ANALYSIS OF CLASSROOM INTERACTION FROM THE COMBINED VIEW OF SELF-REGULATING STRATEGIES AND DISCOURSE ANALYSIS

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Abstract

The purpose of this study is to investigate the relationship between self-regulated learning and mathematical discourse. The study involved a group of Year 9 students (aged between 14 and 15) engaged in mathematical tasks in the East of England. Analysis on the students' interactions was carried out using two types of analytical tools: Pintrich's (1999) model of self-regulated learning strategies, with particular attention to the rehearsal strategies, and Sfard and Kieran's (2001) discourse analysis framework. The findings show the emergence of key mathematical concepts during the engagement, and that the SRL strategies have a positive impact in producing effective and productive discourse among the group members.

Keywords: Self-regulated learning strategies, rehearsal strategies, discourse analysis, secondary mathematics.

Abstrak

Tujuan kajian ini adalah untuk menyelidik hubungan antara pembelajaran kendiri dan diskusi matematik. Kajian ini melibatkan sekumpulan pelajar Tahun 9 (berumur antara 14 dan 15 tahun) dalam melaksanakan tugasan matematik di Timur England. Dua jenis alat analitikal iaitu model pembelajaran kendiri Pintrich (1999) dan kerangka analisis diskusi Sfard dan Kieran (2001) telah diguna untuk menganalisis interaksi pelajar. Dapatan kajian menunjukkan kewujudan konsep-konsep matematik ketika pelajar melibatkan diri dalam strategi pembelajaran kendiri dan ianya memberi impak positif dalam menghasilkan diskusi yang efektif dan produktif dalam kalangan ahli kumpulan.

Kata Kunci: Strategi pembelajaran kendiri, strategi latihan, analisis diskusi, matematik sekolah menengah.

Introduction

This study investigates students' self-regulated learning (SRL) strategies while engaging with mathematical problems. Many studies have been carried out concerning mathematical problem solving processes, heuristics, and strategies but there have been few studies examining the effect of SRL strategies such as cognitive learning strategies, metacognitive and self-regulatory strategies, and resource management strategies on problem solving in mathematics (Pintrich, 1999).

I also looked at students' interactions while engaging with the problems. Researchers in mathematics education agree, "that mathematics can and should, at least partly, be learned through conversation" (Ryve, 2004, p. 157). Communication has been observed as an essential element in mathematics teaching and learning (National Council of Teachers of Mathematics (NCTM), 1989, 2000). NCTM (2000) outlines that a learner has opportunities to engage in mathematical communication including speaking, reading, writing, and listening profits from two different aspects, communicating to learn mathematics and learning to communicate mathematically.

On the whole, my investigation linked the students' SRL strategies with their communication. In this particular study, I would like to discuss my preliminary findings on the participants' engagement with one of the component of SRL cognitive learning strategies, the rehearsal strategies and the participants' interactions in my attempt to observe mathematical learning through group problem solving. Hence the research question is formulated as follow:

What can we learn from the combined view of SRL and group discourse?

Theoretical background

***SRL strategies**:* Drawing from the literature on SRL, Pintrich's (1999) conceptual framework allows me to characterise the various components of SRL during the participants' engagement with a mathematical problem. The components include cognitive learning strategies, metacognitive and self-regulatory strategies, and resource management strategies. The elements of cognitive learning strategies are rehearsal strategies, elaboration strategies, and organisational strategies. The elements of metacognitive and self-regulatory strategies are planning activities, monitoring, and regulation strategies The elements in each component are usually not deployed in a given temporal order and can be used once or more throughout the problem solving process. The third component, resource management strategies are associated to the social contact of the group, which involves the commitment to work collaboratively to solve the problems. In this study, I have decided to focus on the participants' engagement with the rehearsal strategies during the problem solving process, which offers more insights to the development of the group discourse.

In a group problem solving context, the rehearsal strategies include reading the problem and associate it to the relevant mathematics topic or content. The phrase 'reading the problem' refers to a member in the group reads aloud and others listen or all the members read in silent individually. This can be observed through their actions or utterances during the problem solving process. On the other hand, the phrase 'associate it to the relevant mathematics topic or content' refers to identifying the problem and categorising it to the particular topic or content of mathematics. Evoking prior knowledge that is relevant to the problem is also categorised as an element of rehearsal strategies. In addition, the rehearsal strategies can be observed through highlighting and underlining important words or phrases stated in the problem. These activities are ways for learners to take note on information or hints provided in the problem.

***Discourse Analysis**:* Sfard and Kieran (2001) developed a theoretical and methodological framework "which aims at characterising the students' mathematical discourses while they are working in groups" (Ryve 2006, p. 191). This framework, which is also known as communicational approach to cognition provides the platform to examine the efficiency and productivity of mathematical discourses. On the issue of effectiveness of communication, Sfard and Kieran (2001) observe that:

> The communication will not be regarded as effective unless, at any given moment, all the participants seem to know what they are talking about and feel confident that all the parties involved refer to the same things when using the same words (p. 51).

In examining the elements of effective and productive mathematical discourses, the framework offers two types of analyses: *focal* analysis and *preoccupational* analysis. Focal analysis deals with communicative successes or failures with no reasons revealed, while, preoccupational analysis offers the reasons behind the success or failure of a communication. Sfard and Kieran (2001) noted that:

> Focal analysis gives us a detailed picture of the students' conversation on the level of its immediate mathematical contents and makes it possible to assess the effectiveness of communication. This is complemented by preoccupational analysis, which is directed at meta-messages and examines participants' engagement in the conversation, thus possibly highlighting at least some of the reasons for communication failure (p.42).

***SRL and discourse*:** SRL strategies are found to be one of the factors in enhancing students' academic achievement (Zimmerman & Martinez-Pons, 1986). Wang *et al*. (1990) show that high achievement learners engaged more on self-regulative activities, such as orientation, planning, monitoring, re-adjustment of strategies, evaluation and reflection. Apart from SRL, mathematical discourse is also vital in the success of mathematical learning. According to Sfard (2001), "putting communication in the heart of mathematics education is likely to change not only the way we teach but also the way we think about learning and about what is being learned" (p. 13).

Unfortunately, literature associating SRL and mathematical discourse together in mathematical learning is currently limited. Based on this, the study will focus on the combination of SRL and mathematical discourse in a problem solving process.

The study

In this paper I present some of the preliminary results of the participants' engagement with the rehearsal strategies (Pintrich, 1999) and its influence towards the development of the group discourse (Sfard & Kieran, 2001) during the problem solving process. Most importantly, we will observe the emergence of key mathematical concepts and how it contributes to the participants' interactions.

I employed video-recordings as our primary tool in order to have a close examination of the students' interactions. As Griffee (2005) noted, video-recording provides an opportunity to reveal things that might go unnoticed. What is more important is that video-recording enables me "to re-visit the aspect of the classroom events and pursue the answers we seek" (Pirie, 1996, p. 553).

The study lasted for six months and involved a group of four Year 9 students aged between fourteen and fifteen years old at a comprehensive secondary school in the East of England. Video recordings focused on the group engaging in mathematical tasks (20 – 25 minutes towards the end of the one hour lesson). In addition, observational notes were kept and students' written work was taken into account to complement the video data for a more complete record of the actual situation.

A sequence of seven interacting, non-linear phases of Powell *et al.* (2003) model was used to analyse the video data. At the early phases, the process of viewing, listening, and describing the video data were carried out. During these processes, vignettes or episodes that were critical and significant to the study were recorded. This was followed by transcribing the critical events or episodes whereby recordings of participants' utterances and actions were fully transcribed in order to capture both what was said and what was done. Then, the *coding* phase whereby all critical episodes were analysed employing two different analytical tools: the Pintrich's (1999) model of SRL strategies, and Sfard and Kieran's (2001) discourse analysis framework.

All episodes were analysed in-depth to scrutinise students' engagement with the SRL strategies while working on the mathematical problem. Cognitive learning strategies such as *rehearsal strategies, organisational strategies, elaboration strategies*, and metacognitive and self-regulatory strategies, namely *planning activities, monitoring, and regulation strategies* were observed during the analysis process. In addition, the resource management strategies were also employed to scrutinise the social interactions among the participants. The focus of this analysis was to observe the SRL strategies students' engaged to in solving a mathematical problem.

The episodes were also analysed using discourse analysis to capture the ways in which students interacted with each other. The focal analysis focused on the coherence of the utterances involving the tripartite foci: *pronounced focus, attended focus, and intended focus*. This was followed by preoccupational analysis employing the interactivity flowchart. It focused on how students communicate between different channels of communication and different level of talks (Kieran, 2001).

For the purpose of this paper, the discussion will focus on the role of mathematical discourse in the rehearsal strategies phase. I select the rehearsal strategies as an illustrative example of the data analysis carried out for this project. Finally, I selected the triangle problem (Figure 1) as exemplification of a problem-solving instance that was manageable within the scope of this paper.

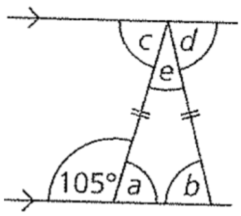

Figure 1 The Triangle problem

This exercise was set to the students as part of a lesson on triangles and parallel lines. The students were given the diagram in Figure 1 and asked to find the angles *p. q m* and *n.* The content of the lesson was on the properties of triangles and parallel lines including: (1) vertically opposite angles are equal, (2) alternate angles are equal, (3) corresponding angles are equal, and (4) supplementary angles add up to 180°. In addition, previously, the students were taught about angles in polygon, and lines and angles.

The following conversation was recorded (time: 00:12:37 – 00:15:52):

[1] Kathy: That one is 75 (pointing at *a*-angle).
[2] Megan: Yeah.
Anne writes the letters a – e in her book.
[3] Kathy: So *a* is 75.
[4] Megan: Yeah.
[5] Kathy: And then *c*…
[6] Kathy & Megan: 75.
[7] Megan: So is *d*. Is *d* the same as *b*?
Anne writes the solutions for a and c in her book.
[8] Kathy: Yeah.
[9] Anne: Yeah, but we don't know what *b* is. **b** would be 105 because it's correspondence.
[10] Kathy: No, it's not.
[11] Megan: No, it isn't.
[12] Anne: Alternate.
[13] Kathy: They are not the same angles.
[14] Anne: No, but that whole angle… they would be 105 (referring to the joined angles of *d* and *e*).
[15] Kathy: Yeah, but that doesn't give us any help. So… you know how to split it. Don't they add up to 180 (referring to the *a* and *b* angles). Oh… no, there has to be a line in between them.
[16] Megan: Yeah.
They pause for a moment.
[17] Anne: But that little line (pointing at the mark on the side of the triangle) means they are parallel, don't they? If they are parallel… no they are not parallel. What is that little one mean?
[18] Kathy: They are parallel… they are parallel.
[19] Megan: Parallel are arrows.
[20] Kathy: That means they are the same length.
[21] Anne: So… that means that would be the same (pointing at the *a* and *b* angles), *a* and *b* they will be the same. So *b* would be 75.
[22] Kathy: Yeah.

[23] Megan: So… is *d* and that makes *e*… 30 (pointing at e-angle).
[24] Anne: Oh… that's hard.

Analysis of the data

The participants' interactions can be divided into three segments. The first segment involves utterances from [1] to [6], the second segment involves exchanges from [7] to [16], and the third segment involves utterances from [17] to [23]. I observe that the participants are engaged with the rehearsal strategy in the first and third segment. No engagement of rehearsal strategy is observed in the second segment. The engagement with this strategy is seen to have a huge impact on the participants' quest to solve the problem. At the early stage of the discussion, the participants utilise the properties of lines and angles, such as supplementary angles add up to 180^o to discuss the unknown angles, *a* and *c* and latter they employ the 'equal length' concept to focus on the value of *b* and *d*.

From the transcript, in the first segment, Kathy is quick to react to the task as she notes that the *a*-angle is 75^o stating that, "*That one is 75*" [1] which Megan agrees to it [2]. Utterances [3] and [4] are exchanges to confirm the value for *a*-angle. Kathy and Megan are observed to agree that 75^o is also the value for *c*-angle ([5] and [6]). However, there is no evidence (oral or written form) that suggests the participants are employing the properties of lines and angles in finding the value of *a* and *c*. During this segment, Anne is observed to be more a listener than to participate in the discourse.

In the third segment, the participants' discourse is focusing on finding the value of *b*-angle. This third segment is a continuation from the second segment. In the second segment, the participants have already begun to find the value for *b*. However, during the discourse, the participants are observed to employ irrelevant properties of lines and angles, which prevents them from obtaining the value for *b*.

The emergence of the 'equal length' concept is observed in the third segment as the participants work on the *b*-angle. Anne begins the third segment noting that, "*But that little line means they are parallel, don't they? If they are parallel… no they are not parallel. What is that little one mean?*" [17]. Anne brings to attention the 'equal length' marks on the sides of the triangles. Consequently, this helps other participants to evoke their prior knowledge on the 'equal length' concept as Kathy notes that, "*That means they are the same length*" [20]. Anne, not only agrees to Kathy but she uses the concept to obtain the value of *b* stating that, "*So… that means that would be the same, a and b, they will be the same. So b would be 75*." [21]. On the same note with Kathy and Anne, Megan uses the concept to find the unknown angle, *d* and she eventually manages to find the value for *e*-angle noting that, "*So… is d and that makes e… 30*" [23]. The capability of the participants to evoke their prior knowledge of the 'equal length' concept shows that they are engaged with the rehearsal strategy.

During the course of finding the solution for the unknown angles, the participants' tripartite foci of the discourse are basically centred on the 'equal length' concept. The emergence of this concept is vital to the discourse as the participants are observed not only justifying their solution using this concept but most importantly have inspired the group members to focus and talk on the same mathematical object as shown in Figure 2.

Figure 2 shows the analysis of the participants' tripartite foci. Looking through the table, the 'pronounced foci' of the participants is centred on the 'equal length' concept in order to find the unknown angle, *b*. For example, Anne proposes the idea of the 'equal length' marks on the sides ([17a] and [17b]) to find the unknown angle, *b*. Responding to Anne, Kathy notes that, "*That means they are the same angle*" [20], which she refers to the sides with equal length will have equal angles, in this case the angles, *a* and *b*. On the other hand, Megan uses the 'equal length' concept to find the unknown angles, *d* and *e*. Megan states that, "*So…is d*" [23a] and "*And that makes e… 30*" [23b].

Anne			Kathy		
Pronounced Focus	**Attended Focus**	**Intended Focus**	**Pronounced Focus**	**Attended Focus**	**Intended Focus**
[17a] But that little line means they are parallel.	Diagram	Solution for *b*-angle	[18] They are parallel…they are parallel.	Diagram	Solution for *b*-angle
[17b] What is that little one?	Diagram	Solution for *b*-angle	[20] That means they are the same angle.	Diagram	Solution for *b*-angle
[21a]So…that means that would be the same, *a* and *b* they will be the same.	Diagram	Solution for *b*-angle	[22] Yeah.	Diagram	Solution for *b*-angle
[21b] So *b* would be 75.	Diagram	Solution for *b*-angle			

Megan		
Pronounced Focus	**Attended Focus**	**Intended Focus**
[19] Parallel are arrows.	Diagram	Solution for *b*-angle.
[23a] So…is *d*.	Diagram	Solution for *d*-angle.
[23b] And that makes *e*… 30.	Diagram	Solution for *e*-angle.

Figure 2 The participants tripartite foci

The second column tells us that the participants share their focus of attention as they are observed using diagram of the triangle as a source of information. From the triangle, the participants manage to infer a key mathematical concept that are relevant to the task. Consequently, the participants' 'intended' focus is to find the value of the unknown angles as required. To summarise, the 'equal length' concept, which are evoked from the participants' prior knowledge, play an important role in guiding the participants' foci. Thus, this produces an effective discourse (Sfard & Kieran 2001).

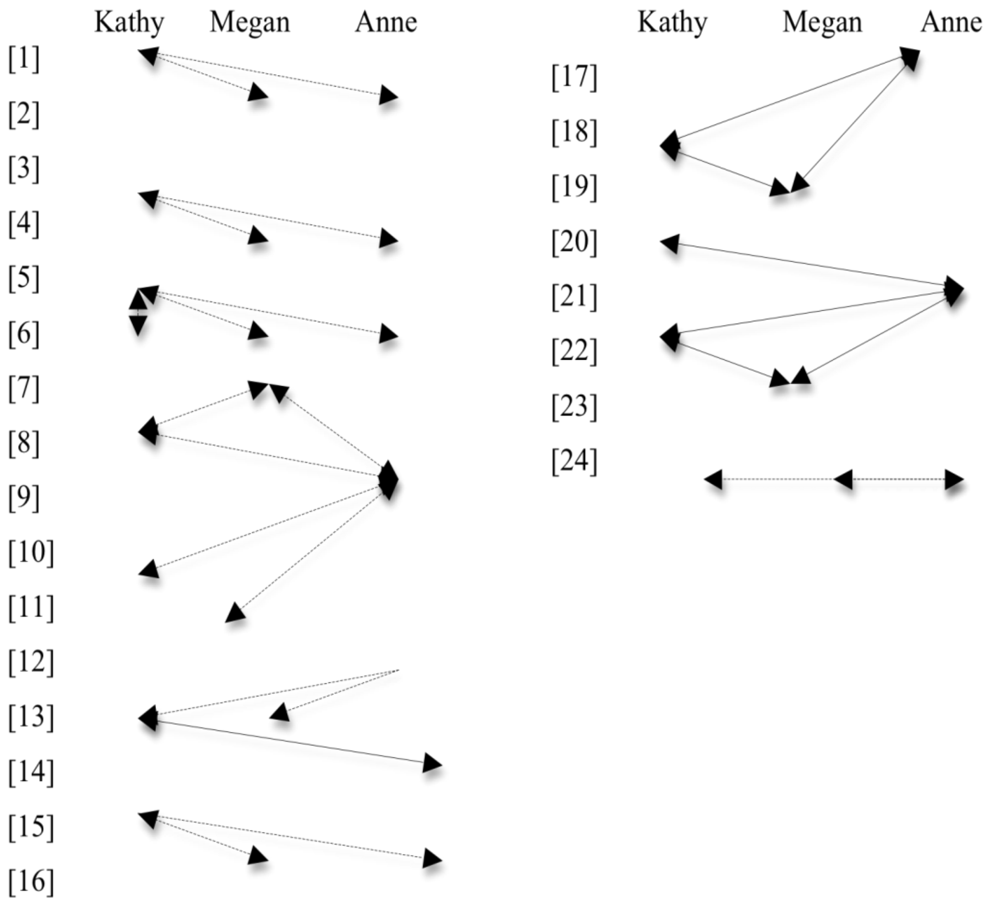

Figure 3 Interactivity flowchart of the Triangle problem

Figure 3 shows the participants' interaction through the interactivity flowchart in order to observe whether the discourse is mathematically productive or not. I can see that during the third segment of the discourse (from [17] to [23]) the participants' interactions are interpersonal utterances of object-level communication (Kieran 2001). This shows that the participants are interacting mathematically with each other with pro-action and reaction utterances, which forms a formation or a pattern of a triangular shape involving the participants' interactions.

The interactivity flowchart shows that two triangular shapes are formed during the discourse from [17] to [19] and from [21] to [23]. A deeper investigation determines that in these two parts the participants are engaged to rehearsal strategy: evoke prior knowledge that is relevant to the problem, with the emergence of a key mathematical concept during these parts of discourse. Using this concept in their interactions, the participants' interactions suggest that the participants not only propose a solution or an idea, but at the same time respond to others. Looking at the pattern formed, the participants' interactions are packed (no open side) with no gaps in between which implies that at this moment the participants are interacting not only mathematically but also developing a meaningful and productive discourse.

Unlike the situation above, there are parts of the discourse that have no formation or pattern. From the flowchart, the occurrence of non-patterned discourse happens during the first (from [1] to [6]) and second segment (from [7] to [16]) of the task solving process. During these segments, the participants' interactions are basically pro-action or re-action utterance and at the same time no engagement of rehearsal strategy is discovered. Thus, the interactions are observed to be loose with a lot of gaps in between which suggests that although the participants are discussing a mathematical task no meaningful mathematical discourse took place involving all the participants.

Discussion and preliminary findings

In the course of solving the *Triangle* problem, the participants were engaged to the rehearsal strategy: evoke prior knowledge that is relevant to the problem, in order to justify the values for the unknown angles. Consequently, this saw the emergence of a key mathematical concept: the 'equal length' concept. This concept was observed to have a positive influence for the group discourse. The participants' capability to monitor their learning through the application of the key concept had successfully developed an effective and productive discourse among the participants. The participants' interactions were focused on the employment of the concept, which encouraged the participants to focus their talk on a similar subject, in this case finding the solutions using the concept. Thus, this was also observe to influence the participants' exchanges as the utterances were of pro-action and re-action. Remarkably, these exchanges created patterns of triangular shape. Consequently, such formation showed that the participants were involved in a meaningful and productive discourse. I observed that utterances not associated to mathematical content such as mathematical concepts had no pattern formation. Thus, this indicates that the discourse is non-productive.

Concluding remarks

This study investigates what mathematical learning that can be achieved during the task solving process with the participants engaged to the rehearsal strategy and discussed the problem as a group. Two different approaches were implemented in the investigation. My approach employs the Pintrich's (1999) SRL framework for investigating the strategies used by students, and Sfard and Kieran's (2001) discourse analysis framework to investigate the effectiveness of verbal communication. The findings suggest that during the participants' engagement with the rehearsal strategy, the emergence of a key mathematical concept that is not only significant to the problem but also crucial to the development of an effective and productive discourse. The participants' interactions involving this concept can be identified clearly through the interactivity flowchart as the utterances formed a pattern of closed triangular shape, which suggests a productive discourse. Besides that, applying this concept encourages the participants to focus and talk on a similar mathematical object. Thus, this produces an effective discourse.

To conclude, the combination of SRL and mathematical discourse offers new insights into the problem solving process. The emergence of key mathematical concept is observed to be an important discovery in the field of mathematics education.

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