

EXPLORING CHANGE IN SECONDARY MATHEMATICS TEACHERS' NOTICING OF ARGUMENTATION

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This study examined changes in secondary mathematics teachers' noticing of argumentation through experiencing a peer assessment cycle. Sixty-one teachers participated in the cycle comprised of (a) analyzing a written argumentative classroom situation (ACS) by using a report format, (b) collaboratively assessing peers' ACS reports using an ACS rubric format, (c) providing feedback to peers, (d) receiving feedback from peers, (e) individually refining the initial ACS reports, and (f) reflecting on their experience. Analysis of teachers' initial and refined ACS reports revealed changes in teachers' noticing of various dimensions associated with argumentation. The study provides evidence of the potential of the peer assessment process for teachers' learning to notice key aspects of argumentation.

INTRODUCTION

The importance of students' engagement in argumentation in the mathematics classroom has been well recognized. It has been shown that participation in argumentation that requires students to explore, confront, and evaluate alternative positions, voice support or objections, and justify different ideas and hypotheses, promotes meaningful understanding and deep thinking (Weber et al., 2008). Research demonstrates that mathematics teachers have difficulties integrating argumentation into classroom practice (Ayalon & Hershkowitz, 2018) and that argumentation in the mathematics classroom is not yet a common practice (Umland & Sriraman, 2020). It appears crucial to investigate how best to devise effective professional learning for enhancing argumentation in the mathematics classroom. We addressed this issue by building on teacher noticing research to explore a particular type of noticing, which we call noticing of argumentation. Noticing is one of the central skills that determine teachers' proficiency, involving three interrelated skills: attending, interpreting, and responding (Jacobs et al., 2010). We assume that teachers who are better able to notice argumentation possess the skills necessary to begin to promote argumentation in the mathematics classroom. We also drew on evidence from research on the potential of using peer assessment techniques for effective learning (Topping, 2010). This study explored the potential of using peer assessment strategies to develop secondary school mathematics teachers' (SMTs) noticing of argumentation.

THEORETICAL PERSPECTIVE

The commonly accepted definition of argumentation is that of van Eemeren and Grootendorst (2004), who maintained that argumentation is “a verbal, social, and rational activity aimed at convincing a reasonable critic of the acceptability of a

standpoint by putting forward a constellation of propositions justifying or refuting the proposition expressed in the standpoint” (p. 1). Following Jacobs et al. (2010), and based on the educational literature on argumentation, we conceptualize the noticing of argumentation as a set of three interrelated skills: attending, interpreting, and deciding how to respond. The study adopted a theoretical perspective according to which productive argumentation (Asterhan & Schwarz, 2016, p. 167) is characterized by co-constructing arguments, critically and respectfully listening to others’ ideas, identifying the weaknesses and strengths in each idea, and searching for alternative ideas while working toward consensus building. *Attending* relates to identifying salient characteristics, structural and dialogic, of the argumentation in a classroom situation (McNeill & Pimentel, 2010). The structural aspect focuses on the proposed claim and the justification for the claim, and in our context, in accordance with the accepted types of justification in the classroom community (Yackel & Cobb, 1996). The dialogic aspect relates to the above-mentioned productive argumentation characteristics of co-constructing of arguments, critiquing arguments, mutual respect, and working toward consensus building (Mueller et al., 2012). *Interpreting* relates to making sense of the argumentation in the classroom situation while considering factors that may enable or inhibit the argumentation. We consider four main factors associated with teaching that create opportunities for students to participate in argumentation, as expressed in the literature: (a) task characteristics, for example, implementing open-ended tasks that invite multiple representations and strategies (Mueller et al., 2014); (b) teaching strategies, such as encouraging students’ participation and thoughtful questions (Mueller et al., 2014); (c) students’ cognitive and affective characteristics, such as prior knowledge, common ways of thinking, and argumentation skills, as well as self-confidence, interest, and enjoyment (Knuth & Sutherland, 2004); and (d) socio-cultural characteristics, such as recognizing the value of argumentation and expectations of critique, collaboration, mutual respect, and socio-mathematical norms related to the kinds of justifications accepted in the classroom (Mueller et al., 2014; Yackel & Cobb, 1996). Finally, *deciding how to respond* relates to what one would do assuming that one was the teacher in that situation, to promote argumentation. Figure 1 summarizes our conceptualization of argumentation in the mathematics classroom and of noticing of argumentation. We used this framework in building the research tool and in analyzing the data, aiming at exploring changes in (SMTs) noticing of argumentation through experiencing a peer assessment cycle.

RESEARCH QUESTIONS

RQ1: What change occurs in SMTs’ noticing of argumentation, if any, through experiencing peer assessment strategies?

RQ2: What factors promoted or inhibited the change in SMTs’ noticing of argumentation, from the teachers’ point of view?

RESEARCH CONTEXT AND PARTICIPANTS

The study was conducted in Israel at the beginning of a course focused on argumentation in mathematics teaching, as part of a master's degree in mathematics

education. It is part of a larger research exploring the development of secondary in-service and pre-service mathematics teachers' skills of noticing of argumentation during their participation in a course focusing on analysis of argumentation classroom situations (ACSs), which serve as both research and pedagogical tools. An ACS is a written representation of an instructional situation that took place in the mathematics classroom, which provides teachers with opportunities to attend to structural and dialogic aspects of argumentation. ACSs also allow teachers to offer interpretations for the argumentation sequence in the situation, and to address factors that seem to enable or inhibit the argumentation. A group of 61 SMTs participated in a peer-assessment cycle comprised of (a) individually analyzing an ACS using a report format, (b) collaboratively assessing peers' ACS reports using an ACS rubric, (c) providing feedback to peers, (d) receiving feedback from peers, (e) individually refining the initial ACS reports, and (f) reflecting on their experience. The teachers in this group were not formally exposed to argumentation before the study.

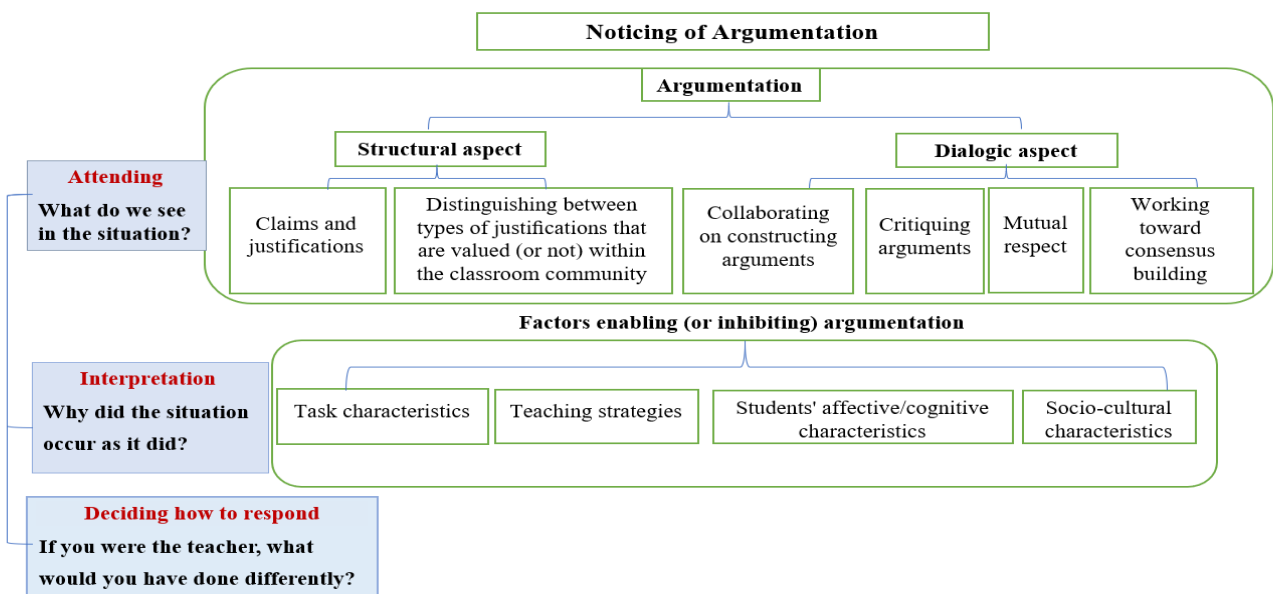


Figure 1: Theoretical perspective of argumentation in the mathematics classroom and the components of noticing of argumentation.

RESEARCH TOOLS

(a) an ACS focusing on the issue of “Abbreviated multiplication formulas” in a 9th grade class; (b) an ACS report format (adapted from Jacobs et al., 2010) that includes prompts related to the three skills of noticing of argumentation: *attending prompts* (a request to describe in detail those parts of the ACS that the SMTs deem important for argumentation, with reference to structural and dialogic aspects); *interpreting prompts* (a request to provide possible answers to the question “why did the ACS occur as it did?” by referring to possible factors that enabled or inhibited the sequence of argumentation); and *deciding how to respond* (a request to offer warranted alternatives to the teaching in the ACS, aiming to promote student participation in argumentation); (c) ACS rubric format, developed during a previous pilot course (Table 1). (The research tools and illustration of their use will be presented at the conference).

Noticing skill	Levels of noticing
Attending to structural aspects	<ol style="list-style-type: none"> 1. Identified correctly some claims and justifications; identified types of justification partially or not at all; or incorrectly identified some of the types of justification. 2. Identified correctly all claims and justifications; identified correctly all types of justifications.
Attending to dialogic aspects*	<ol style="list-style-type: none"> 1. Paid no attention to the dialogic aspect. 2. Paid attention to the dialogic aspect, lacking or general description of how the aspect is manifested in a given situation. 3. Paid attention to the dialogic aspect, detailed description of how the aspect is manifested in a given situation.
Interpreting**	<ol style="list-style-type: none"> 1. Did not address the factor. 2. Addressed the factor, the response is mostly descriptive or evaluative, little or no use of evidence to support claims. 3. Addressed the factor, some evidence to support claims. 4. Addressed the factor, robust evidence to support claims.
Deciding how to respond	<ol style="list-style-type: none"> 1. Offered no ideas for alternatives, or offered ideas for alternatives that were unconnected to the situation. 2. Offered ideas for alternatives that were relevant to the situation; provided some evidence to support claims. 3. Offered ideas for alternatives relevant to the situation; provided robust evidence to support claims.

* for each of the four dialogic aspects mentioned above

** for each of the five factors mentioned above

Table 1: Coding framework of SMTs' noticing of argumentation.

DATA COLLECTION

(a) SMTs' reports focusing on analysis of the "Abbreviated multiplication formulas" ACS. Each SMT submitted a report in Phase 1 of the peer-assessment cycle (initial ACS report) and a refined report in Phase 5, after giving and receiving feedback to and from peers (refined ACS report). The reports served as the main data source for characterizing the participants' skills of noticing of argumentation, and the change in skills following their participation in the peer-assessment cycle (RQ1); (b) written reflections, focusing on SMTs' experiences through the sequence of activities, their perceived strengths and difficulties, the similarities and differences between the initial and refined ACS reports, and what caused these. The reflections served as a source for identifying the factors affecting the change in SMTs' noticing of argumentation, from their perspective (RQ2); (c) individual, semi-structured interviews with 20 SMTs conducted to gain more insights related to the findings and the factors affecting the change in noticing of argumentation, from the SMTs' perspective.

DATA ANALYSIS

For RQ1: In Stage 1, we used the rubric to analyze the initial ASC reports, by applying the quality levels presented in the rubric format, focusing on what and how the components of the ACS report were noticed. In Stage 2, we applied the same process to analyze the refined ACS reports. Stage 3 focused on measuring the change in the

participants' noticing of argumentation using the assessment obtained in the previous two stages. We used percentages to describe the distribution of responses in the initial and refined ACS reports. For statistical inference, we applied non-parametric methods because of the ordinal nature of the variables examined. We used McNemar's test to determine whether there was a change in SMTs' *attending* to structural aspect of argumentation because only two scores were used (1 and 2). We used the Wilcoxon signed-rank test to determine whether there was growth in the other components of SMTs' noticing of argumentation (RQ1). For RQ2: Stage 4 focused on exploring the factors affecting the changes in SMTs' noticing of argumentation, from the SMTs' perspective. We conducted interpretive and in-depth qualitative analysis of the written reflections and interview transcripts. Using inductive line-by-line coding, we sought descriptions of the factors that shaped the change in SMTs' noticing of argumentation.

FINDINGS

Change in SMTs' noticing of argumentation

To determine whether there was a change in SMTs' attending to structural aspects of argumentation, we used McNemar's test to compare the scores of the initial and refined ACS reports. The results indicated a statistically significant change ($p=0.001$): 18% of SMTs increased their score of *attending* to structural aspects of argumentation from level 1 to level 2. The Wilcoxon signed-ranks test, applied to the other components, indicated a statistically significant change in the three SMTs' skills of noticing of argumentation: attending to dialogic aspects, interpreting, and deciding how to respond, between the initial and the refined ACS reports (Table 2). We also found that about one third of the teachers attended to more dialogic aspects in the refined ACS report than in the initial one. Similarly, in their interpretation, many teachers addressed more factors in the refined report than in the initial one. We found variation between the levels of interpretation among the factors after the intervention: most teachers reached high levels (3&4) with respect to the teaching strategies, student cognitive characteristics, and task characteristics factors. By contrast, only about half the teachers reached high levels of interpretation when addressing the factors affective students' characteristics and socio-cultural characteristics. Regarding *deciding how to respond*, most teachers offered ideas for alternatives relevant to the situation; some provided robust evidence to support claims (Level 4), while others provided some evidence to support claims (Level 3). (Findings will be presented and illustrated at the conference).

Noticing skills	Different aspects of argumentation	Time	Mean	Z	Effect size (r)	Percentage of increase
Attending	Co-building of arguments	Initial	2.52	3.58***	0.46	24.6%
		Refined	2.84			
	Critique arguments	Initial	2.39	3.64***	0.47	26.2%
		Refined	2.75			
	Mutual respect	Initial	2.21	4.40***	0.56	36.1%
		Refined	2.64			
Working toward consensus building	Initial	2.11	4.51***	0.58	41%	
	Refined	2.72				
Interpreting	Task characteristics	Initial	2.07	4.53***	0.58	42.6%

		Refined	2.84			
	Teaching strategies	Initial	3.30	3.94***	0.50	29.5%
		Refined	3.67			
	Students' cognitive characteristics	Initial	2.70	4.45***	0.57	39.3%
		Refined	3.28			
	Students' affective characteristics	Initial	1.57	4.77***	0.61	47.5%
		Refined	2.54			
	Socio-cultural characteristics	Initial	1.51	5.02***	0.64	52.5%
		Refined	2.46			
Deciding how to respond		Initial	2.20	5.2***	0.67	44.3%
		Refined	2.64			

***p<0.001

Table 2: Percentage of increase, Wilcoxon signed-ranks test, and effect size for initial/refined ACS reports.

Thematic analysis of the transcripts of the SMTs' written reflections and interviews

The analysis process of the written reflections and interview transcripts resulted in a coding scheme with ten themes grouped into three main types. (1) Seven themes related to **factors associated with the peer assessment experience**, which according to the SMTs contributed to their noticing of argumentation: being exposed to a variety of peer reports, discussing their assessment with peers, and the assessments received contributed to (a) improvement in attending a wide variety of details and aspects of the situation; (b) developing flexibility in interpreting a given situation, different from one's initial interpretation; (c) developing skills of providing evidence of interpretations; (d) increasing awareness of the distinction between quality levels; (e) increasing the motivation to look for and analyze the expressions of the various aspects of argumentation in the given situation; (f) increasing knowledge of argumentation, for example, what counts as acceptable justification and teaching strategies for encouraging argumentation; finally, (g) as the group discussion of assessing peer reports was argumentative, it contributed to understanding the concept of argumentation. (2) Two themes related to **teacher factors**, which according to the SMTs, enabled, but also constrained their noticing of argumentation: (a) the SMTs' views on teaching and learning that promoted (or restricted) opportunities for addressing some aspects of argumentation. For example, a teacher reflected that her thinking that students' cognitive skills are vital in determining the argumentation process, whereas social and emotional factors are much less critical, restricted her interpretation process; and (b) the SMTs' self-confidence in analysis (for example, hesitation in discussing students' characteristics) promoted (or restricted) their interpretation of certain aspects. (3) One theme related to the **specific ACS characteristics**: the specific ACS enabled but also restricted certain opportunities for addressing some aspects of argumentation, for example, students' affective characteristics were not prominent in the given situation.

DISCUSSION

The results of the study provide evidence of growth in SMTs' noticing of

argumentation following their participation in a peer assessment process. A significant change took place in the three skills of SMTs' noticing of argumentation: *attending to structural aspects and dialogic aspects* (co-constructing arguments, critiquing arguments, mutual respect, and working toward consensus building) *of argumentation*; *interpreting* the argumentation in the situation through various factors that may enable or inhibit the argumentation, including task characteristics, teaching strategies, cognitive and affective students' characteristics, and socio-cultural characteristics; and, *deciding how to respond*. These findings suggest the possibility of developing the teachers' skills of addressing at the same time multiple dimensions of argumentation in a given situation. This contrasts with a previous study showing that many teachers focused on one dimension of argumentation and had difficulty noticing multiple dimensions (Ayalon & Hershkowitz, 2018). We found that teachers have difficulty offering an interpretation for how the students' affective and the socio-cultural aspects may have shaped the argumentation in the situation. Such factors adhere to important notions of argumentation that promote learning (Asterhan & Schwarz, 2016) and therefore deserve attention. After the assessment process, most of the teachers provided alternatives relevant to the situation to encourage argumentation, but some teachers still had difficulty providing robust evidence to support their alternatives. The findings suggest that there is still a way to go in improving SMTs' skills of interpreting the argumentation by using various perspectives and offering possible responses. Considerations should be given to how to design research interventions that promote these skills.

Our research design does not allow making firm claims regarding the reasons for change in participants' noticing of argumentation, but analysis of the SMTs' reflections provides some indication of the factors that supported or constrained their noticing. According to the teachers' responses, three types of factors were involved. Prominent were factors relating to the SMTs' experience of the peer assessment process. Giving and receiving feedback using the rubric—considered critical in effective formative assessment (Swan & Burkhardt, 2012)—seemed to support their noticing. Through negotiation with peers about the rubrics and assessments they noticed various details related to argumentation in the classroom situation, which they had not considered before, and attended more reflexively to their practice in interpreting the situation. These findings resonate with those of research indicating that when learners analyze the work of others, they have access to a variety of examples that help them better see nuances in quality of the work (Topping, 2010). From the teachers' reflections we also learned that teacher factors, such as views on teaching and learning, and confidence in analyzing the situation, also shaped their noticing, in particular, their interpretation of the situation. A few SMTs pointed at the specific given ACS that helped them address several aspects of argumentation, and at the same time hindered the noticing of some other aspects, such as student's affective and socio-cultural characteristics.

This study's findings contribute to the literature on professional learning, specifically on developing teachers' noticing of argumentation, by providing evidence of the potential of the peer assessment strategy for teachers' learning and noticing of key

aspects of argumentation practice. Exploration of the change that occurs in SMTs' noticing of argumentation, even for a short duration and with only one peer assessment cycle, enabled us to consider some of the likely advantages and challenges associated with using peer assessment as a learning tool in teacher preparation courses. One of the limitations of the study is that we do not know whether the change in noticing following the peer assessment process will remain. Further research is needed to explore the ways in which the effect of participation in professional learning of this type can be sustained, and whether it is realized in classrooms.

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