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Development of the diagnostic competence of pre-service primary teachers – first results of an empirical study in Chile

Comprehending students' mathematical thinking is crucial for effective teaching and, thus, a key professional competence. Error analysis provides a valuable insight into students' reasoning and was used in this study as a means for developing future primary teachers' diagnostic competence. The development and assessment of this competence during initial primary teacher education in Chile is discussed and first results are presented.

Future teachers' diagnostic competence

Teaching mathematics for understanding requires teachers to start from each student's current level of comprehension to provide effective pedagogical strategies that will meet the needs of their students and promote building of further knowledge. Therefore, teachers need to identify and understand a wide variety of students' mathematical thinking, which requires specialized knowledge and abilities (Radatz, 1979; Barmby, Harries, Higgins & Suggate, 2007). Such a set of knowledge and abilities, has been referred to as diagnostic competence (Prediger, 2010).

Diagnostic competence shifts the focus from evaluating students' achievement to understanding students' learning and thinking. However, students' thinking is not always straightforward, may be communicated incompletely and even not clearly understood by themselves. Mathematical errors found in students' work are a useful source of information about their erroneous conceptualizations or misconceptions and hence a good opportunity for teachers to interpret and analyze students' understanding and make decisions to deliver targeted learning experiences (McGuire, 2013).

This study focuses on the development of future primary teachers' diagnostic competence as used in error analysis. Therefore, a three-phases model developed by Heinrichs and Kaiser (2018) was used to describe the ideal diagnostic process followed by teachers when errors arise during students learning. The first phase of this model consists on the attention to students' work and the perception or identification of the error. Next, the model states that errors are interpreted and possible causes for that particular error and situation are hypothesized. Finally, considering which aspects of students' knowledge need further improvement, a decision on how to deal with the error is made and targeted instructional strategies are designed.

Methodology

With the aim of studying how the development of the error-diagnostic competence of future primary teachers can be fostered, a university course and an online pre- and post-test assessment were designed. Future teachers from 11 Chilean universities participated in the sessions and answered the questionnaires (N=131). The course consisted of four 90-minutes sessions in which future teachers engaged in individual and collaborative analyses of students' work presented both in video clips and paper formats. Future teachers worked through the three phases of the diagnostic competence model several times and were involved in productive discussions about students' thinking and mathematics teaching and learning.

The pre- and post-test assessment included a background information questionnaire, a set of beliefs questionnaires about the nature of mathematics and mathematics teaching and learning from the TEDS-M study (Tatto, Schwille, Senk, Ingvarson, Peck & Rowley, 2008), a multiple-choice Mathematical Knowledge for Teaching questionnaire from the MKT framework (Hill, Ball & Schilling, 2008) adapted and validated for Chile in the Refip project (Martínez, Martínez, Ramírez & Varas, 2014) and an online error-diagnostic competence test developed based on Heinrich's model described above. This video-based-test comprised both open- and close-ended and items that were evaluated using qualitative text analysis and Item-Response-Theory, respectively.

First results

The causes-hypothesizing feature of the error-diagnostic competence was evaluated with a set of close-ended items (EAP Reliability=0.65) and showed a significant improvement from pre- to post-test. In the pre-test, future teachers showed a mean of 50 with a SD=10, whereas in the second testing time, they showed a mean of 52.6 (SD=10). The conducted paired samples t-test confirms there is a significant difference between these means, with a small size effect ($t(130)=-2{,}649$, $p=.009$, $d=.231$).

In relation to their beliefs, future teachers exhibited in the pre-test a tendency towards constructivist views about the nature of mathematics and about the learning of mathematics, i.e. they agreed with statements that understand mathematics as a process of inquiry and the learning of mathematics as an active process. A significant correlation of a medium-size effect was found between the causes-hypothesizing feature of the error-diagnostic competence and the beliefs about the nature of mathematics as an inquiry process ($r=.378$, $p=.000$). A similar correlation was found with the beliefs about learning mathematics as an active process ($r=.384$, $p=.000$).

Similarly, it was of interest to study the relationship of the professional knowledge needed for teaching with the causes-hypothesizing feature of the error-diagnostic competence. Analyses indicated a significant and medium-size effect correlation between them (r=.307, p=.000).

Additionally, the relationships between the causes-hypothesizing feature and other background information deserve some attention. Although the type of teacher education program future primary teachers were enrolled in does not make a significant difference on their causes-hypothesizing competence, as revealed by the one-factor ANOVA (F(3,127)=1.637, p=.184), or the semester of studies they are attending does not correlate significantly with this competence (r=.121, p(one-tailed)=.084), significant correlations were found with other variables. For instance, there were found significant correlations with small-size effects of the causes-hypothesizing feature of the error-diagnostic competence with the number of mathematics or mathematics education courses they have approved (r=.144, p (one-tailed)=.050) and also with the number of school practices they have done (r=.164, p (one-tailed) =.031).

Although the correlation of the number of school practices with the causes-hypothesizing competence may seem small, the differences in the means obtained by future teachers who have none teaching experience in primary classrooms and those who have some or frequent of such experiences is significant and medium in effect size (t(124)=-3,023, p (one-tailed)=.001, d=.543). A similar difference was exhibited between those having and those who do not have experience teaching mathematics in primary classrooms (t(129)=-2,297, p (one-tailed)=.011, d=.404).

The experience of future teachers giving private lessons was also considered because a higher and closer exposure to student's errors is expected in such situations. Interestingly, while no significant differences in the causes-hypothesizing competence of those with and without private lessons experience (for any age-group) was found (t(129)=-1,367, p (one-tailed)=.087), when grouped by their experience giving private lessons to primary students a significant difference was revealed in favor of those who have had such kind of practice (t(129)=-1,630, p (one-tailed)=.052, d=.284).

Discussion

First results suggest that it is possible to promote the development of future primary teachers' causes-diagnostic-competence even within a brief university course. In particular, the causes-hypothesizing competence was found to correlate with constructivist beliefs about teaching and learning mathematics and with mathematical knowledge for teaching on the same subject area as

the analyzed errors. This is in line with the view that both knowledge and beliefs are relevant for the development of professional competencies. In regards to knowledge, not only theoretical but also practical knowledge, shown by the number of school practices, teaching and private lessons experience in primary grades are linked to better causes-hypothesizing competence.

Altogether, these first results suggest that the development of the causes-diagnostic-competence is a complex phenomenon, where a number of factors interact, including beliefs and opportunities to learn theoretical and practical knowledge closely related to the situations on which it would be applied. This, in turn, implies great challenges for teacher educators, who need to provide complex opportunities to learn, in which these dimensions can be promoted.

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