International Journal of Educational Research 63 (2014) 79–93

Contents lists available at SciVerse ScienceDirect

International Journal of Educational Research

journal homepage: www.elsevier.com/locate/ijedures

Engaging with others' mathematical ideas: Interrelationships among student participation, teachers' instructional practices, and learning

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ARTICLE INFO

Article history:
Received 2 November 2012
Received in revised form 8 January 2013
Accepted 4 February 2013
Available online 28 February 2013

Keywords:
Classroom dialog
Student learning
Teacher practices

ABSTRACT

This paper explores the relationships between student participation in classroom conversations, teacher practices, and student learning in elementary school mathematics classrooms. Six teachers and 111 children aged 8–10 participated in the study. Students and teachers were videotaped as they discussed how to solve mathematical problems during whole-class and small-group discussions. The results show that the level of student engagement with each other's ideas and the incidence of students providing detailed explanations of their problem-solving strategies were positively related to student achievement. While teachers used a variety of instructional practices to encourage students to attend to and engage with each other's thinking, how teachers followed up on their initial moves was important for whether students engaged with others' ideas at a high level.

1. Introduction

Researchers, policy makers, and practitioners increasingly realize that engaging students as active participants in conversations in classrooms is central to the development of their skills and understanding. Indeed, the U.S. Common Core Standards for Mathematical Practice calls for students at all grades to be able to "construct viable arguments and critique the reasoning of others" (Standards for Mathematical Practice #3), which includes students justifying their conclusions, communicating them to others, listening to the arguments of others, responding to the arguments of others, deciding whether they make sense, and asking useful questions to clarify or improve the arguments (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010, pp. 6–7). Embedded in these recommendations concerning classroom dialog are two related dimensions of participation that underlie the sharing of ideas: voicing one's own ideas and engaging in the ideas of others. Both dimensions are necessary for productive conversations.

Elaborating one's own thinking and engaging with each other's ideas at a high level are at the heart of many researchers' perspectives on productive classroom dialog. For example, justification of one's own ideas and critical and constructive engagement with each other's ideas are the foundation of Mercer (1996) exploratory talk, in which students jointly consider, evaluate, challenge, and justify hypotheses. Mercer contrasts exploratory talk with other forms of engagement that are less

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0883-0355/$ – see front matter
http://dx.doi.org/10.1016/j.ijer.2013.02.001

constructive and involve less student engagement with each other's ideas. Disputational talk is characterized by disagreements but little constructive criticism of suggestions, and cumulative talk is characterized by positive but uncritical building upon each other's suggestions.

Engagement with others' ideas is also central to Barron's (2000, 2003) description of highly coordinated groups, in which students propose ideas for joint consideration and acknowledge each other's ideas, repeat others' suggestions, and elaborate on others' proposals. Speakers' turns are tightly connected, with group members paying close attention to, and responding to, what other members do and say. Students' proposals are directly linked to the prior conversation, are acknowledged and discussed, are not ignored, and are not rejected without reasons being given (Barron, 2000). In uncoordinated groups, in contrast, students may propose ideas but engage less (or not at all) in each other's ideas, for example, by ignoring others' suggestions, rejecting them out of hand without elaboration or justification, or talking over or interrupting others (see also Sfard & Kieran, 2001, for a detailed analysis of uncoordinated communication).

A related characterization of engagement that requires students to generate ideas and to attend to and engage with each other's ideas is co-construction, where students contribute different pieces of information and build upon others' explanations to jointly create a complete idea or solution (Forman & Kraker, 1985; Hatano, 1993). In co-construction, students acknowledge, clarify, correct, add to, build upon, and connect each other's ideas and suggestions (Hogan, Nastasi, & Pressley, 2000). This process of co-construction is consonant with Roschelle's (1992) notion of convergence in which group members construct shared meanings by monitoring the degree to which they understand each other's thinking, extending other's ideas and applying them in new ways, acknowledging divergent interpretations, and resolving inconsistencies between ideas proposed. Such reasoning about fellow discussants' ideas has also been described as transactive discussions or transactive dialogs (Azmitia & Montgomery, 1993; Berkowitz & Gibbs, 1985; Kruger, 1993; see also Goos, Galbraith, & Renshaw, 2002), and is a central feature of Volet, Summers, and Thurman's (2009) high-level co-regulation and Iiskala, Vauras, Lehtinen, and Salonen's (2011) shared regulation (see also Roschelle & Teasley, 1995; Vauras, Iiskala, Kajamies, Kinnunen, & Lehtinen, 2003).

Multiple mechanisms have been advanced to describe how such interaction may benefit participants in these conversations. First, offering ideas to others encourages students to monitor their own thinking. Speakers must transform what they know into communication that is relevant, coherent, and complete so that others can understand it (Benware & Deci, 1984). During the processes of formulating ideas to be shared and then communicating the ideas, students offering explanations may recognize their own misconceptions, or contradictions or incompleteness in their ideas more than they would when simply vocalizing aloud to oneself (Forman & Cazden, 1985; Whitebread, Bingham, Grau, Pino Pasternak, & Sangster, 2007). Second, listening to others' ideas encourages students to monitor their own thinking. When comparing their own knowledge with what is being presented, students may recognize gaps in their knowledge, misconceptions, or contradictions between their own ideas and those they are hearing. Third, having one's own ideas challenged, as well as justifying one's ideas in the face of challenges, may encourage students to engage in a number of processes that promote learning, including re-examining and questioning one's own ideas and beliefs; seeking new information to correct misconceptions, fill in gaps in understanding, develop new ideas, or reconcile conflicting viewpoints; building new connections between pieces of information or concepts; and linking new information to information previously learned (Bargh & Schul, 1980; Chi, 2000; Wittrock, 1990).

Empirical findings from previous studies generally support the hypothesized benefits of active student participation for student learning (e.g., Brown & Palincsar, 1989; Chinn, O'Donnell, & Jinks, 2000; Fuchs et al., 1997; Gillies & Ashman, 1998; Howe & Tolmie, 2003; Howe et al., 2007; King, 1992; Mercer, Dawes, Wegerif, & Sams, 2004; Nattiv, 1994; Saxe, Gearhart, Note, & Paduano, 1993; Slavin, 1987; Veenman, Denessen, van den Akker, & van der Rijt, 2005; Webb & Palincsar, 1996; Yackel, Cobb, Wood, Wheatley, & Merkel, 1990; Palincsar & Brown, 1984). For example, correlational research has linked giving explanations and learning outcomes (Howe et al., 2007; Veenman et al., 2005), especially when explanations are complex (e.g., reasons elaborated with further evidence, explanations that integrate multiple concepts), elaborated, or fully detailed (Chinn et al., 2000; Fuchs et al., 1997; Roscoe & Chi, 2008; Webb et al., 2008, 2009). Other researchers have found that students trained to provide elaborated descriptions of their own ideas and to engage with others' ideas showed greater learning outcomes than students without such guidance (e.g., Gillies, 2004; Howe & Tolmie, 2003; Mercer et al., 2004). Still other research has used close case-study analysis of student engagement with each other's ideas to reveal benefits for the participants in these conversations. For example, Brown, Campione, Webber, and McGilly (1992, pp. 177–178) described how challenges to explainers' incomplete or incorrect ideas help students to re-examine their prior knowledge, to formulate and test predictions based on their incorrect mental models, and to use information provided by others in response to their predictions to revise their ideas.

Most previous research directly linking student participation and their learning outcomes has focused on the extent to which students provide explanations, without acknowledging possible distinctions between explaining one's own thinking and engaging with others' ideas. The first purpose of this study, then, is to extend previous research on student participation and learning by examining these multiple dimensions of student participation—explaining one's own ideas and engaging with the ideas of others—and investigating how they relate to learning outcomes. Specifically, this study seeks to understand the relationship between student participation on learning from the point of view of a student sitting in the classroom: the extent to which a student explains his or her ideas, the level at which the student engages with others' ideas, the level at which other students engage with the ideas of the first student, and how these multiple dimensions relate to learning outcomes.