully as they like, regardless of the content. One student said, "Maybe the color changes depending on how I am feeling that day." Finally, copying the textbook was coded by students who reported that they would copy diagrams and other information from the

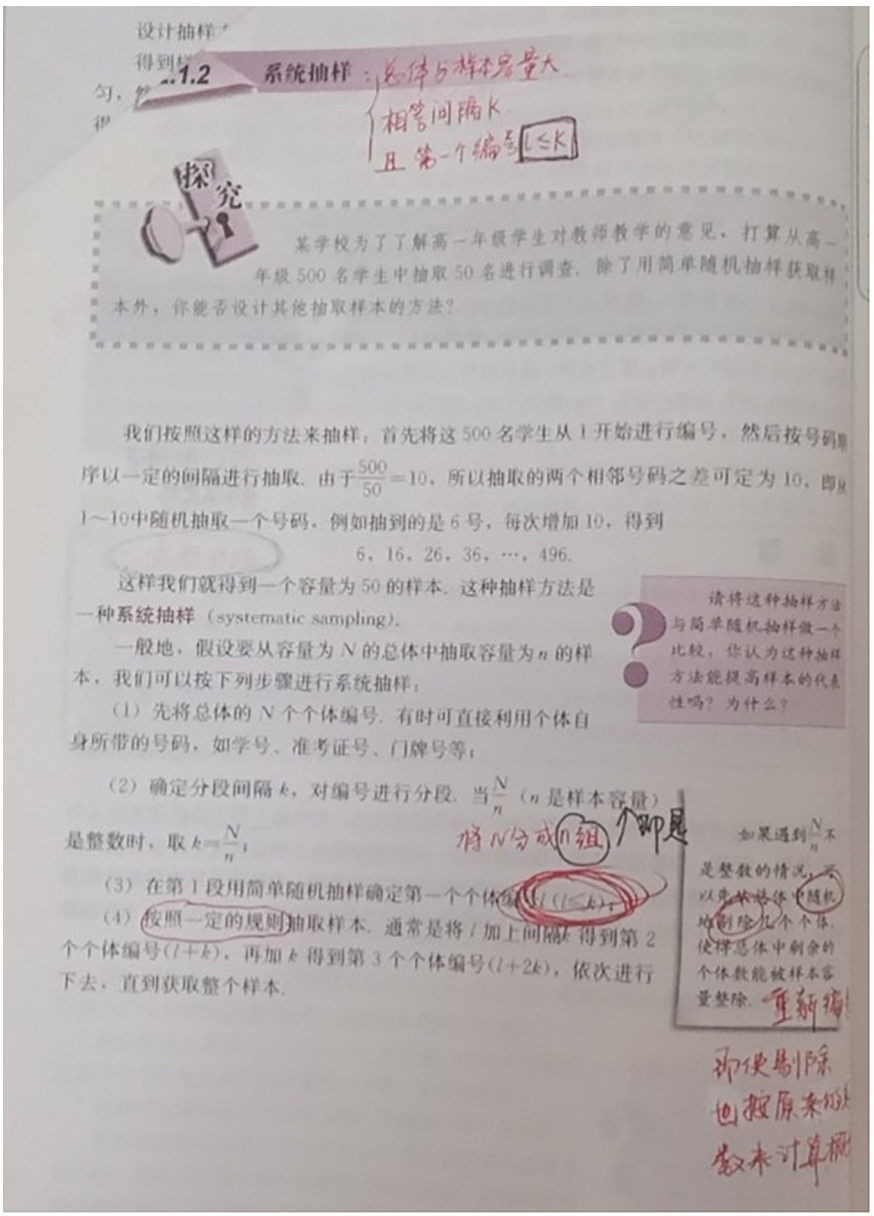

FIGURE 2 | Lecture notes in the Chinese group. The mathematics textbook used was published by the People's Education Press.

textbook directly into their notes during class. For example, another student said, "While looking at the textbook, my teacher would say, 'Write here,' and I would copy those—some summarized detailed sentences in the textbook—into my notebook."

Deep Lecture Note-Taking

Contrastingly, lecture note-taking that required extra activities to improve understanding of the meaning (such as elaboration of information and evaluating information) was categorized as deep lecture note-taking, which was further divided into cognitive, metacognitive, and resource management functions of lecture note-taking.

Cognitive Function

The students reported several cognitive strategies in lecture note-taking for processing information from lectures; these were categorized as the cognitive function of lecture note-taking. These were: (a) Notes from verbal explanations, (b) paraphrasing difficult words, (c) teacher's supplement, (d) notes on what were considered important, (e) notes on the emphasis, (f) choosing what to write down, and (g) distinguishing content by color. Notes from verbal explanations refer to making supplemental notes regarding what their teacher is explaining verbally. Paraphrasing difficult words was explained as rephrasing mathematical terms and solutions into simple words to make them easier to understand. For example,

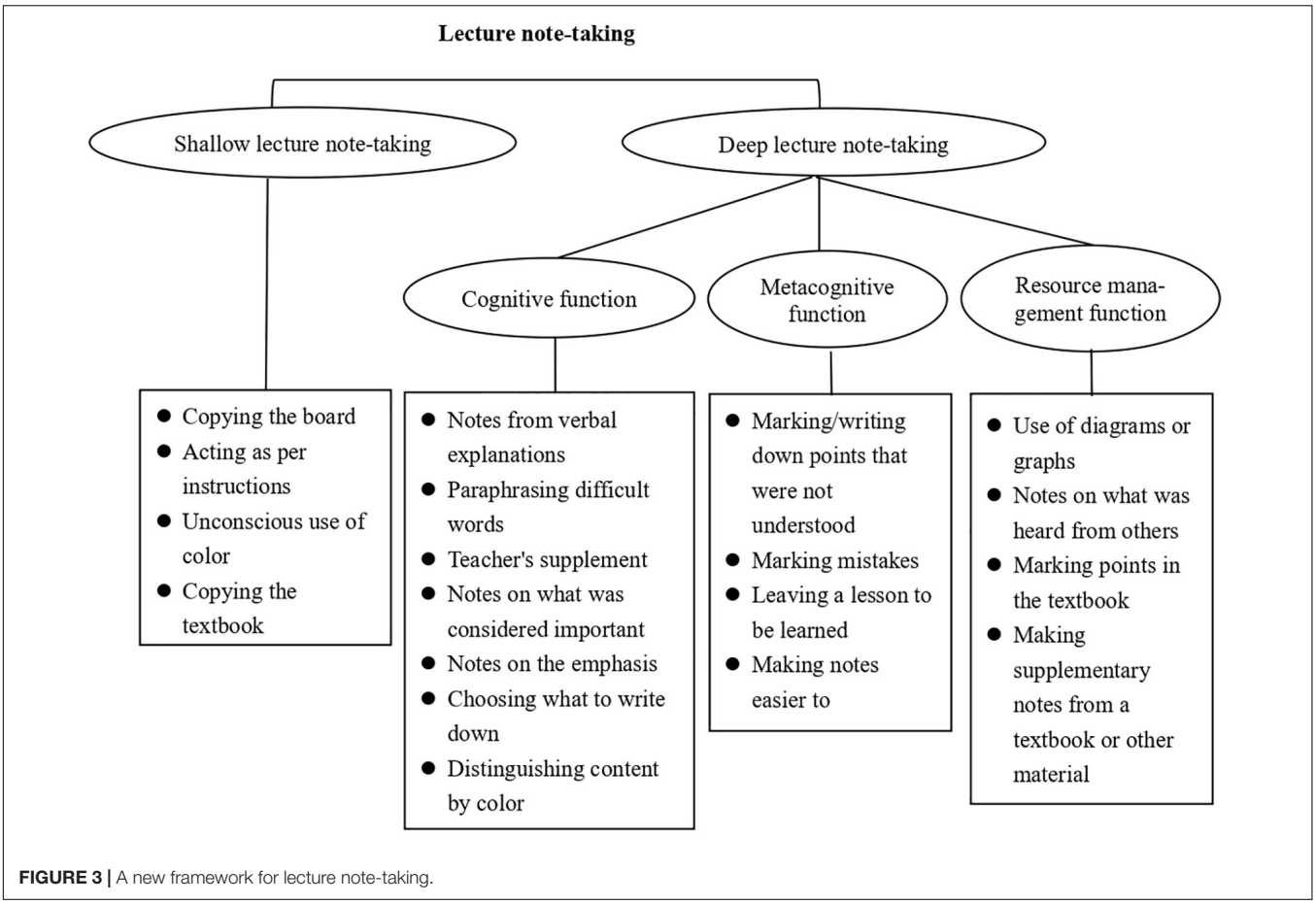

FIGURE 3 | A new framework for lecture note-taking.

"An easier way of reviewing is to break down the teacher's words into my own words so that it would not become too formal." The teacher's supplement shows that students take notes on things that are not in the textbook, such as alternate solutions to solve a problem provided by the teacher. For instance, one student stated, "The teacher gives us variants, and those are often used more. For example, like this one, which is not in the book at all, but they often show up on exam." Notes on what was important were coded by students stating that they mark what they think is essential. Notes on the emphasis convey that students usually take notes of what the teacher is emphasizing on. For example, "Also, these notes and stuff like that, where the teacher would draw a line that said it is important." The label of choosing what to write down signifies that they do not view all the information indiscriminately. Instead, they would selectively decide what to note. For example, one student said, "So, I only write the ones I do not understand, and the ones I do understand would be just written in the textbook." Finally, distinguishing content by color means that students use different color pens according to the content of their notes. For example, one student said, "The orange ones are teacher's notes, the ones written in pencil are my answers to the question, and the red ones are the correct answers to the questions."

Metacognitive Function

The second subcategory is metacognitive function of lecture note-taking that help students control and regulate their own cognition following four activities reported by the students: (a) marking/writing down points that were not understood, (b) marking mistakes, (c) leaving a lesson to be learned, and (d) making notes easier to understand.

First, marking/writing down points that were not understood was coded by the participating students as writing or marking down something they did not understand in the class. For example, "I did not understand this unit vector's meaning, so I added a question mark here." Marking mistakes means that they leave a reminder to themselves about the mistakes in the problems they solved. For example, a student said, "Umm. . .I would definitely mark the mistakes I made." Moreover, leaving a lesson to be learned conveys that students would leave a notice or lesson to prevent the same mistakes in the future. For example, one student stated, "I made a note of things like, "You need to be careful here." Making notes easier to understand signified the students' efforts to make their notes understandable from the perspective of others or their own perspective in the future. For example, "I am always conscious of making a notebook that could be readily understood by others as if I were showing it to someone else, and I have probably always been conscious of that for a long while." Further, one student stated that "If not (there are some

markings in the notebook), I would feel confused about its extent. That is why I wrote it down."

Resource Management Function

The students also reported their regulatory strategies for controlling other resources besides their cognition; these were categorized as the resource management function of lecture note-taking. These were: (a) Notes on what was heard from others, (b) use of diagrams or graphs, (c) marking points in the textbook, and (d) making supplementary notes from a textbook or other material. Notes on what was heard from others refer to taking notes on the doubts they asked their teachers or friends to explain. For example, one student said, "If I did not understand what the teacher was saying, I asked my friend, who is a little bit smart, 'Why is this happening?,' and I would write down what he told me." The use of diagrams or graphs indicates that they are drawn to facilitate understanding of the concept or to think. For example, one student said, "It is easier to understand if I draw diagrams by myself, so I try to draw what I can in diagrams as much as possible in this way." Marking points in the textbook was coded by students stating that they underlined or marked essential concepts and points in the textbook. For example, one student said, "I would use a color pen, like a red pen, to circle it (considered important) with emphasis." Furthermore, the act of making supplementary notes from a textbook or other material means adding content from the textbook or other materials while taking notes in class.

Lecture Note-Taking Strategy Uses of Japanese and Chinese Students in the New Framework of Lecture Note-Taking

Overall, it was observed that both Chinese and Japanese students consistently exhibited two categories of lecture note-taking strategy, accompanied with cognitive activities: shallow lecture note-taking, and deep lecture note-taking consisting of cognitive, metacognitive, and resource management functions. We compared the categories and subcategories across the two groups (see **Table 3**) to explore their lecture note-taking precisely. In addition, **Figure 4** graphically presents the similarities and differences between the two groups.

In terms of shallow lecture note-taking, Japanese students reported more passive use of note-taking. Japanese students' lecture note-taking seemed to be more comprehensive, while that of Chinese students was more selective, which can be glimpsed from the materials they brought over to the interview. The total units of note-taking contents were 88 units for the Japanese students (Mj = 8.8) and 46 units for the Chinese students (Mc = 4.6). Thus, this implies that, in general, Japanese students took more detailed notes than their Chinese counterparts. Although several students in the two groups both reported that they simply copied what the teacher wrote on the board, only Japanese students reported their note-taking as both an "act as per instructions" and "copying the textbook." Two of the Japanese students mentioned that they wrote it down just as the teachers told them. For example, one student said, "The teacher said, "let us remember it and write it here!" so, I just wrote it like this." (J3)

TABLE 3 | Comparing the note-taking classifications between the two groups.

Categories	Japanese group	Chinese group
Subcategories	**(Participant ID)**	
Labels	***(J1-10)***	***(C1-10)***
Shallow lecture note-taking		
Copying the board	J1, J2, J3, J4, J5, J6, J7, J9	C3, C6, C9, C10
Acting as per instructions	J2, J3	
Unconscious use of color	J1, J3	C6
Copying the textbook	J1, J2, J7	
Deep lecture note-taking		
Cognitive function		
Notes from verbal explanations	J2, J3	C3, C4, C7, C10
Paraphrasing difficult words	J2, J3, J9	
Teacher's supplement	J3	C2, C3, C5, C7, C9
Notes on what was considered important	J1, J2, J3, J4, J7, J8, J9, J10	C1, C4, C7, C8, C9, C10
Notes on the emphasis	J1, J3, J5, J6, J9	
Choosing what to write down	J9	C3, C5, C6, C7, C8, C9, C10
Distinguishing content by color	J1, J2, J3, J9	
Metacognitive function		
Marking/writing down points that were not understood	J5	C2, C5, C9
Marking mistakes	J3, J4, J5, J6, J7	C1, C4, C10
Leaving a lesson to be learned	J2, J3, J5, J6	C8, C9
Making notes easier to understand	J1, J3, J6	
Resource management function		
Use of diagrams or graphs	J4, J6, J7, J10	C3, C5, C9
Notes on what was heard from others	J2, J4, J7	
Marking points in the textbook		C3, C4, C5, C10
Making supplementary notes from a textbook or other material	J5	

In addition, three of the ten Japanese students reported copying diagrams and other information from the textbook directly into their notes during class. For instance, "While looking at the textbook, my teacher would say, "Write here," and I would copy those—some summarized detailed sentences—in the textbook, into my notebook." (J2) Thus, as shown in **Figure 4**, although both Chinese and Japanese exhibited instances of passive note-taking, it might be more prevalent among Japanese students.

In terms of deep lecture note-taking, Chinese and Japanese students were relatively consistent in utilizing these cognitive, metacognitive, and resource management functions for their learning. Yet, specific differences were seen by comparing the two groups using thematic analysis. Concerning the cognitive function in lecture note-taking, only Japanese students reported their note-taking as "paraphrasing difficult words," "notes on the emphasis," and "distinguishing content by color." Meanwhile, we also found the metacognitive function in lecture note-taking in both groups; however, the activity "making notes easier to understand" was only reported by Japanese students. Furthermore, there were differences in the resource

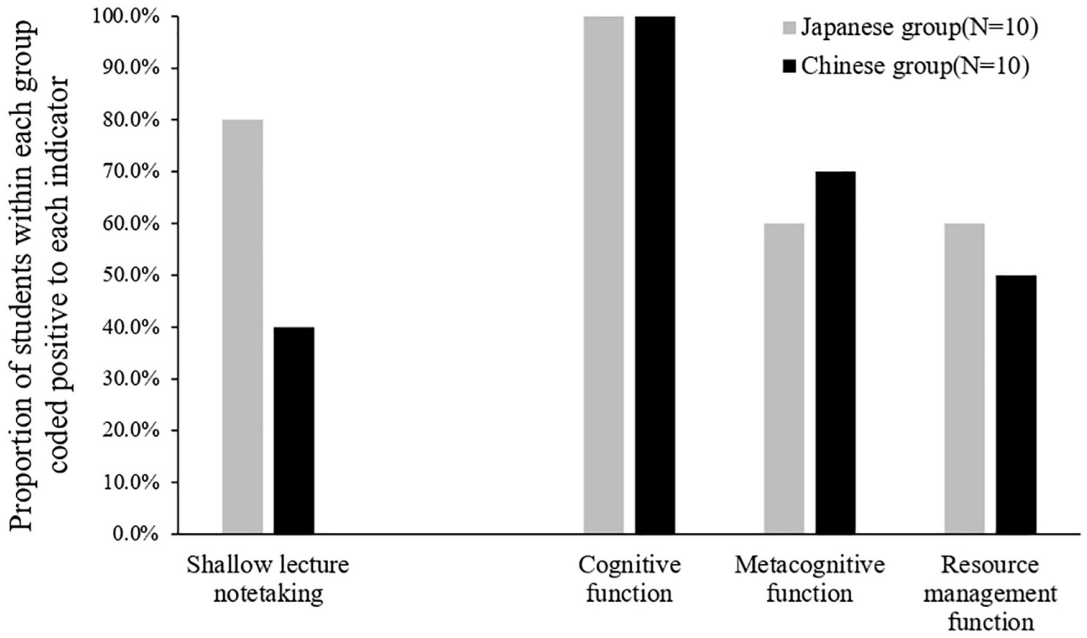

FIGURE 4 | Indicators of lecture note-taking activities.

management function. For instance, note-taking activities such as "notes on what was heard from others" and "making supplementary notes from a textbook or other material" were only found among Japanese students. In contrast, only Chinese students reported their note-taking as "marking points in the textbook."

Exploring the Background Factors Behind the Differences

The remaining thematic analysis data were used to explore the potential factors behind the differences in lecture note-taking between Japanese and Chinese high school students. The examination of each country's distribution across the beliefs and teachers' instruction of lecture note-taking involved in our research are shown in **Tables 4**, **5**.

Table 4 shows that, consistent with the encoding perspective of note-taking, 30% of students in both groups stated that they take notes because it helps them understand lecture content. For example, a student reported that "I also copy down the graph of a function, because it makes it easier for me to understand." (C3) Moreover, in line with the external storage perspective on note-taking, both Japanese and Chinese students mentioned that they take notes because doing so gives them material to review. However, the way in which notes are used for review differs. Approximately 90% of Japanese students reported taking lecture notes for reviewing later; for instance, "Because I would review it, I thought it would be better if it were easy for me to understand." (J10) While some students in the Chinese group took notes for simple reviewing too, a larger number of students mentioned that they were doing so for note-making after class. For example, "I wrote it down also for organizing my error book after class." (C9) In terms of the findings in **Table 4**, it can be inferred that these differences in the purpose of note review may cause the differences among the Japanese and Chinese high school students' lecture note-taking.

Meanwhile, **Table 5** indicates the effect of teachers' instruction on lecture note-taking as perceived by the two groups of students. First, only Japanese students stated that they took notes because the teachers gave explicit directions for writing. In addition, students of both groups reported that the teacher's cues on what is essential influence their lecture note-taking. Moreover, more students in Japan (vs. their Chinese counterparts) perceived the effect of the notes assessment (30%) and teachers' instruction (50%). In general, this implies that Japanese students are more aware of their teacher's instruction when taking lecture notes, which may be conducive to taking a few more notes.

DISCUSSION

This study applied the interview method to explore how lecture note-taking is used as a cognitive activity and the factors influencing the use of note-taking. Through thematic analysis, a new framework consisting of shallow and deep lecture note-taking was derived. Moreover, the interviews allowed us to clarify the specific characteristics of shallow and deep lecture note-taking. In addition, by comparing students from Japan and China, we inferred that the differences in lecture notes may result from the influence of the students' beliefs and teachers' instruction styles.

Regarding lecture note-taking as a cognitive activity, based on models of learning strategies studies and using thematic analysis,

TABLE 4 | Summary of the influence of beliefs on participants' note-taking.

	Lecture understanding		External storage			
			Simple review		Note-making after class	
	Number of students	Percentage	Number of students	Percentage	Number of students	Percentage
Japanese	3	30.0%	9	90.0%	9	10.0%
Chinese	3	30.0%	3	30.0%	4	40.0%

TABLE 5 | Summary of the influence of teachers' instruction on participants' note-taking.

	Teachers' instructions							
	Directions for what to write		Cues for what is important		Note assessment		Note instruction	
	Number of students	Percentage	Number of students	Percentage	Number of students	Percentage	Number of students	Percentage
Japanese	3	30.0%	5	50.0%	3	30.0%	5	50.0%
Chinese	0	0.0%	5	50.0%	1	10.0%	2	20.0%

a new framework of lecture note-taking comprising shallow lecture note-taking and deep lecture note-taking (cognitive function, metacognitive function, and resource management function) was proposed. In this new framework, some new aspects of lecture note-taking, such as the metacognitive function, were identified. This allowed us to go beyond and extend the previous discussion (e.g., Di Vesta and Gray, 1972; Kiewra and Benton, 1988; Nakayama et al., 2017) in note-taking.

Moreover, based on this new framework, similarities and differences in lecture note-taking between Japanese and Chinese students were also clarified. From a glimpse of the participants' actual notes, we found that the overall difference was that Japanese students take comprehensive notes in their notebooks while Chinese students take selective notes directly in their textbooks. Meanwhile, more specific characteristics between the two groups were found using the comparison method in the thematic analysis. Regarding shallow lecture note-taking, Japanese students reported more passive use of note-taking. On the other hand, although Chinese and Japanese students were relatively consistent in utilizing deep lecture note-taking for their learning, specific differences were seen in each function by comparing the two groups through the thematic analysis. For example, in terms of the resource management function, activities such as "notes on what was heard from others" were only reported by Japanese students. It can be inferred that there might be more interactive activities in the Japanese classroom, allowing students to ask others in class. Furthermore, only Chinese students addressed "marking points in the textbook." We could ascertain that textbooks may be used more often in a Chinese math class so that students take notes directly in the textbook.

Regarding which factor would affect the use of note-taking, we explored how students' perceptions of note-taking and beliefs about teachers' instruction might influence their note-taking. First, consistent with the encoding perspective of note-taking theory, both groups of students stated that they take notes because it helps them understand lecture contents (Van Meter et al., 1994; Bonner and Holliday, 2006). Nevertheless, in contrast to the previous study's finding that college students mentioned little about taking notes for review, high school students in our study explicitly talked about it, suggesting the need to examine note-taking at different stages. In addition, there were differences in the students' beliefs regarding lecture note-taking for review. Almost all Japanese students took notes for simple review, while some Chinese students took lecture notes to make their own notes after class, which may explain the abovementioned differences in their lecture note-taking.

However, in contrast to prior studies (e.g., Marsh and Sink, 2010), we found several aspects of instruction about note-taking—directions for what to write, cues for what is essential, note assessment, and note instructions—that influence lecture note-taking. Based on the differences between Japanese and Chinese students in lecture note-taking, it can be inferred that Japanese students are more aware of their teacher's explicit instructions on the notes' content and the assessment of their notes. This may lead to taking a few more notes, but not necessarily better ones. This study also explored different instructional approaches to note-taking, knowing that there are instructional approaches at the secondary level that are different from those at the university level; this gives us insights into the instructions that should be provided to improve student learning.

This study has several limitations and recommendations for follow-up research. Although the potential factors affecting note-taking have been discussed, there is no discussion on their specific effects. Second, the small sample size does not allow generalization to all secondary school students; thus, a

larger sample of Japanese and Chinese students would allow for a more representative picture of secondary school students' lecture note-taking. Moreover, since this study explored note-taking activities in mathematics classes, whether the findings are transferable to other content area or subjects remains to be investigated. Furthermore, we also discussed the possible influences of teachers; however, the findings are derived from a student-based survey. Further evidence of this finding and new findings can be obtained by conducting teacher-based observation surveys. Last, in exploring the cognitive activities that underlie lecture note-taking, we did not assume the existence of gender differences and therefore did not fully balance the male and female participants. However, previous studies have illustrated gender differences in note-taking activities (e.g., Reddington et al., 2015). Therefore, caution may be needed in the interpretation of the framework proposed.

This study has several implications for educational practice. First, the present study pointed out the necessity to consider the cognitive activities involved in lecture note-taking. Future work is expected on new measures based on the proposed theoretical framework that gauge the cognitive activity of lecture note-taking. Meanwhile, whether the deep lecture note-taking effectively promotes learning requires empirical evidence. On the other hand, note-taking instruction may prompt students to take more notes; however, this does not necessarily have a positive effect on helping students understand the lecture. This study reveals that instructions promoting deep lecture note-taking should be emphasized. For example, the metacognitive function of lecture note-taking should be exploited more. In addition, encouraging students to utilize resources, such as textbooks for note-taking might be effective. These have important implications for reconsidering the need for note-taking instructions and the exploration of effective note-taking instruction that takes into account the cognitive activities of note-taking.

DATA AVAILABILITY STATEMENT

The original contributions presented in this study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Tokyo/Office for Life Science Research Ethics and Safety. Written informed consent to participate in this study was provided by the participants.

AUTHOR CONTRIBUTIONS

ML conceived the present idea, carried out the implementation, performed data analysis, and took the lead in writing the manuscript. ML and YU contributed to the study design. Both authors provided critical feedback and helped shape the research, analysis and manuscript.

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REFERENCES

Bonner, J. M., and Holliday, W. G. (2006). How college science students engage in note-taking strategies. *J. Res. Sci. Teach.* 43, 786–818. doi: 10.1002/tea.20115

Boyatzis, R. E. (1998). *Transforming Qualitative Information: Thematic Analysis and Code Development*. London: Sage Publications.

Chen, J. (2000). Discussion on the guidance of students' lecture notes. *Shandong Educ. Res.* Z2:123. doi: 10.1152/advan.00126.2020

Christopoulos, J. P., Rohwer, W. D., and Thomas, J. W. (1987). Grade level differences in students' study activities as a function of course characteristics. *Contemp. Educ. Psychol.* 12, 303–323. doi: 10.1016/S0361-476X(87)80003-6

Di Vesta, F. J., and Gray, G. S. (1972). Listening And Note Taking. *J. Educ. Psychol.* 63, 8–14.

Dunlosky, J., Mueller, M. L., and Tauber, S. K. (2015). "The contribution of processing fluency (and beliefs) to people's judgments of learning," in *Remembering: Attributions, Processes, and Control in Human Memory: Essays in Honor of Larry Jacoby*, eds D. S. Lindsay, A. P. Yonelinas, and H. I. Roediger (New York, NY: Psychology Press), 46–64.

Fukawa-Connelly, T., Weber, K., and Mejía-Ramos, J. P. (2017). Informal Content and Student Note-Taking in Advanced Mathematics Classes. *J. Res. Math. Educ.* 48:567. doi: 10.5951/jresematheduc.48.5.0567

Kiewra, K. A. (1985). Providing the Instructor's Notes: an Effective Addition to Student Notetaking. *Educ. Psychol.* 20, 33–39. doi: 10.1207/s15326985ep2001_5

Kiewra, K. A., and Benton, S. L. (1988). The relationship between information-processing ability and notetaking. *Contemp. Educ. Psychol.* 13, 33–44. doi: 10.1016/0361-476X(88)90004-5

Kobayashi, K. (2006). Combined Effects of Note-Taking/-Reviewing on Learning and the Enhancement through Interventions: a meta-analytic review. *Educ. Psychol. Rev.* 26, 459–477. doi: 10.1080/01443410500342070

Marsh, E. J., and Sink, H. E. (2010). Access to handouts of presentation slides during lecture: consequences for learning. *Appl. Cogn. Psychol.* 24, 691–706. doi: 10.1002/acp.1579

Marton, F., and Säaljö, R. (1976). On qualitative differences in learning-II outcome as a function of the learner's conception of the task. *Br. J. Educ. Psychol.* 46, 115–127. doi: 10.1111/j.2044-8279.1976.tb02304.x

Ministry of Education, Culture Sports Science and Technology (2020). Shin Gakushu Shido Yoryo No Zemmen Jisshi to Gakushu Hyoka no Kaizen Ni tsu i te [Full Implementation of the New Courses of Study and Improvement

of Learning Assessment]. Available online at: https://www.mext.go.jp/content/20201023_mxt_sigakugy_1420538_00002_004.pdf (accessed April 1, 2022).

Mueller, P. A., and Oppenheimer, D. M. (2014). The pen is mightier than the keyboard: advantages of longhand over laptop note taking. *Psychol. Sci.* 25, 1159–1168. doi: 10.1177/0956797614524581

Murayama, K. (2007). "Gakushu horyaku: kodomo jishin no jiritsuteki na gakushu wo mezashi te [Learning Strategies: for children's self-regulated learning]," in *Zettai yakudatsu kyoiku shinri gaku*, ed. T. Fujita (Kyōto: Mineruvua Shoboō), 85–100.

Nakayama, M., Mutsuura, K., and Yamamoto, H. (2017). The possibility of predicting learning performance using features of note taking activities and instructions in a blended learning environment. *Int. J. Educ. Technol. High. Educ.* 14:6. doi: 10.1186/s41239-017-0048-z

OECD iLibrary (2015). *OECD Skills Outlook 2015: Youth, Skills and Employability*. Paris, Ile-de-France: OECD iLibrary.

Ohtsubo, and Higashibata. (2012). Writing on blackboard' by teachers and 'Note-taking' by students. Bulletin of the Faculty of Education, Kagoshima University. *Stud. Educ.* 63, 107–119.

Patricia, P. A., Dale, D. H., and Jeffrey, J. A. (2017). *Handbook of Self-Regulation of Learning and Performance.* New York, NY: Routledge.

Peper, R. J., and Mayer, R. E. (1986). Generative effects of note-taking during science lectures. *J. Educ. Psychol.* 78, 34–38. doi: 10.1111/j.1751-0813.2002.tb10969.x

Peverly, S. T., Brobst, K. E., Graham, M., and Shaw, R. (2003). College adults are not good at self-regulation: a study on the relationship of self-regulation, note taking, and test taking. *J. Educ. Psychol.* 95, 335–346. doi: 10.1037/0022-0663.95.2.335

Peverly, S. T., Ramaswamy, V., Brown, C., Sumowski, J., Alidoost, M., and Garner, J. (2007). What predicts skill in lecture note taking? *J. Educ. Psychol.* 99, 167–180. doi: 10.1037/0022-0663.99.1.167

Peverly, S. T., and Sumowski, J. F. (2012). What variables predict quality of text notes and are text notes related to performance on different types of tests? *Appl. Cogn. Psychol.* 26, 104–117. doi: 10.1002/acp.1802

Peverly, S. T., Vekaria, P. C., Reddington, L. A., Sumowski, J. F., Johnson, K. R., and Ramsay, C. M. (2013). The relationship of handwriting speed, working memory, language comprehension and outlines to lecture note-taking and test-taking among college students. *Appl. Cogn. Psychol.* 27, 115–126. doi: 10.1002/acp.2881

Ramsden, P. (1988). "Context and strategy: situational influences on learning," in *Learning Strategies and Learning Styles,* ed. R. R. Schmeck (New York, NY: Plenum Press), 159–184.

Reddington, L. A., Peverly, S. T., and Block, C. J. (2015). An examination of some of the cognitive and motivation variables related to gender differences in lecture note-taking. *Read. Writ. Interdiscip. J.* 28, 1155–1185.

Ruhl, K. L. (1996). Does nature of student activity during lecture pauses affect notes and immediate recall of college students with learning disabilities? *JPED* 12, 16–27.

Shiba, S. (2018). "). Improvement of learning ability by "Summary Notebook" to overcome learning difficulties," in *2018 Case Studies in Learning Support: Cognitive Counseling Practices for Developing Independent Learners (Excerpt)*, eds Y. Uesaka, S. Shiba, and S. Ichikawa (Japan: University of Tokyo), 36–52.

Titsworth, B. S. (2001). The effects of teacher immediacy, use of organizational lecture cues, and students' notetaking on cognitive learning. *Commun. Educ.* 50, 283–297. doi: 10.1080/03634520109379256

Titsworth, B. S. (2004). Students' notetaking: the effects of teacher immediacy and clarity. *Commun. Educ.* 53, 305–320. doi: 10.1080/0363452032000305922

Titsworth, B. S., and Kiewra, K. A. (2004). Spoken organizational lecture cues and student notetaking as facilitators of student learning. *Contemp. Educ. Psychol.* 29, 447–461. doi: 10.1016/j.cedpsych.2003.12.001

Uosaki, Y. (2017). Students' Note-taking Styles and Instructed Experiences. *Bull.Faculty Educ. Tamagawa Univ.* 17, 173–185. doi: 10.3390/brainsci8120220

Van Meter, P., Yokoi, L., and Pressley, M. (1994). College students' theory of note-taking derived from their perceptions of note-taking. *J. Educ. Psychol.* 86, 323–338. doi: 10.1037/0022-0663.86.3.323

Wang, C. (2014). An introduction to lecture notes in mathematics. *Spiritual Leaders* 2014:144.

Williams, W. L., Weil, T. M., and Porter, J. C. K. (2012). The relative effects of traditional lectures and guided notes lectures on university student test scores. *Behav. Anal. Today* 13, 12–16. doi: 10.1037/h0100713

Witherby, A. E., and Tauber, S. K. (2019). The current status of students' note-taking: why and how do students take notes?. *J. Appl. Res. Mem. Cogn.* 8, 139–153. doi: 10.1016/j.jarmac.2019.04.002

Yokoi, L. M. (1999). *The Developmental Context of Notetaking: A Qualitative Examination of Secondary-Level Student Notetaking (Junior High School Students, High School Students)*. Ph.D. thesis, Albany: University at Albany, State University of New York.

Zimmerman, B. J. (2008). Investigating Self-Regulation and Motivation: historical Background, Methodological Developments, and Future Prospects. *Am. Educ. Res. J.* 45, 166–183. doi: 10.3102/0002831207312909

Zimmerman, B. J., Bonner, S., and Kovach, R. (1996). *Developing Self-Regulated Learners: beyond Achievement to Self-Efficacy*. Washington DC: American Psychological Association, doi: 10.1037/10213-000

Zimmerman, B. J., and Schunk, D. H. (2011). "Self-Regulated Learning and Performance," in *Handbook of Self-Regulation of Learning and Performance*, eds B. J. Zimmerman and D. H. Schunk (New York: Routledge), 1–12.

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