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INVESTIGATION OF CONTINGENCY PATTERNS OF TEACHERS' SCAFFOLDING IN TEACHING AND LEARNING MATHEMATICS

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Abstract

The purpose of this study is to investigate the patterns of scaffolding contingency in teaching and learning mathematics carried out by three teachers. Contingency patterns are obtained by examining the transcription from video recording of conversation fragments between teachers and students during the provision of scaffolding. The contingency patterns are drawn in three strategies: diagnostic strategy, intervention strategy, and checking diagnosis. The result shows that the three teachers expressed different interaction contingencies in their scaffolding activities: contingent dominant, non-contingent dominant, and pseudo-contingent. It is also found that the learning interaction performed by experienced teachers tends to be contingent dominant compared to novice teachers.

Keywords: Contingency, Contingent Dominant, Non-Contingent Dominant, Pseudo Contingent, Scaffolding

Abstrak

Penelitian ini bertujuan menginvestigasi pola kontingensi interaksi pembelajaran tiga guru ketika memberikan *scaffolding* dalam pembelajaran matematika. Pola kontingensi diperoleh dengan memeriksa setiap fragmen percakapan antara guru dan siswa menggunakan tiga strategi yaitu: strategi diagnostik, strategi intervensi, dan pengecekan diagnosis. Data diperoleh dengan cara merekam fragmen percakapan guru dan siswa saat pemberian *scaffolding*. Selanjutnya, setiap fragmen percakapan ditranskripsikan dan dianalisis. Hasil penelitian menunjukkan bahwa ada tiga pola kontingensi interaksi pembelajaran antara guru dan siswa ketika pemberian *scaffolding* pada pembelajaran matematika, yaitu dominan kontingen, dominan non-kontingen, dan kontingen semu. Selain itu, interaksi pembelajaran yang dilakukan oleh guru yang lebih berpengalaman cenderung dominan kontingen dibandingkan dengan guru pemula.

Kata kunci: Kontingensi, Dominan Kontingent, Dominan non-kontingent, Kontingen Semu, *Scaffolding*

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Scaffolding is part of the learning strategies to facilitate student learning (Lin et al., 2012) and to produce effective learning (Van de Pol, 2012, p. 6), especially for those who are unable to complete their tasks independently (Alibali & Nathan, 2007). Through the provision of scaffolding, students are expected to become independence in learning (Anghileri, 2006).

Teachers' knowledge, skills, and experiences are among the success factors of scaffolding provision (Holton & Clarke, 2006). However, Holton & Clarke (2006) also mention that teachers may use different ways in providing scaffolding. Some teachers are able to provide scaffolding in a certain way, but unable to use other ways. Therefore, this is important to study the ways of the teachers in facilitating scaffolding in teaching and learning mathematics.

Although scaffolding is considered as an effective teaching method (Anghileri, 2006; Danilenko, 2010; Ferguson & McDonough, 2010; Koedinger, 2005; Thompson, 2013; Unal, 2012; Zambrano and

Noriega, 2011), it is still somewhat rare studied by researchers (Van de Pol, Volman, & Beishuizen, 2010). The results of meta-analysis Van de Pol, Volman, & Beishuizen, 2010) on 66 research journals from 1989 to 2009 related to scaffolding indicate that more research on scaffolding studied in literacy, but it is a few researches in science and mathematics learning and teaching process.

Based on previous studies, there are a few researches that consider the effectiveness of scaffolding (Van de Pol, Volman, & Beishuizen, 2010). Although there are three stages of providing effective scaffolding, namely: contingency, fading, and transfer of responsibility, Van de Pol, Volman, & Beishuizen (2010) and Van de Pol (2012, p. 32) suggested the contigency as the most important part and the main caharacteristics in providing the scaffolding. Contingency is seen as a prerequisite and key characteristic of scaffolding. Therefore, the authors are interested to focus the study on the contingency of scalffoding.

Van de Pol (2012: 98) investigated the contingency of teaching interaction by giving scaffolding in small group on social science subject. The findings indicated that there are two patterns of interaction contingency of teachers when offering scaffolding to students, which are contingent and non-contingent.

The characteristics of mathematics subject could be different from social science subjects. Its abstract content which require deductive thinking imply different approach in facilitating students learning than approach for learning social science. This may lead to different patterns of interaction contingency of mathematics teachers than social science contingency patterns. Unfortunately, there is no such information available yet. Therefore, the authors are interested to investigate the possible patterns of interaction contingency during the provision of scaffolding in mathematics learning.

The aim of this study is to investigate the patterns of contingency interaction in mathematics teaching and lerning process in which teachers provide scaffolding to students. By having the patterns, it drives to explore the teachers' thinking process when providing scaffolding in teaching and learning mathematics. Based on the interaction contingency in classroom activities, this study can also be a basis mapping for the teachers to develop their professionalism in teaching mathematics.

METHOD

Considering the previous study done by Van de Pol (2012), this study focuses on the interaction between teachers and students as individual. The study was conducted at a private junior and senior high school in Malang on 9-14 October 2014. Three teachers are involved in the study, namely: DN, HY and LD. DN is a prospective teacher who taught open and close sentences for 25 students in grade 7. HY is a new teacher who taught composition of function in grade 10 with 13 students. LD is a novel teacher who taught the equation of straight line at grade 8 with 25 students.

All of teachers are given freedom in teaching and learning process. Using video recorder, the authors recorded the teaching processes, especially on interaction between teachers and students during scaffolding activities. Students were familiar with video recording so that they acted naturally. The authors then conducted semi-structured interviews for teacher and some students in order to determine the advantages of scaffolding for teacher and to keep track student's understanding.

Furthermore, the fragments of the interaction as transcribed from videotape helps researchers to investigate what kind of context happened during the process. Therefore, to determine the patterns of contingency in fragment interaction in the scaffolding, authors examined it using three strategies such as coding diagnostic strategies (D), intervening strategies (I), and checking of a diagnosis (C). Furthermore, based on teachers provided scaffolding, researchers quantified the amount of strategies of D, I, or C in order to determine the type of contingency interaction patterns.

RESULT AND DISCUSSION

The general information about the interaction of the three fragments from the three teachers are shown in Table 1. All the teachers presented differences in terms of the number of fragments interaction, the average of duration in one-fragment interactions, and summary.

Table 1. Summary of Provision Scaffolding in Mathematics Teaching and Learning Based on Subject Matter, Duration Time, and Fragment Interaction per Teacher

Teacher's code	Subject Matter	Duration (minutes) of *scaffolding* (number of fragment)	Mean of duration provision of *scaffolding* per fragment (in second)	Comparing of the contingency strategies used by teachers			Summary
				Number of diagnostic strategies (D)	Number of intenvention strategies (I)	Number of *Checking of a diagnosis (C)*	
LD	equation of straight line	20(22)	54 (37,8%)	41 (47,1%)	67 (33,8%)	41 (45,6%)	contingent dominant
HY	Compo-sition of function	12(19)	38 (26,6%)	8 (9,1%)	39 (19,7%)	13 (14,4%)	non-contingent dominant
DN	open and close sentences	29(34)	51 (35,7%)	38 (43,7%)	92 (46,5%)	36 (40%)	pseudo-contingent
Total		61	143	87	198	90	

DN's Description of Teaching Interaction

Here is the fragment of teaching interaction in facilitating open and close sentences.

Fragment 1

S: *Open sentences is a sentence that could or could not, Ms? It can be stated right or wrong or could not be declared right or wrong Ms?*
T: *This example ... [pointing phrase "The capital city of Indonesia is x"]. It can be declared right or wrong? [D]*
S: *Lha, it can*
T: *How do you know it? [D]*
S: *From x*
T: *Can be justified? [D]*
S: *it can be Surabaya ... or it can be Jakarta.*

T: *If I replace x to be Jakarta? [I]*
S: *Right.*
T: *If I change x to be Surabaya? I]*
S: *False*
T: *If I do not change it, it still x [I]*
S: *It can not be said right or wrong ... oh it cannot be declare!!...*
T: *[leave the student]*

Based on fragment 1 above, DN provided the actual scaffolding that led to contingent interaction. DN promoted diagnostic and intervention questions. Nevertheless, she did not justify student's answer and left the student in that way, so that student became less understand. In this case she did not use checking of diagnosis. Moreover, in other fragments, she stated incorrect definition (it can be observed in fragments 2 and 3).

Fragment 2

S: *Ms, open sentences.*
T: *If the open sentences... we already know that open sentences is the sentences can be expressed correctly or incorrectly or not both. Well if the close sentences means.... what? [I]*
S: *oh.*

Fragment 3

T: *So the conclusion ... what is closed sentences? The example of closed sentences is this ... this ... until here ... grouping to be this group ... this group ... this group ... So that, what is the closed sentences ? [D]*
S: *[silent]*
T: *Sentences that. That cannot be.*
S: *be declared "right"*
T: *Or ..? [I]*
S: *be declared "wrong"*
T: *Please write with your own words*

Based on the DN's interaction as shown in fragments 1, 2 and 3, it can be concluded that the interaction fragment is encoded as a pseudo-contingent. We said that the interaction as a pseudo-contingent because the providing of scaffolding was not assisting a students' understanding properly. This happened because of teacher misconception on definitions and concept.

Actually, DN's teaching interaction has led to the contingent dominant (55.8%), but 32.3% including pseudo-contingent. As a result, the implementation of contingency strategies looks less meaningful for the students' understanding. At the end of students' activities, they are still straggling to understand the materials. The results of the analysis from video recorder show that DN often make mistake in her teaching about open and close sentences and she seems hesitant. Here is one of definitions she gave, such as: "*close sentence is a sentence that cannot be declared right or wrong, or both. Open sentence is a sentence that cannot be expressed with true and false, or both* ". These statements are precisely the same as she convey when the researchers interviewed her after teaching process.

HY's Description of Interaction

Here is a fragment interaction in establishing contingency interaction when he was teaching the composition of functions.

Fragment 4

T: *are you done?*
S: *Here ...Sir.*
T: *The domain from the earliest is this [teacher shows a special set]*
S: *So, f (a) = 3... is it the domain, right?*
T: *The domain, are these one a ... b ... c ...The codomain are... p, q, r, s*
S: *What is the range, Sir?*
T: *That is the pointed here... yes ... the same...*
S: *Yes yes ...*
T: *[leaving student]*

Fragment 5

T: *How about the square of x cubed? [D]*
S: *x to the power five .. added ...is'nt it?*
T: *x to the power of five?*
S: *Oh, x to the power nine*
T: *x to the power six, right? ...the square of x cubed is the same as multiplication this addition is ... multiplication of x....the x cubed times x squared is just x to the power five [Explaining* $(x^3-1)^2$*] [I]*
S: *It means that this one is correct, sir?*
T: *Yes*
S: *Sir ... if this g o f correct, have I?*
T: *x squared...x cubed ... [while pointing* $(x^2)^3$*] [I]*
S: *Oh, six ... yes. yes just a minute ...*

In the first row at fragment 5, HY tried to do a diagnostic strategy, but in the next lines, he dominantly performed an intervention strategy by giving a direct answer. This fact is consistent with the findings of Elbers et al. (2008) that the teachers rarely explore the nature of the right of students' problems, but teachers began to give a direct explanation. That interaction mostly occurred in his teaching process. In this case, the interaction of fragment in scaffolding provided by HY encoded as the non-contingent dominant.

The result of observation shows that HY did 19 fragments of interactions with the students, 6 of its as a general interaction fragment (whole class). This is corresponding to the direct approach. The average duration in scaffolding was 38 seconds for each fragment. According to authors, HY is a teacher who master that material. However, he mostly used scaffolding, which tend to directive or intervention strategies. If the student needs help, he gave the answer directly or he wrote the answer by himself. Almost every issue that student asked, he generally assisted it. HY dominantly (60%) uses intervention strategies to provide assistance to students. The authors also call this as directive strategy. Implementation of these strategies appears less significant for students. Moreover, the results of research show that the timing in helping students too short. As a result, students are not undergoing construction their own thinking during teaching and learning process, so that what students was experiencing just a temporary memories. This is why the authors called this interaction as the non-contingent dominant.

LD's Description of Interaction

Here is the fragment that LD showed as a contingent pattern of interactions when she taught the straight line equation, especially in determining y = mx + c.

Fragment 6

S: *Mrs. LD ... [A student called LD associated the first part of worksheet which is y = mx + c when teacher was still far away from the student]*
T: *If there was an x ... what was an m named? [D]*
S: *Not constant...isn't it ...*
T: *what is it named? [D]*
S: *Coefficient ...*
T: *Em ...*
S: *After that...why?*
T: *But it was given the general shape like that ...? [D]*
S: *Yes ...*
T: *the straight line equations ... now you are told to write its example, means that how is the straight line looks like? [C]*
S: *I do not understand ...*
T: *Likes yesterday, yesterday ... I gave a linear function form f (x) = ax + b [I]*
S: *e e ..*
T: *Then I wrote to an example ... means f (x) is equal to ... 2x plus five [I]*
S: *Oh, so ... this... this*
T: *aa ... you can just give an example ... [I]*
S: *number ...used number?.*
T: *aa ...*
S: *But it's up to us like what we want...right?*
T: *aa ...*
S: *mx plus c the result that y, isn't it?*
T: *That y ... the equation y equals to mx plus c ... [I]*
S: *Oo e e ... Thank you Mrs.*

Fragment 7
S: *[Student is pointing towards the beginning of worksheets that he does not understood]*
T: *If yesterday ...the equation ... e ... that's a linear function f (x) = ax + b..What do we change, which one? [D]*
S: *Letter a*
T: *the answer should be the same [I]*
S: *Oh it means the x ... it we do not know how ...*
T: *yes ...*
S: *Earlier, for example f (x) = 4x + 2 ...*
T: *y is the same as what...I have been described it to you yesterday? [D]*
S: *y ... [students still confused]*
T: *If you draw a rectangular coordinate ...is should be y in there? [D]*
S: *e e ... yes*
T: *In there... isn't, it should be a general equation y there? [D]*
S: *Yes ...*
T: *So what? [C]*
S: *So f (y) ... there should be y?*
T: *em em ... yes .... If f (x) must be exist x. Now, the general form is y = mx+ c.... [I]*
S: *ee ...*
T: *Well, it's mean that what can we changed? [C]*

S: *m and c ...*
T: *It means that x and y is ...? [C]*
S: *Yes, fixed like that?*
T: *Ok?*
S: *Oh, yes I know ...yes, Mrs*.

From fragments 6 and 7, we notice that LD performed contingently fragments interaction. She often uses this interaction in entire teaching activities. In this study, the interaction fragment of scaffolding showed by her encoded as the contingent dominant. When it is viewed as a whole interaction, she is almost continually implemented the three strategies in presenting scaffolding (can be seen in Table 1). Although the strategy of intervention is more dominant than the other two strategies, but her intervention strategies were not directive. It means that she did not provide the answers but she interven the students to think about the issues that are considered it.

From 22 fragments interaction between LD and the students, two of them as fragments of public interaction. Students were divided into two groups, where students were facing each other. The duration of time in presenting scaffolding was 54 seconds. In her activities, she has used a strategy as outlined Van de Pol (2012), the diagnostic strategies, intervention strategies, and checking of diagnosis. This makes student become motivated to learn the materials.

Although this study did not generalize the findings, but it shows the empirical facts that there are the differences in interaction fragments between three teachers when providing scaffolding, namely: the contingent dominant, the non-contingent dominant, and the pseudo-contingent. Those findings provide some contributions into our understanding of teaching mathematics and the provision of scaffolding. The finding of this study differs from the findings of Van de Pol (2012) who found two contingency patterns of teaching interaction by different teachers with the same material, namely: contingent and non-contingent.

Moreover, this study has some limitations. The dissimilarity of three teachers' interaction when providing scaffolding in this study are likely influenced by several factors, such as: the teaching experience of teachers, subjects were given, and a learning approach that transactions are carried out (Corey et al., 2010), and the use of worksheets. First, in general, the three teachers in this experiment are classified as new teachers. This factor will impact on the lack of teaching experiences and influence their teaching interactions. This makes teachers tends to non-contingent or pseudo-contingent. As a young teacher, the possibility of stress happens when one is teaching. For example, DN is a prospective teacher (practitioner) and HY is a new teacher who has taught for two months. As Travers & Cooper (1996) says that teaching is one of the most stressful of human service work. Borko & Putnam (1996) says that beginning teachers may be too stressful to teach efficiently from their teaching experience.

Nevertheless, it is interesting in this study is that even though the teacher with experience teaching less than 3 years likes LD who experience a little longer than DN and HY, but LD was able to demonstrate the mathematics teaching of interaction with the contingent dominant patterns? This is supported by the findings of Unal (2012) that the more experienced teacher, the more he gets control the setting behavior and teaching. Therefore, as a young teacher or a new teacher (HY or DN), it is natural that they show the non-contingent dominant interactions and even the pseudo-contingent interactions. These findings are also quite similar to the findings of Van de Pol (2012) even they teach at the same level but is still difficult to contingent approach occurs.

Second, the characteristics of the materials observed in this study are also different hierarchically. This research was conducted in the same school environment with different levels of education, namely: junior high school and senior high school. These differences would affect the difference in the level of difficulties of presenting the materials, and the readiness of teachers in presenting the materials. Evans (2011) found that high school teachers had significantly higher knowledge than the secondary school teachers and then teachers who have strong mathematical backgrounds; they had significantly higher level of materials knowledge then teachers who do not have the strong mathematics backgrounds. Feldon (2007) states that teachers have a high cognitive load when teaching material that is difficult especially when teachers provide learning assistance to students. It is understood that the composition of functions facilitated by HY at the high school level is harder than the material that is assisted by the DN and LD at the secondary school level.

Refers to Gresalfi & Cobb (2007), HY is not an effective teacher. Effective teachers are teachers who engage in activities that focus on the discussion, collaboration and improving on visions. Effective teachers are able to handle the students' difficulties (Sowder, 2007). Teachers know how to provide scaffolding that to encourage students to develop their understanding. Teachers know what kind of knowledge needed in order to understand new materials. On the other hand, other teachers, DN and LD, although they used traditional worksheets, they still showed different patterns of contingency. It can be said that LD understands the materials while DN is still less understood. As an initial and natural research, researchers do not know much about the strengths and weaknesses of them. This condition will be considered in the future when taking some teachers with different schools, the same grade level, and the same material in order to obtain better findings.

Third, in this study, teachers have not been trained on how to conduct contingent interaction. Moreover, teaching process held by HY using direct instructional approach (textbooks, without worksheet), seem less well planned. Errors also occurred when HY gave examples of function composition, he could not be found the inverse of that function. As a result, teachers do not always know how to diagnose students' understanding (Morrison & Lederman, 2003). This condition affects the difficulty of implementing contingent in the classroom. Although it looks difficult to produce a contingent strategy, this is an essential part in every lesson. According to Corey et al. (2010), considering the development of teachers-students on building the contingency interaction process, it requires more practices. Therefore, in this research, these are commonly happened that teachers are teaching with incorrect concept, too direct, and taking a quick action on students' respond before diagnosed students' questions.

According to researchers, all strategies that want to be built by a teacher as a diagnostic strategies, checking of diagnosis and intervention strategies need guidance and experiences, including language problems or questioning skills. As Mercer & Littleton (2007) argue that if learning process occurs in social interaction, language or expression is an important tool for communicating and guiding. Through the use of language, teachers can proficiently explain, instruct, and ask to conduct learning and teaching process. Through language, a student can express his understanding, gives some reasons, poses a problem, and learns. Through language, teachers and students are able to build knowledge together in interaction, in which they will be thinking together. Therefore, teachers need to have questioning skills.

Krulik & Milou (2003, p. 61) says that questioning has three objectives according to its characteristics: 1) Investigate the attention of students, 2) Determine if the students learn what was discussed, 3) Knows whether students interested in mathematics. While according its level, inquiring has two levels: 1) a low level which is questioning skills, and 2) a high level that is ask or encourage thinking likes asking to explain the process of what was found. The ability of questioning is an important skill to create a contingent learning. Unfortunately, there are less of these skills especially because of limitation of time approximately 50 minutes in this study. According to Meyer (2002), the class structure complicates many critical aspects of scaffolding interaction of individuals.

Contingency patterns obtained in these findings can be used as a teacher's professional judgment in the future. For example, preparing teaching materials including how to construct worksheet, contingent teachers are expected to constuct a better worksheet. These considerations should be a demand for teachers in implementing the curriculum. If teachers’ decisions in providing scaffolding are obscure, it will make students confuse. As in these findings, DN looks less mature in preparing worksheets so that it is make students confuse. The lacking of conceptual understanding causes students’ confusion and misleading students. Another thing that she was done, although she used technology to improve her teaching process, it was not significantly to help students understand the materials. Wilson et al. (2011) says that the uses of technology can help or hinder teaching and learning process depend on the teacher's decision to use it. Therefore, future research needs to explore the process of teacher’s thinking in considering, assessing and deciding assistance related to materials that will be presented in classroom, such as the providing of student worksheets.

CONCLUSION

This research has found three patterns of contingent teaching in teacher-student interaction for the provision of scaffolding on mathematics, namely the contingent dominant, the non-contingent dominant, and pseudo-contingent were obtained naturally. In teaching activities, if the interaction of contingent fragment more frequently occurs than the non-contingent, this interaction is called as the contingent dominant and vice versa. However, although the fragments of interactions that occur in a mathematics teaching is more contingent, but the teacher has wrong interpretation or hesitant in facilitating the conceptual understanding. This teaching interaction is called as a contingent pseudo. The results of this study have also demonstrated that experienced teacher tend to shows the dominant interaction contingent compared to novice teachers. Furthermore, it is suggested that in order to achieve a contingent teaching in teacher-student interaction, math teachers need to be trained in order to produce dominant interaction such as to practice the implementation of diagnostic strategies, to initiate intervention strategies, and to learn checking of diagnosis about the provision of scaffolding.

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