

A PRELIMINARY INVESTIGATION INTO PROSPECTIVE TEACHERS' PRODUCTIVE STRUGGLES FOR MAKING SENSE OF MATHEMATICAL PRACTICES

Nitchada Kamlue
Western Michigan University
nitchada.kamlue@wmich.edu

Lauren Van Zoest
Western Michigan University
laura.vanzoest@wmich.edu

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For prospective teachers to become teachers who can bring the mathematical practices (NGACBP & CCSSO, 2010) into their classrooms, first, they need to experience those practices themselves. We used the frog problem (see Dixon & Watkinson, 1998; Andrews, 2000 for details) as the first activity of a middle school methods course to provide a chance for the 13 prospective teachers enrolled to *make sense of problems and persevere in solving them* (MP1; NGACBP & CCSSO, 2010). After engaging in making sense of the problem across multiple class sessions, the prospective teachers completed an activity where they analyzed their experiences in relation to the mathematical practices (MPs).

Since productive struggle is an opportunity for students to make sense of mathematics within their *zone of proximal development* (Vygotsky, 1978) and deepen their mathematical ideas and the relationship among those ideas (NCTM 2014; Warshauer, 2015; Zeybek, 2016; Peterson & Viramontes, 2017), productive struggle related to the MPs may also support prospective teachers in making sense of MPs. Our observations of the prospective teachers' struggles during the frog activity led us to the following research question: *What struggles of prospective teachers when engaging with the frog problem support them in making sense of mathematical practices?*

Data collection included videos of all classroom sessions and electronic copies of all prospective teacher work completed in connection with the frog activity. We used Warshauer's (2015) kinds of student struggles for identifying instances of struggle. Then, we applied Kelemanik et al.'s (2016) diagram of three avenues (*Quantities and Relationship, Structure, and Repetition*) leading to MP1 as a framework for identifying which avenues or specific MPs the prospective teachers struggled with. After that, we used *expectations for students* from Smith (2000, as cited in NCTM, 2014) as formative indicators to help us decide whether the identified struggles were productive. We used the prospective teachers' MP analysis document as a final indicator of whether the struggles identified as productive supported the prospective teachers in making sense of MPs.

The initial results show that the prospective teachers struggled with looking for a pattern to generate a rule that works for all cases (e.g., "I have a pattern but I don't know how to put it in the equation.") and with providing a meaning behind their expressions or equations in relation to the frogs' movements (e.g., "Even if we know the answer, we don't know why we need to move like that."). Both types of struggles generated opportunities for the prospective teachers to make sense of MPs, especially, MP2, MP4, MP7, and MP8. Those struggles seemed productive as they provided the prospective teachers with an object lesson in the meaning and purpose of the MPs. For instance, most of them mentioned the same key statement from CCSS about MP1 that related to their experience of engaging with the frog problem— "[Mathematically proficient students] consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution" (NGACBP & CCSSO, 2010, p. 6).

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