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Commognitive responsibility shift and its visualizing in computer-supported one-to-one tutoring

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ABSTRACT
This study is the extension of our previous visualizing study on the commognition processes in computer-supported one-to-one tutoring. With the help of the scale of commognitive responsibility score, we found that the main triggers of the commognition process shift are the positive transfer of knowledge and cognitive conflict. On the basis of Fisher and Frey’s theory and our practical experience, we suggest the online teachers to provide (1) prompts to invite; (2) robust questions to access; (3) cues to find mistakes; (4) discussion to develop and (5) spiral review to connect.

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Commognitive responsibility; visualizing; one-to-one tutoring; computer-supported; mathematics

1. Introduction
In recent years, the increasing desire to advance multifaceted competences and skills required for individual adaptation to the Information Age has promoted the rise of Web-based Instruction (Varier et al., 2017), which includes the computer-supported one-to-one tutoring. Computer-supported one-to-one tutoring is an extended form of online instruction based on the communication and cognition interaction between the teacher and the student (Humphry & Hampden-Thompson, 2019). It is increasingly popular due to its individualization and effectiveness (Weston & Bain, 2010), especially in China when the COVID-19 epidemic moves all the instruction and tutoring online. Considering that, similar to the common focus on the change of teaching in school from teacher-centered to learner-centered (Hershkovitz & Karni, 2018; McCombs, 2013; Reigeluth, 2017), the shift of communicative and cognitive work in one-to-one online tutoring out of school deserves further investigation since it plays a core role in the effectiveness and efficiency of teaching and learning.

Based on Anna Sfard’s commognitive framework which suggests that individual cognition can be reflected by the discourse in communication (Sfard, 2008), our previous study (Lu et al., 2019) found that the commognition of the teacher and the student in a series of one-to-one online tutoring courses can develop as the sequence of three processes: teacher-led commognition process, comparison of commognitive process and student-led commognition process. In order to figure out what triggers the shift, we conducted a further and more detailed study to investigate the commognitive processes in computer-supported one-to-one tutoring.

1.1. Background
Along with the widespread of computer-supported one-to-one tutoring, much discussion and practice have been conducted concerning its benefits. Evidenced by empirical researches, this form of private tutoring is relevant to students’ increased engagement and interest level (Bebell & O’Dwyer, 2010; Mo
et al., 2013). Some quantitative results also further revealed that it contributes to lecture reinforcement, motivation, and problem-solving (Kulik, 2002; Pinder, 2008). Moreover, if the online tutoring is synchronous, the teacher is more able to integrate student’s interests and learning styles (Hastie et al., 2007).

However, a number of studies also have emphasized the precedent or potential issues of one-to-one online tutoring, such as student discipline problems, absence of paralinguistic cues and over-dependency on information technology (Lei & Zhao, 2008; Price et al., 2007). Compared with face-to-face teaching, online tutoring is less targeted, focused and clearly identified (Jopling, 2012). Although the one-to-one form might make up for the shortage, the fact that teachers are lack of preparation, field experience and a model or benchmark for teaching online still leaves doubts on the efficacy of one-to-one online tutoring (Kennedy & Archambault, 2012; Schmidt et al., 2016).

What’s more, over the last two decades, there is a debate on the relationship between teacher and student in one-to-one online tutoring. It is articulated by some researchers that tutor-centered is the preferred instructional type of one-to-one online tutoring oriented to examinations (Chung et al., 2006), and the teacher should hold the responsibility for the effective implementation of one-to-one initiatives (Bebell & Kay, 2010; Shapley et al., 2010). However, some other studies put forward different claims, advocating the teachers to minimize or even relinquish their control of the tutoring (Bennett & Marsh, 2002; Hastie et al., 2007; Stickler & Hampel, 2007). But the agreement they have reached is that there is an urgent need for further investigation and better training to help tutors understand the distinctive qualities and characteristics of one-to-one online tutoring (Jopling, 2012).

1.2. Purpose of this study
The primary purpose of this study was to figure out the reasons behind the process shift in computer-supported one-to-one tutoring. The study mainly focused on the following questions:

1. How can we locate the time points when teaching and learning activities that trigger the cognition process shift happen?
2. What are those teaching and learning activities that trigger the process shift?

2. Methodology
2.1. Lesson samples
One-to-one online tutoring lessons in mathematics include three types: (1) the preview of knowledge before classes in school; (2) the review of knowledge with explanation for exercises after classes in school and (3) extracurricular knowledge development. In this study, we still select the original four lessons given by the teacher to the student in July 2018 as samples. All of the four one-to-one online tutoring lessons (hereinafter referred to as OTO) are the preview type of online tutoring concerning set theory, which is a basic branch of mathematics and occupies an important place in mathematics, penetrating various fields of mathematics.

There was one lesson of 60 min and three lessons of 90 min, for a total of 330 min. The specific lessons’ contents in the sequence are as follows: (1) the meaning and representation of the set; (2) the basic relationship between the sets, (3) the first part of the basic operation of the set and (4) the second part of the basic operation of the set, which are the beginning lessons of high school in China.

2.2. Participants
The teacher in the lesson samples is a young teacher from Zhejiang Province, China, with a 6-year online math tutoring experience. The content of his tutoring mainly focuses on the college entrance math examination.
The student involved is a 15-year-old boy from Fujian Province, China. According to our 20 min interview with the teacher, this boy was a grade 10 student with medium performance in mathematics during the lesson samples.

2.3. Online environment

The four-lesson samples are supported by computer-supported one-to-one tutoring platforms. As shown in Figure 1, the platform is composed of three components: (1) the window of a student, in which the real-time image of the student is shown and the student can send a text message to the teacher; (2) the window of teacher, in which the real-time image of the teacher is shown and the teacher can send a text message to the student; (3) courseware – a PowerPoint window, in which the courseware can be shown, and both the teacher and the student are able to write or draw on it. The whole process of the lesson can be recorded by the platform so that both the teacher and the student can review it after class.

2.4. Commognitive responsibility score

In our previous study (Lu et al., 2019), we coded the discourses between the teacher and student in the sample lessons from 0 to 5 according to their commognitive level. After visualizing the coding result, we analyzed the commognitive development of the teacher and student from a macroscopic perspective. However, in this study, since a more microscopic investigation is needed, the framework used to determine the commognitive level of discourse seems not robust enough. Therefore, we drew lessons from the concept of cognitive responsibility in Douglas Fisher and Nancy Frey’s Gradual Release of Responsibility Instructional Framework (Fisher & Frey, 2013), and built a scale of commognitive responsibility score (Table 1) to describe the teacher’s and the student’s roles in the communication and cognitive interaction during a computer-based one-to-one tutoring lesson.

We firstly divided each sample lesson into 5 min sub-processes as the units of investigation. Then we scored the teacher’s and the student’s commognitive responsibility in each sub-process with the help of our previous visualization result of commognitive processes. In each sub-process, if the visualization curve of teacher’s commognition scores shows a rapid growth while the curve of student’s commognition merely presents a gentle change, it is acceptable to regard that the teacher mainly

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**Figure 1.** Online teaching demonstration platform. Note: The Chinese characters in the center of are the title of the lesson, which means “Chapter 1 Concepts of Sets and Function”, “1.1 Sets”, “1.1.1 The meaning and representation of the set”.
### Table 1. Scale of commognitive responsibility score.

<table>
<thead>
<tr>
<th>Sub-process category</th>
<th>Role description</th>
<th>Teacher score</th>
<th>Student score</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-held sub-process</td>
<td>Teacher mainly holds the commognitive responsibility</td>
<td>5</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Sharing sub-process</td>
<td>Teacher and student share the commognitive responsibility</td>
<td>3</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>
Student-held sub-process: Student mainly hold the commognitive responsibility.

OTO2

OTO2
takes the commognitive responsibility and leads the interaction with the student, so we assign 5 points to the teacher and 1 point to the student. On the other hand, if the visualization curves of student’s commognition have more noticeable growth than the curve of teacher’s commognition in turn, the commognitive responsibility transfers. In those kinds of sub-processes, it is the student who leads the commognitive interaction. Accordingly, we assign the student 5 points, while the teacher can only gain 1 point. What’s more, there is also an intermediate condition when both the value of teacher’s and student’s commognition have roughly the same tendency of change. Under those kinds of circumstance, the teacher and the student share the commognitive responsibility, leading the development of commognition corporately by active questioning, answering and discussing. In those kind of sub-processes, we equally assign 3 points both to the teacher and the student.

There were two researchers participating in the scoring process and the coding $\kappa$ coefficient of the results was 0.908, which was appropriate. After we reached an agreement about the inconsistent coding results by discussion, we plotted the sum commognitive responsibility score of the teacher and the student along the timeline. The plots obtained showcase the concrete procedures of commognitive responsibility development, helping us locate the time points when tutoring activities that trigger the commognition process shift happened.

3. Results

3.1. Overview of commognitive responsibility

The percentage of each sub-process category in the four-lesson samples is shown in Figure 2. It is noticeable that the percentage of teacher-held sub-process decreased in turn from OTO1 to OTO4,
which echoes the findings of our previous study, indicating that the commognitive responsibility of the teacher was gradually released in the series of computer-based one-to-one tutoring lessons. What’s more, it is noteworthy that not all the teacher-held sub-processes shifted to student-led time. As the lesson progressed, more and more units of time were distributed to sharing sub-process while the percentage of student-held sub-process only changed mildly.

3.2. Commognitive responsibility in teacher-led commognition process

Our previous study has illustrated that OTO1 is a typical sample lesson of teacher-led commognition process. The category of each sub-process in OTO1 is shown in Figure 3, with the curve of the sum of teacher’s and student’s commognitive responsibility score. Since the teacher mainly adopted lecture as the teaching method, he firmly held the commognitive responsibility most of the time while the student only asked questions and grasped the commognitive responsibility once in a while. Therefore, the sum of teacher’s commognitive responsibility score was higher than the student’s all the time.

Since OTO1 is the first lesson of the tutoring series, the lesson began with teacher-held sub-processes, in which the teacher introduced himself, established tutoring purposes and laid out the basic notions of set theory, while the student merely listened with little commognitive reaction. During the whole lesson, time is mainly taken up by teacher-held sub-process since the teacher mainly took lecture as his teaching method. Student-held sub-process merely occurred three times followed by (or following) a sharing sub-process. For the first time, the student raised questions in mathematical symbol expression when the teacher associated the symbol of “not belong to” in set theory with the student’s previous knowledge: the sign of inequality. For the second time, the student expressed his confusion to the claim that all equilateral triangles can form a set, which conflicted his original understanding of the triangle. Finally, the student brought out that he was obstructed by a set problem with parameter. All the questions raised by the student were timely solved by the teacher with explanation, demonstration and think-alouds.

3.3. Commognitive responsibility in comparison commognition process

According to our previous study, OTO2 is a typical example of comparison commognition process. In OTO2, the three categories of sub-process appeared alternatively, indicating that the commognition responsibility commutatively shifted between the teacher and the student. As shown in Figure 4, OTO2 began with student-held sub-processes in which the student did several exercises to review the knowledge of OTO1. And then the responsibility was shifted to the teacher when the teacher started to introduce the way of representing a set in a lecture way. Afterwards, when it’s time to

![Figure 4. The commognitive responsibility in comparison commognition process.](image-url)
solve some relevant problems as exercise, the teacher changed his tutoring strategies. At first, modeling and thinking aloud were still used by the teacher to demonstrate how to figure out the solution, so the commognitive responsibility was still teacher-held. Then, the teacher gradually changed to guide on the side and released the responsibility. He provided verbal and virtual cues as guidance, encouraging the student to apply what he has learned and solved the problems independently. At the end of exercising, the teacher set a robust question to trigger cognitive conflict about the concept of void, to which the student respond with active feedback. After this question, the student became increasingly agile in the communication and cognitive interaction with quickly-increased commognitive responsibility score.

3.4. Commognitive responsibility in student-led commognition process

OTO3 and OTO4 exemplify the computer-based one-to-one tutoring in student-held sub-process. In the two lessons, sharing sub-process and student-held sub-process dominated the time, while much less teacher-held sub-process occurred. In OTO3, the lesson begun by reviewing the homework of the previous lesson, led by the student. Then the teacher and the student started to solve some math problems with high difficulty together. Usually, the teacher would wait for the student until he spoke out his own problem-solving ideas, then they would discuss with each other whether the solution was right. It was not until the end of the lesson when the teacher had to summarize the whole lesson that the teacher-held sub-process emerged. Similarly, in OTO4, the lesson began by the previous review which was led by the student. After that, since the new knowledge of complement is a little abstract for the student, the teacher drew back the commognitive responsibility to explain this point more in-depth. Then, the teacher and the student shared the commognitive responsibility and solved some math problems as the same way in OTO3. At the end of the lesson, there appeared a teacher-held sub-process when the teacher conducted a summary of the whole lesson, followed by a sharing sub-process and student-held sub-process when the student tried to do some exercises independently (Figure 5).

4. Discussion

By comparing the percentage of each sub-process category in the four-lesson samples, we found that while the computer-based one-to-one tutoring gradually shifted from teacher-led process to student-led process, most of the original teacher-held sub-processes in a lesson shifted to sharing sub-process rather than student-held sub-process. It reflects that the teacher did not tend to relinquish his commognitive responsibility even in the student-led process, which offers a different empirical explanation of the relationship between teacher and student from the existing researches in online one-to-one tutoring (Bennett & Marsh, 2002; Chung et al., 2006; Hastie et al., 2007; Stickler & Hampel, 2007). Neither a dominator nor a “laisser-faire”, the teacher is supposed to be the companion of the student to develop. This echoes Reigeluth’s theory of on-campus and offline instruction paradigm, which advocates that the role of the teacher should change from sage on the stage to guide on the side (Reigeluth, 2017).
The main trigger of the commognition process shift.

<table>
<thead>
<tr>
<th>Lesson</th>
<th>Trigger</th>
<th>TS</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>OTO1</td>
<td>Positive transfer of knowledge (teacher-led)</td>
<td>prompts</td>
<td>Teacher: a is not an element of set A, we could regard it as a kind of “not equal to” relationship. So do you remember what we add on an equals sign to represent “not equal”? Student: A directory string</td>
</tr>
<tr>
<td></td>
<td>Cognition conflicts at lower level (conceptual, descriptive conflicts)</td>
<td>/</td>
<td>Student: I think all the equilateral triangles have the same inner angles. Why they are different and can be in one set as different elements? Teacher: Yes, all the inner angles of equilateral triangles are 60°, but the side length can be different</td>
</tr>
<tr>
<td>OTO2</td>
<td>Positive transfer of knowledge (student-led)</td>
<td>Spiral review cues</td>
<td>Example: Please judge whether the following objections can form a set Exercise: Please express the set composed of the integer whose remainder divided by 3 is 1</td>
</tr>
<tr>
<td></td>
<td>Cognition conflicts at higher level (conflicts concerning problem-solving strategy)</td>
<td>Robust questions</td>
<td>Example: If there are 3 elements in set A, then set A has 7 true subsets.</td>
</tr>
<tr>
<td>OTO3 and OTO4</td>
<td>Positive transfer of knowledge (student-led)</td>
<td>Spiral review discussion</td>
<td>Example: It is known that the set</td>
</tr>
</tbody>
</table>
|        | Cognition conflicts at higher level which are difficult to remove | | A = {(x, y)|y = ax + 1}, B = {(x, y)|y = x + b}, and A ∩ B = {(2, 5)}, then a = ____, b = ____.

TS means Teaching strategies. “/” in this column means the activity happened unintentionally.

Through more detailed analysis and comparison of the commognitive responsibility development procedure in each sample lesson, we get Table 2 to demonstrate what triggers the commognition development from teacher-led process to student-led process.

From the perspective of teaching strategies, the findings of the study are good empirical experience in computer-based one-to-one tutoring of the Gradual Release of Responsibility Instructional Framework (Fisher & Frey, 2013). Though Fisher and Frey’s instructional suggestions actually are served for offline teaching in the classroom, our study has demonstrated that those teaching strategies such as providing prompts, cues, robust questions and spiral reviews are also conducive to the commognition process shift in computer-based one-to-one tutoring. To be more specific, at the very beginning of the tutoring when the student has not accustomed to hold the commognitive responsibility, prompts may function as an effective catalyst since it can remind the student about prior knowledge and open a window for him/her to participate in the commognitive interaction. Also, robust questions can serve as stairs for the student to learn new concepts and skills, or think previous knowledge more deeply. Then, emphasis cues like stressed vocal pitch or underlying keywords in questions may help the student find his/her flaws when he/she tries to apply the knowledge to solve some problems. Since the mistakes were figured out by themselves rather than pointed out directly by the teacher, the student may regard this as an encouraging process and become more confident to continue interact with the teacher. What’s more, after the student accumulate some interaction experience, spiral review exercises would also be an efficient way for the student to lead a learning sub-process and speak out his/her own opinion.

However, in computer-supported one-to-one tutoring, Fisher and Frey’s suggestion to organize collaborative learning is not suitable since there is no classmate. Fortunately, according to the experience of our study, the discussion between the teacher and the student also can prompt the
construction of student-centered tutoring, working as a robust substitute for group work. Both OTO3 and OTO4 are good examples in which the student mainly led the communication and cognitive interaction by discussing the difficult math problems actively with the teacher. The teacher also combined all the teaching strategies mentioned above during the discussion to promote the commognition development. As a result, the student showed a higher level both in commognition and commognitive responsibility (obtained higher scores).

If we try to figure out why those teaching strategies can trigger the commognition process shift, both positive transfer of knowledge and cognitive conflicts may stand out as the answer. In the four sample lessons, the student was compelled to get involved in a more complex and effective commognitive activity when he was encouraged by the prompts, cues and spiral reviews to recall the prior knowledge and construct scaffold to reach the new content. It echoes the classical transport theory that indicates the positive effects of knowledge transfer (Bransford & Schwartz, 1999; Gray & Orasanu, 1987; Simons, 1999; van de Pol et al., 2010). Meanwhile, conceptual cognition conflict also stimulated the shift of commognitive responsibility in the process, which has been supported by previous studies that cognition conflicts have the opportunity to contribute to student’s conceptual change and understanding (Kang et al., 2004; Lee & Yi, 2013; Limón, 2001). In the sample lessons, it is by creating cognitive conflicts that the teacher successfully stimulated the student’s enthusiasm and activity. Additionally, some unintentional cognitive conflicts also greatly improved the student’s level of commognitive responsibility.

5. Conclusion

In this study, we built a scale of commognitive responsibility score to describe the commognitive relationship between the teacher and the student in computer-based one-to-one tutoring. With the help of the scale, we located the time points when teaching and learning activities that trigger the commognition process shift happen. By reviewing the lesson videos, we found that the main triggers are a positive transfer of knowledge and cognitive conflict. On the basis of Fisher and Frey’s theory and our practical experience, we came up with the following suggestions for the teachers working on computer-supported one-to-one tutoring to realize those triggers:

1. provide prompts to invite: design questions of prompts to remind the student about what he/she has learned before in order to invite he/she join in the interaction with you.
2. provide robust questions to access: put forward robust questions that inspire the student to recognize his/her flaws of academic understanding, so that he/she will be compelled to access to new knowledge with strong curiosity and activity.
3. provide cues to find mistakes: when doing exercises, offering cues to help the student find his/her mistakes on their own, which can encourage them to think more deeply and ask more high-quality questions.
4. provide discussion to develop: combine all the suggestions above and discuss with your student when you are facing some tough, or complicated problems.
5. provide spiral review to connect: set spiral review at the beginning of each lesson, then the student may get better prepared and braver to express.

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References


