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Closing the Gap between current knowledge level of UAE mathematics teachers and the ideal level

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Abstract

This research project aims to characterize the gap between the mathematics teachers' current knowledge of mathematics and the ideal mathematical understanding for teaching in the United Arab Emirates (UAE) context. In particular, as part of a research project proposal that was submitted to UAE National Research Foundation and going through the final stage of review and approval, this study aims to investigate "how in-service mathematics teachers understand and think about fundamental mathematical ideas in major strands (geometry, algebra, measurement, probability and statistics, and numbers)" as well as "the nature of the gap between 'what teachers know' and 'what they should know' to teach mathematics effectively in UAE schools." To answer these questions, a profile of UAE mathematics teachers will be determined, and investigated through qualitative and quantitative research techniques. Such work is expected to inform researchers, mathematics teacher education programs and policy makers.

Keywords: Teacher knowledge; teacher competency; mathematical ideas; understanding; mathematical concepts.

1. Background, Rationale, Research Questions

Mathematics is undoubtedly important in the cognitive development of students at all grade levels (National Council of Teachers of Mathematics, 2000). The success in mathematical education of students in K-14 is positively correlated with the teacher knowledge. The better quality knowledge the mathematics teachers have, the more quality mathematics learning experiences students will receive. This idea is supported by research studies that highlight the importance of having quality teachers with strong background on the subject they teach (e.g., Fennema & Franke, 1992). Lappan and Theule-Lubienski (1994) concluded that teachers need to have knowledge of mathematics, knowledge of students and knowledge of the pedagogy of mathematics "to be effective in choosing worthwhile tasks, orchestrating discourse, creating an environment for learning, and analyzing their teaching and student learning" (p.253). In supporting this idea, Even and Tirosh (1995) considers the first two knowledge types as factors affecting teachers' ways of teaching mathematics. Additionally, Wenglinsky (2002) highlighted the importance of teacher quality (regarding content background and experience) in students' mathematics achievement

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based on 1996-NAEP data on 7000 students. Other researchers (e.g., Hill, Rowan, & Ball, 2005) also have called attention to the impact of teachers' mathematics knowledge and use of it in facilitating and improving students' understanding. These research studies, and many others, direct our attention to the fact that teacher knowledge plays a significant role in student learning and success. Teacher knowledge is an important factor directly impacting the education of students because teachers with a strong mathematical background will choose or create appropriate mathematical tasks to foster students' conceptual and procedural development and will be more attentive to students' reasoning (Ball, 2000), which in turn will impact students' understanding of mathematics and their success in mathematics classrooms.

Since the quality of teachers' knowledge of mathematics is positively correlated with students' learning of mathematics, teachers should have a profound understanding of core mathematical ideas (Ma, 1999) to promote students' understanding of those ideas. Judging whether teachers have such understanding requires having a profile of teacher knowledge. Considering the fact that UAE does not have such profile, it is crucial to characterize the quality of mathematics teachers in UAE context. The purpose in so doing is not only about informing different parties (e.g., teacher education programs in universities, Ministry of Education, education policy makers) with some numeric figures about the mathematics teachers, but it is also to investigate, understand and characterize the nature of the gap between teachers' current level of understanding of mathematical ideas and the ideal level. Doing so will also help us quantify the gap and generate solutions to close the gap. Portrayal of such a gap and a characterization of it will inform future practice of Ministry of Education with respect to mathematics curricula. It will also enlighten mathematics teacher education programs of universities, mathematics education researchers and teachers themselves, both locally and globally. Having a database illustrating this gap will help these parties to work toward creating solutions for closing the gap between where teachers are and at what level they should be.

Therefore, the current research study, which has been submitted to UAE National Research Foundation for funding and going through the final stage of reviews, aims to develop a profile of mathematics teacher knowledge in UAE context. In so doing, a characterization of the gap between the current understanding of mathematics teachers and the research-based expected mathematics teacher knowledge level will be the focus. Specifically, this study aims to investigate the following research questions within UAE context.

1. How do (primary and secondary) in-service mathematics teachers understand and think about some of the fundamental mathematical ideas in major mathematics strands (geometry, algebra, measurement, probability and statistics, and numbers)? How does it compare to expected mathematics teacher knowledge as identified in the relevant literature?
2. What is the nature of the gap between 'what teachers already know' and 'what they should know'? What are the main components and characteristics of this gap?

The project will be limited with the public schools registered in the UAE schooling system for several reasons. First, all the public schools in UAE are going through a continuous assessment of Ministry of Education through observations and they have better established rules and regulations when compared to private schools. Second, public schools are more representative of the UAE student and teacher population than private schools because mostly expatriate children are enrolled in private schools and taught by foreign teachers, whereas it is the opposite case for public schools. Finally, the teacher turnover rate in the private schools is much more than that of public schools which makes it almost impossible to gather consistent data about the teachers working in private schools.

One would argue about why it would be important to have data within the UAE context. It is possible to respond to such argument using the results of a survey, conducted by a number of prominent scholars (Adler, Ball, Krainer, Lin, & Novotna, 2005), about the nature of published research in mathematics education journals, handbooks and conferences at regional (USA) and international arena during 1999-2003 period. As a result of such investigation, Adler et al. (2005) concluded that "research in countries where English is the national language dominates the literature" (p.372). For example, when they checked the published work in Journal of Mathematics Teacher Education (JMTE), Journal for Research in Mathematics Education (JRME) and International Group for the Psychology of Mathematics Education (PME), Adler and colleagues found that Middle East region contributes 2% of the articles published in JMTE and 14% of the articles published in JRME and PME conference each during the period of 1999-2003. What is interesting in these results is that all of these contributions came from one single country, Israel. Hence, the work published (in famous resources) by Israeli scholars seems to represent the work throughout the Middle East region, which of course is misleading. This proposed study therefore may serve as the voice for the Middle Eastern region in mathematics education research in the international arena.

2. Facts about UAE and Challenges for the Study

The proposed work is a challenging task considering the fact that there are currently 765 public schools in total in UAE. Most of these schools are located in the city of Al Ain and in the three big Emirates, Abu Dhabi, Dubai and Sharjah, as outlined in Table 1 (Ministry of Education, 2009). When this is the case with regard to number of public schools, the number of mathematics teachers in these schools makes the main task of this project even more challenging. For example, only in the city of Al Ain, there are 114 elementary, 254 preparatory, and 152 secondary school mathematics teachers, totaling 520 (272 females and 248 males). Table 2 is derived from the UNESCO (2009) statistics about total number of teachers in general to give the reader a sense for the student and teacher population in UAE.

Considering the average number of mathematics teachers per school as four, total number of mathematics teachers throughout the country is roughly about 3000, which in itself makes the project a challenging one. This challenge is not solely dependent on the number figures of mathematics teachers in UAE but the following issues to be addressed during the implementation of this study:

1. Characterizing the portrayal of these teachers' mathematical understandings,
2. Understanding the gap between such a portrayal and research database for what is expected of teachers,
3. Illustrating the nature of this gap by identifying the contributing factors to the gap,
4. Making data-based inferences about possible solutions to close the gap.

Hence, this project will serve the mathematics education community in understanding the components contributing to this gap and inform the community about the possible actions to be taken to close the gap. For this reason, this research project can be considered as a first step to take action in closing the gap at least in Middle Eastern Region.

Table 1. Public school distribution in United Arab Emirates.

Emirate/Educational Zone	Number of Public Schools	Number of KG	Number of Primary and Secondary Schools (Grades 1-12)
Abu Dhabi	143	14	129
Al Gharbeya	58	6	52
Al Ain	134	16	118
Dubai	93	13	80
Sharjah (including Sharjah Inst. Office)	128	14	114
Fujairah	37	8	29
Ras Al Khaimah	100	15	85
Umm Al Qaywain	28	4	24
Ajman	44	7	37

Table 2. Teaching staff distribution in public and private schools in UAE (2007 data)

Teaching staff in primary education (all programs)	Teaching staff in lower secondary (general programs only)	Teaching staff in upper secondary (general programs only)	Pupil-teacher ratio – primary (all programs)	Pupil-teacher ratio – secondary (all programs)
16523	7604	5712	17	13

One other challenge to be addressed by the proposed study is that it will be a large-scale research study in the area of mathematics teacher education. Adler et al. (2005) as a result of their analysis of the current research in mathematics education arena concluded that "small-scale qualitative research predominates" (p.368) the research in mathematics education. As Deborah Ball commented on scale issue in Adler et al. (2006, p.378), "for the field to grow to contribute to policy and practice, and to teachers' learning, however, we need to build capacity for smart, probing, comparative and large scale studies." The current study will target about 20% of UAE mathematics teacher population (about 600 teachers) and the results of the analysis of the data from such a sample are believed to have a significant impact on issues regarding policy and practice.

3. Methods and Framework

The research team (consisting of PI, research assistant(s) and a post doctoral fellow) will determine a profile of UAE mathematics teachers regarding teachers' current knowledge of mathematics and teaching and learning of it through surveys and interviews using the most representative schools of different areas in UAE as the sample. The focus will be more on mathematics subject matter knowledge of teachers than their ways of teaching since the latter matter is mostly dealt with in the literature as outlined before.

Considering the distribution of the public schools in UAE (see Table 1), most of these schools are located in the three big Emirates, Abu Dhabi, Dubai and Sharjah, and the city of Al Ain. These three big emirates and the city of Al Ain (totaling 498 schools) represent about 2/3 of the UAE with respect to the total number of public schools they have. The number of schools in the other Emirates and educational zones is less than the total number of schools in Al Ain and Abu Dhabi. Therefore, the research team will mostly work with teachers from primary and secondary schools of these areas with dense mathematics teacher population. The survey is expected to be applied to a sample of mathematics teachers (about 20% of the whole mathematics teacher population) throughout the country but mostly from Emirates with high density. The choice of schools and teachers will be determined by random sampling procedure based on weighted scores of each Emirate, educational zone or city. In other words, more teachers will be chosen from the cities or Emirates with high density of teacher population and vice versa. Based on the results of the initial survey, about 10% of this teacher poll (50-60 interesting cases only) will be interviewed (Hunting, 1997) for further analysis.

The study is planned to be completed within three years. The first year in the project is considered to be as a preparation period and will completely be devoted to preparation and piloting, which will set the stage for the whole study. Research assistants (up-to-two) and a doctoral fellow will be hired during this phase. The second year will be devoted to setting up connections with the teacher participants and data gathering process. Finally, the third year will be devoted to data analysis process. All the survey and interview questions will be piloted during the first year of the study as mentioned previously. The initial survey will consist of multiple-choice and essay questions targeting teachers' understanding of core mathematical ideas in number theory, geometry, measurement, algebra, and data analysis and probability. There will be questions to be commonly applied to both elementary and secondary teachers as well as questions to be separately applied to elementary and secondary teachers. Considering the geographic and cultural limitations in UAE, there will be two versions of the same survey, one in paper form and one in online form. The model generated and offered as part of Early Numeracy Research Project conducted during 1999-2001 period (Victoria Department of Education, 2009) in assessing understanding through online interviews will be adapted for the online version of the survey (after some modification to have a fit with the current study).

The interviews on the other hand will be audio-taped and/or video-taped by a member of the research team. Because of the cultural limitations, it is expected that the teachers will most likely choose the online version of the surveys or audiotaping during the interviews as opposed to videotaping. To test teachers' understanding of types of numbers, for example, in the survey the participant teachers will be asked a question like: "What makes the addition of two even numbers even? Why?" In the follow-up interviews, the selected teachers will be questioned, for example, about these number types. The data in this sense will have quantitative (e.g., how many of them can answer the number-type question, what percentage of teachers knows addition rules, what is the variation between primary and secondary teacher responses, to what extent is there a correlation between experience in teaching and the quality of teacher knowledge, what are the mostly used teaching methods, etc.) and qualitative features (e.g., to what extent teachers can conceptualize the types of numbers, do they have a memorized procedure or conceptual underpinning for adding even numbers, are their understandings at an appropriate depth, etc.).

Once the data in this nature is collected the researcher will then qualitatively and quantitatively analyze this profile through comparing it with expected mathematics teacher knowledge that is to be driven from research and professional standards set by international and national authorities. In qualitatively analyzing the data, Ma's (1999) framework for mathematics knowledge will be used as a general guide. In this framework, mathematics knowledge is considered through three components, depth, breadth and thoroughness. Understanding a mathematical topic with depth means "connecting it with more powerful ideas of the subject" (p.121), whereas understanding a topic with breadth means "connecting it with those of similar or less conceptual power" (p.121). On the other hand, thoroughness refers to connecting pieces of mathematics into a "coherent whole." For example, an equation, like $2x^2+5 = 13$, may have several meanings for a mathematics teacher. A mathematics teacher having a depth of

understanding considers such equation as a set of points, {-2, 2}, or as an intersection of a parabola with a line with zero slope ($y = 2x^2 + 5$ and $y = 13$), or as an algebraic equation to be manipulated and solved. A teacher with breadth of understanding may consider this equation as a curve only and connect equations with curves at surface level [A parabola looks like a U shape]. A teacher with thorough understanding may look at this equation and think about different systems of mathematics (geometry, algebra, and number theory) and connections in between these systems. In this study, in addition to the use of descriptive statistics and certain statistical tests (t-test, etc.) in generating accounts of the difference between different groups of teachers with respect to teachers' current knowledge of mathematics, the research team will qualitatively characterize teachers' understanding of mathematics using Ma's (1999) framework. The results will be compared to the expected teacher knowledge levels outlined in the mathematics education research arena. Then, the difference between the current knowledge level and expected level will be characterized based on the main components (e.g., teachers focusing only on procedures in problem solving, etc.) contributing to the gap. Once these characterizations are generated, possible solutions to close the gap will be highlighted to inform the mathematics education research arena.

4. Possible Outcomes and Concluding Remarks

Even though this study is limited to the UAE context, a project with this scope will certainly inform the global mathematics education community since it will help mathematics educators and policy makers to understand and see an illustration of the qualities that foster or hamper the gap between the current level of mathematics teachers and the expected level. Doing so will also inform the mathematics education community in thinking about possible ways to close the gap which is a major recent challenge in mathematics teacher education. The major outcomes of the study are the knowledge profile of UAE mathematics teachers with attached descriptive statistics, a characterization of the aforementioned gap and the possible solutions (supported by inferential statistics techniques) to close the gap.

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