Developing Rubrics & Measures for Evaluation of Mathematics Teachers Pedagogical Content Knowledge of Geometry & Measurement at the Lower Secondary Level: Delphi Study

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For the past twenty years researchers have described and developed different aspects of mathematics teachers knowledge including, pedagogical content knowledge, mathematical knowledge for teaching, and profound understanding of fundamental mathematics (Ball, D., 1990; Ball & Bass, 2000; Hill, H. C., Schilling, & Ball, D., 2004; Ma, L., 1999; Shulman, L., 1987). Recently scholars in the US used a wide variety of methods to develop complex measures and ways for evaluating mathematics teachers' knowledge (Hill, H. C., Schilling, & Ball, D., 2004; CRMSTD, 2004; CTL, 2007; IQA, 2006; KAT, 2007; Manizade, 2006). In this paper, we describe a research project in which a new assessment tool was developed and operationalized to measure teachers' pedagogical content knowledge of geometry and measurement at the lower secondary level using Delpi method (Manizade, 2007). The description of this method allows us to consider what and how we evaluate when considering different forms of mathematics teachers' knowledge. The researcher suggests that the Delphi method should be replicated with other populations and broader content in different areas of mathematics education, and education research (Manizade, 2006).

This study focused on teachers' knowledge known as pedagogical content knowledge (PCK) in geometry and measurement. PCK includes knowledge of students understanding, mathematical content and curriculum, and instructional strategies (Grossman, 1990; Shulman, 1987). The researcher developed the measures of such knowledge and created rubrics for evaluation of teacher responses. The unique feature of this study was the utilization of the Delphi methodology. This method, often used in the field of economics, allowed a panel of experts to come to a consensus about a given set of tenants or beliefs about knowledge. The method involved administering two to three rounds of survey of the experts, in the field being considered, in this case, the mathematics education field. It is especially beneficial when time and distance do not permit face – to – face contacts. Delphi methodology allows an opportunity for experts to receive feedback and to modify and refine their judgments based upon their reaction to the collective views of the group (Altschuld, 1993; Dalkey, Rourke, Lewis, & Snyder, 1972; Debecq, Van de Ven, & Gustafson, 1975; Edwards, 2003). In addition, it provides anonymity to the individuals, ensuring ease and confidence of response. The validity of resulting judgment of the entire group is typically measured as a function of the group consensus. This research method does not include extreme positions, but identifies the areas of agreement. In this project the researcher used the Delphi method to structure a communication process among a group of expert mathematics educators in order to reach a professional consensus on each of the designed PCK measures and evaluation rubrics.

Researchers as Instrument

In the Delphi methodology the researcher plays a key role as the lens through which the data is processed during collection, revisions and analysis. In this study the researcher collected data from expert participants. The researcher then translated, and interpreted data generated from the respondents into meaningful information. Also the researcher made the final decision regarding modification of the design instrument and the rubrics of PCK of geometry and measurement at the lower secondary level. The researcher's educational background and unique set of experiences along with her perspective and conceptual framework affected the data analysis process.
The researcher was aware of the challenges of conducting the study using a research instrument which required a balance of skills, competence, and rigor with flexibility, insight and tactic knowledge (Lincoln & Guba, 1981).

Delphi Methodology in the Context of the Study

Due to the requirements of the Delphi methodology, the researcher chose participants with specific backgrounds. In selecting the participants for this project several factors had to be taken into consideration: a) the number of participants, b) their expertise, and c) the difference in their perspectives. When using Delphi method for research it is generally recommended to identify between twelve and twenty participants (Altschuld, 1993; Dalkey, Rourke, Lewis, & Snyder, 1972; Debecq, Van de Ven, & Gustafson, 1975; Edwards, 2003). For the purpose of this study the researcher chose twenty participants.

As Delphi Method participants are generally picked based on their expertise they will be referred as experts from this point on. The experts were selected from four categories: a) researcher experts, b) mathematics educator experts, c) teacher experts, d) mathematics education leader experts.

In this study the development and administration of this survey was interconnected. The researcher's role in the data collection process was a) gathering the data from the research literature and creating the initial measures, b) identifying a panel of experts, c) corresponding with experts, collecting their ratings of the measures, and feedback on each measure, and d) analyzing collected data and reporting the results. To construct the instrument and the rubric the researcher conducted two types of data analysis: a) qualitative; b) quantitative. The qualitative analysis included: a) the review of literature, b) the content analysis of the data, c) the identification of emerging categories of the data, and d) the operationalization of the instrument. The qualitative analysis included: a) calculating reported rating means for each item of the instrument, b) identifying outliers in the reported data, c) recalculating reported rating means of the items, d) conducting factor analysis, and e) establishing reliability, such as test-retest, etc. The researcher decided to use three rounds to elicit experts' suggestions for developing appropriate measures of PCK. The data analysis and data collection were done parallel to each other. The instrument was modified based on experts' feedback, and analyzed according to the categories of the table of specifications developed by the researcher. New categories in the table of specifications emerged from the data, and were used to complete the analysis. More detailed explanation on the development of the table of

specifications, reliability and validity considerations, and other aspects of the Delphi method in the context of developing instruments of teacher knowledge, as well as strengths and limitations of this method will be available during the discussion. The Delphi method used in this project may be further adapted in the context of the broader instrument development process.

As a result of the study, the instrument and the evaluation rubric for assessing teachers' PCK were developed with respect to number of topics in geometry and measurement at the lower secondary level. Selected items from this instrument as well as the initial scoring rubrics will be available during the discussion (Manizade, 2007).

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(Note: Additional references mentioned in the paper will be provided during the discussion)