# Analysis of classroom interaction from the combined view of self-regulating strategies and discourse analysis: What can we learn?

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The purpose of this study is to investigate the relationship between self-regulated learning (SRL) and mathematical discourse. The study involved a group of Year 9 students in the East of England engaged in mathematical tasks. Analysis on the students' interactions was carried out employing 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 with SRL strategies have positive impact in producing an effective and productive discourse among the group members.

**Keywords: Self-regulating strategies, rehearsal strategies, discourse analysis, secondary mathematics.**

## Introduction

Our study investigates students' 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).

We 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 to be an essential element for mathematics teaching and learning (NCTM, 1989; NCTM, 2000). NCTM (2000) outlines that a learner who 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.

Our investigation linked the students' SRL strategies with their communication. In this particular study, we would like to discuss our preliminary findings on the participants' engagement with one of the component of SRL cognitive learning strategies, the rehearsal strategies and the participants' interactions in our attempt to observe mathematical learning via group problem solving. Hence our 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 us 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 interaction of the group which involves the commitment to work collaboratively to solve the problems. In this paper we have decided to focus on the participants' engagement with the rehearsal strategies as an exemplification of the development of the group discourse.

In the language context, rehearsal strategies, (Pintrich 1999) "involve the recitation of item to be learned or the saying of words aloud as one reads a piece of text" (460). Highlighting and underlining text informally is also considered as rehearsal strategy. Pintrich (1999) observes that via rehearsal strategies, students will be able to attend to and select important information from text.

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 via 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 an element of rehearsal strategies. In addition, the rehearsal strategies can be observed via highlighting and underlining important words or phrases stated in the problem. These activities are ways for learners to take note of 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 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 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. (Sfard and Kieran 2001, 51)

In examining the elements of effective and productive mathematical discourses, the framework offers two types of analyses: *focal* analysis and *preoccupational* analysis. On one hand, focal analysis deals with communicative successes or failures with no reasons revealed. On the other hand, preoccupational analysis offers the reasons behind the success or failure of a communication. Sfard and Kieran notice 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. (Sfard and Kieran 2001, 42)

**SRL and discourse:** SRL strategies are found to be one of the factors in enhancing students' academic achievement (Zimmerman and Martinez-Pons 1986). Wang et al. (1990) show that high achievement learners engaged more in 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: "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" (Sfard 2001 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 we 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 and 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.

We employed video-recordings as our primary data 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 us "to re-visit the aspect of the classroom events and pursue the answers we seek" (Pirie 1996 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 set by the teacher (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. This was followed by 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, metacognitive and self-regulatory 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 used by students engaged 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. We select the rehearsal strategies as an illustrative example of the data analysis carried out for this project. Finally, we selected the triangle problem as exemplification of a problem solving instance that was manageable within the scope of this paper.

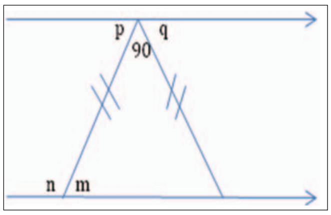


Fig 1: The *Triangle* problem

This exercise was set to the students as part of a lesson on triangles and parallel lines carried out in autumn, 2008. The students were given the diagram in Fig. 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 180p. In addition, previously, the students were taught about angles in polygon, and lines and angles. The following conversation was recorded:

**[1]** Megan: *n* and *m* are 90.

**[2]** Kathy: Are they?...no... oh yeah. (*pause for a moment*) Hah...they look like 90.

**[3]** Megan: So is *p*

**[4]** Kathy & Anne: No, they are 45 (*referring to p and q*).

**[5]** Kathy: Because they are same length.

**[6]** Megan: That is what does it... they will be the same, *m* and *p* (*pointing at m and p*).

**[7]** Kathy: Oh..yeah..

**[8]** Anne: Yes, that is not 90 (*referring to n and m*)...that means *m* is 45.

**[9]** Kathy: Let start again.

**[10]** Anne: *m* will be 45.

**[11]** Kathy: Do *n* first.

**[12]** Anne: Do this first (*pointing at p and q*). That’s 45 each.

**[13]** Kathy: So *p* and *q* are 45.

**[14]** Megan: They will be equal, right?

**[15]** Kathy: Because they got them though (*pointing at the two small lines which mean equal length*).

**[16]** Anne: *n* is definitely 90 (*pointing at n*).

**[17]** Kathy: No, it’s not.

**[18]** Megan & Anne: Yes, it is.

**[19]** Kathy: No, it is not a zig-zag (*referring to the alternate angles between n and 90*)

**[20]** Megan: Yeah...it has to be that one (*showing the top parallel line with the q-angle*). It has to be like that (*as though she is drawing the z*). So *n* is not 90.

**[21]** Anne: Alright... so *p*, *q* are definitely 45... Then that would be 45 (*pointing at m*) and that would be 45 (*drawing an interior angle on the left of the triangle*)... because these are the same length

**[22]** Kathy: Yeah...

**[23]** Anne: So *m* is definitely 45...and then so is *p*... and so is *q*... and then *n* is 145...

**[24]** Kathy: No.

**[25]** Megan: No. 135.

**[26]** Anne: Yeah.

## Analysis of the data

The participants' interactions can be divided into two parts. In these two parts, we observe that the participants are engaged in the rehearsal strategy. The engagement with this strategy is seen to have a huge impact on the participants' quest to solve the problem. We observe here the emergence of two key mathematical concepts, the 'equal length' concept and the 'alternate angles' concept. At the early stage of the discussion, the participants utilise the 'equal length' concept to discuss the unknown angles, *m, p,* and *q* and later they employ the 'alternate angles' concept to focus on the value of *n*.

From the transcript, we discover that in these two parts the participants evoke their prior knowledge to justify their solution or to object to others' solution. Kathy justifies her answer to utterance [4] stating that "*Because they are the same length*" [5]. Her justification is solely based on the diagram of an isosceles triangle provided which underlines her prior knowledge of properties of lines and angles. At the later stage, Kathy demonstrates that the *n*-angle and 90-angle are not alternate angles, *"No, it is not a zig-zag"* [19] to oppose the value proposed by Anne [16]. Megan supports Kathy's ideas as she responds convincingly assuring her friends and herself that the values for *m* and *p* angles are indeed the same [6]. Based on the concept of 'equal length' and via her demonstration about alternate angles [20] Megan knows which two angles are alternate angles. On the other hand, Anne also demonstrates her prior knowledge in agreeing with the concept 'equal length' but doubts the solution proposed by Megan and proposes that the value of *m* is 45 [8], which is indeed correct. In addition, Anne is satisfied with her friends' justification and agrees upon the 'alternate angles' concept in obtaining the value of *n* [21].

We observe that during the course of finding the solution for the unknown angles, the participants' tripartite foci are centred on the 'equal length' concept and the 'alternate angles' concept. The emergence of these concepts is vital to the discourse as the participants are observed not only justifying their solution using these concepts but most importantly has inspired the group members to focus and talk about the same mathematical object as shown in Fig. 2.

| Megan | | | Kathy | | |
|---|---|---|---|---|---|
| Pronounced Focus | Attended Focus | Intended Focus | Pronounced Focus | Attended Focus | Intended Focus |
| [6a] That is what does it<br><br>[6b] they will be the same | Diagram<br><br>Diagram | Solution for m and p angles<br><br>Solution for m and p angles | [5] Because they are the same length | Diagram | Solution for p and q angles |
| [20a] Yeah… it has to be that one | Diagram | Solution for n-angle | [19] No, it is not a zig-zag | Diagram | Solution for n-angle |

| | | | | | |
|---|---|---|---|---|---|
| [20b] It has to be like that | Diagram | Solution for n-angle | | | |

| Anne | | |
|---|---|---|
| Pronounced Focus | Attended Focus | Intended Focus |
| [8] that means m is 45 | Diagram | Solution for m |
| [21] Alright<br>[23] … and then n is 145 | Diagram<br>Diagram | Solution for n-angle |

Fig. 2: The participants' tripartite foci

Fig. 2 shows the analysis of the participants' tripartite foci. Looking through the table, we observe that the 'pronounced' focus of the participants is centred on the 'equal length' concept and the 'alternate angles' concept. Kathy proposes the concept of 'equal length' to support her solution for *p* and *q* angles stating that, *"Because they are the same length"* [5] and employing the 'alternate angles' concept [19] to rule out any possibilities of *n* equals 90 as proposed by Anne. Agreeing to the 'equal length' concept, Megan insists that her solutions of *m* and *p* angles are similar based on the concept ([6a] and [6b]). In another instance, Megan not only accepts the 'alternate angles' concept but also demonstrates the angles involved noting that, "*Yeah… it has to be that one*" [20a] and "*It has to be like that*" [20b]. In a similar tone, Anne uses the 'equal length' concept to determine the value of *m* [8] and applies the 'alternate angles' concept to confirm the value of *n* [23].

The second column of Fig. 2 tells us that the participants share their focus of attention as they are observed using the diagram of the triangle as a source of information. From the triangle, the participants infer the two key mathematical concepts that are relevant to the problem. Consequently, the participants' 'intended' focus is to find the value of the unknown angles as required.

To summarise, we observe that the concepts which are evoked from the participants' prior knowledge, play an important role in guiding the participants' foci. Thus, this produces an effective discourse (Sfard and Kieran 2001).

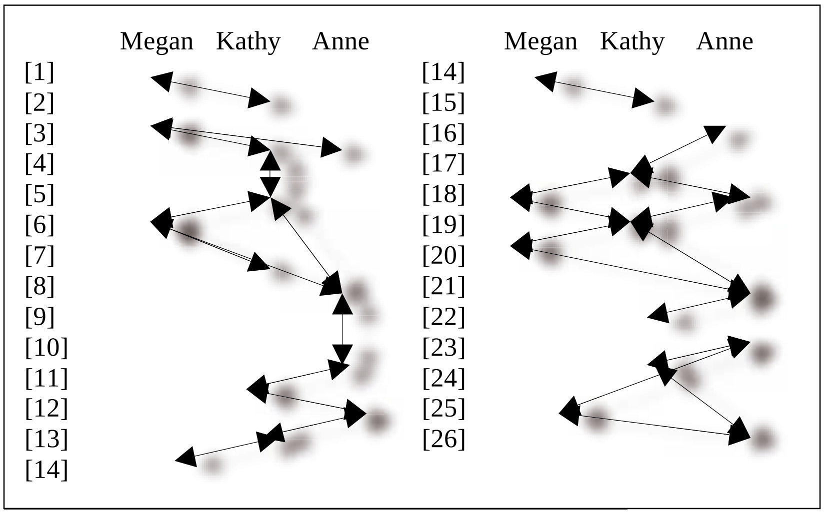


Fig. 3 Interactivity flowchart of the Triangle problem

Fig. 3 shows the participants' interaction via the interactivity flowchart in order to observe whether the discourse is mathematically productive or not. We can see that 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. Nevertheless, the flowchart shows a pattern of discourse which is an interesting focus for discussion.

The interactivity flowchart demonstrates that in certain parts of the discourse a formation or a pattern is observed such as a triangular or a rectangular shape involving the participants' interactions, for instance utterances from [5] to [8] and from [17] to [21]. A deeper investigation determines that the participants are engaged to rehearsal strategy: evoke prior knowledge that is relevant to the problem, with the emergence of two key mathematical concepts during these parts of discourse. Using these concepts in their interactions, the participants' interactions are of pro-action and re-action utterances which suggests 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 normally happens during the beginning and the ending of the problem solving process. This is demonstrated in three different parts: utterances from [1] to [4], from [8] to [16], and from [23] to [26]. During these periods, 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 problem no meaningful mathematical discourse took place.

## Discussion and preliminary findings

In the course of solving the *Triangle* problem, the participants were engaged in 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 two key mathematical concepts: the 'equal length' concept and the 'alternate angles' concept. These concepts were observed to have a positive influence for the group discourse. The participants' capability to monitor their learning via the application of the key concepts had successfully developed an effective and productive discourse. The participants' interactions were focused on the employment of the concepts which encouraged the participants to focus their talk on a similar subject, in this case finding the solutions using the concepts. Thus, this was also observe to influence the participants' exchanges as the utterances were pro-action and re-action. Remarkably, these exchanges created patterns of triangular and rectangular shapes. Consequently, such formation showed that the participants were involved in a meaningful and productive discourse. We 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 problem 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. Our 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. Our findings suggest that during the participants' engagement with the rehearsal strategy, we observe the emergence of two key mathematical concepts that are not only significant to the problem but also crucial to the development of an effective and productive discourse. The participants' interactions involving these concepts can be identified clearly via the interactivity flowchart as the utterances formed a pattern of closed triangular and rectangular shapes which suggests a productive discourse. Besides that, applying these concepts 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. It highlights the relevance of the emergence of key mathematical concepts both as a guide for productive discourse and as an outcome of the rehearsal strategy.

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