Women Achievers

Jill Adler – A South African Mathematics Education Researcher

Practice Makes Perfect

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Jill Adler, a mathematics education researcher from South Africa, received the Hans Freudenthal Medal for 2015. This is one of the top two medals given by the International Commission on Mathematics Instruction (ICMI) for achievement in mathematics education research. The award is given every two years and recognizes a major cumulative programme of research. The recipients of the award are leading researchers who have shaped the field of mathematics education. Adler is the seventh researcher to receive the Freudenthal medal.

Even among mathematicians, not many are aware that mathematics education has emerged as a robust academic discipline with its own community of researchers and set of research practices. Fewer still have an idea of the highly inter-disciplinary nature of mathematics education research, which requires not only a thorough understanding of mathematical content at the relevant educational level, but also draws on theories and methods in education, the social sciences and the humanities. The institution by the ICMI of the Freudenthal medal, along with the Felix Klein medal (awarded for lifetime achievement in mathematics education research), is a very significant step. It has served to give direction and momentum to the growth of the discipline of mathematics education.

Keywords: *Mathematics education, Mathematics education research, ICMI, Hans Freudenthal medal, multilingual education, PCK, mathematics teacher education*

Jill Adler's work is located squarely in a developing world context. South Africa freed itself from its apartheid past in 1994 and embarked on the transition to a more equitable society. During the apartheid era, access to education was segregated by race and quality education was denied to most of the population. With the commitment of the new government to provide all citizens better education, South Africa faced the problem of hugely inadequate numbers of qualified teachers. Unequal access to education and the shortage of capable and qualified teachers are problems that feed into each other. They require sound and long-term policies to be effectively implemented by a government that prioritises education. Many countries in the developing world, including India and South Africa, struggle to overcome these problems.

Adler's work is driven by a strong resolve to address the gaps in mathematics education in South Africa. In particular, she has grappled with the problem of enhancing the capacities of teachers, both pre-service and in-service. To quote the citation for her Freudenthal medal, "her work epitomizes what Wits University has called the 'engaged scholar', that is, doing rigorous and theoretically rich research at the cutting edge of international work in the field, which at the same time contributes to critical areas of local and regional need in education."[1] Adler began her career as a high school mathematics teacher in a so-called "coloured" school. She then spent several years in developing learning materials in mathematics for adult and youth learners who were excluded from learning mathematics due to the apartheid regime. She became a teacher educator in the 1980s, completing a PhD in 1996 on teaching and learning mathematics in multilingual classrooms. Her work, together with student colleagues, on multilingual education was pioneering and placed her as one of the leading researchers in mathematics education (Adler, 2001). Her subsequent work focused on studying the mathematical knowledge that is central to the work of teaching and designing and implementing teacher education programmes that sought to build strong mathematical capability among teachers. I will discuss these various aspects of her work.

The work of Adler and her colleagues on the challenges of teaching mathematics in multilingual environments was pioneering in two ways. First, it brought the crucial issue of language in mathematics teaching and learning to focus in the international mathematics education community, a focus that was unlikely to have emerged from research done in predominantly monolingual cultures. Second, it addressed a critical local issue, which was central in the South African context, to mathematics and science education, and to education generally. Adler's approach was sensitive to the specific contexts and challenges of South Africa, where language issues are complex and politically charged.

South Africa is a multilingual nation with 11 officially recognized languages. The earlier apartheid regime recognized only two official languages – English and Afrikaans.[2] It is common in urban and semi-urban schools to find multiple home languages even in a single classroom. Many South Africans learn to speak several languages. However, the language issues related to education are complex and difficult to resolve. As in many countries with a colonial history, it is not any of the African languages, but English which is recognized as the language of power and opportunity. Official education policy recommends beginning with education in the mother tongue, with the learners gradually acquiring capability in the language of teaching and learning, which is generally English. The current policy, in fact, requires children to learn three languages in school – the home language and two additional languages.

As Adler and her colleagues point out, despite the official policy that early education must be in the home language, in practice, education starting from primary school is almost invariably in the English medium, except for those whose

[1] *The citation is available at http://www.mathunion.org/icmi/activities/awards/the-hans-freudenthal-medal-for-2015/*

[2] *Afrikaans, derived from Dutch, is the language of the Dutch settlers, who came to South Africa before the English. According to Wikipedia, it is the mother tongue of about 13.5% of the South African population, which includes white and coloured (mixed racial descent) South Africans.*

mother tongue is Afrikaans. This is due to the overwhelming demand for English education among black South Africans. (Parents have the freedom to choose the medium of education – a freedom won through the historic struggles against the apartheid regime.) In fact, despite the official policy of mother-tongue-based education in the primary grades, there are hardly any science and mathematics textbooks in the African languages. This is perhaps because of the demand for English medium education – maths textbooks in African languages may have no takers. Part of the reason for such a demand lies in South Africa's recent political history, in the language-in-education policy that the apartheid regime tried to force on the black population. It decreed that the first eight years of schooling would be in the home language and that secondary school education would compulsorily be half (i.e., half the subjects) in English and half in Afrikaans. The policy, which was interpreted by the majority of the black population as a way of denying their access to English language and education, was one of the triggers for opposition to the regime.

The research studies by Adler and her colleagues contended with the reality of English being the language of learning and teaching in most schools. Adler proposed the concept of the "English language infrastructure" in a school environment, which refers to the kinds of English language resources available to the learners both in and outside school. She distinguished between environments where students had minimal or no exposure to English outside the school and those where students had exposure to spoken and written English outside the classroom. The former environment, Adler found, was typical of rural areas in some South African provinces. In such environments, she argued, English functioned essentially like a foreign language. In contrast, in urban and semi-urban contexts, where students were exposed to English outside school, English functioned like an "additional" language (i.e., a second or third language). The educational contexts in these two kinds of English learning environments were very different.

By official policy, and in actual practice, teaching in many classrooms in South Africa is

multilingual. Adler and her colleagues studied the practices adopted by teachers in a range of multilingual classrooms. One of the practices that she studied was code-switching, which refers to the switching between languages while speaking in the classroom. In many South African classrooms, teachers switch between English, which is the medium of instruction, and the home language of the children in the classroom. Indeed, code-switching in classroom teaching is not uncommon in English medium schools in India. Adler studied the prevalence of code-switching as well as the function that it served. It is natural to expect that code-switching would be more frequent in "English as a foreign language" environments, where students had little or no outside exposure to English. One of the surprising findings of her study was that code-switching was far less prevalent in classrooms where English functioned like a foreign language in comparison to classrooms where English functioned like an additional language. The reason was that in an environment where there was very limited English infrastructure in the surrounding community, it was the responsibility of the teachers to provide exposure to English. The students needed to learn English and the classroom was the only place where they had exposure to it. So teachers, usually guided by the school policy, tended to maximise their use of English in the lesson time available.

This finding pointed to the challenge faced by mathematics teachers in complex multilingual environments. They had responsibility for their students learning not only the mathematics in

the curriculum, but also the English language in which mathematics was taught and learnt. In her analysis of mathematics lessons, Adler distinguished classroom talk that was exploratory in nature from discourse that was more formal and mathematical in character. The former allowed for exploring the meaning of the mathematical concepts and ideas through a two-way discussion and interaction. In the context of educational reforms that stressed the importance of exploratory talk for learning mathematics, Adler pointed out that the subject-specific mathematical language is equally important for students to acquire. In other words, formal mathematical discourse is as important as exploratory talk. Many teachers in her study recognized this and explicitly articulated the dilemmas that they faced in managing more than one language. They were trying to carefully balance the use of home language to facilitate exploration and understanding with the need, to learn the English language on the one hand, and the discourse and language of mathematics on the other.

Adler pointed out that the dilemma of code-switching faced by teachers is also an opportunity for the teachers' professional development, for crafting approaches to teaching mathematics that are context-specific, that use the resources of multiple languages in a thoughtful and explicit manner. It is such approaches that are more likely to be effective in classrooms in which teachers address several challenges at the same time. The other dilemmas faced by teachers that Adler identified in her work have to do with how much scaffolding to provide to students as they struggled to solve mathematical problems, and how explicit the teachers' explanations of concepts and procedures should be (Adler, 2001). These are dilemmas for the teacher because there are good reasons for both offering and withholding support. Similarly, too much or too little of explicit telling may inhibit learning.

The work of Adler and her colleagues on multilingual classrooms shaped this area of research internationally. The theoretical perspectives that she introduced have been useful for subsequent researchers. In the words of the award committee, Adler's work shows a "strong theoretical grounding that has served to advance the field's understanding of the relationship between language and mathematics in the classroom."

Alongside her research studies, Adler was active in shaping new approaches to the preparation of teachers. The segregated education policies of the apartheid era had led to a majority of black teachers entering the profession without adequate preparation. Most of them had a three-year teacher education degree, instead of a four-year degree which was required of teachers from the more advantaged communities. The post-apartheid South African government called for educational programmes that would allow under-qualified teachers to acquire the extra year of qualification. Many of these teachers did not have a strong background in terms of subject content. Adler stepped in to meet this challenge. In the mid-1990s, she co-ordinated the curriculum development for a one-year diploma programme at the University of Witwatersrand in teaching mathematics, science and English language. The challenge in the programme was to provide opportunities for teachers to gain knowledge and confidence in mathematics in a way that would positively impact their teaching. A few years later, Adler initiated and developed a curriculum for a post-Bachelor's honours programme in science and mathematics education. The programme is now a decade and half old and has produced a few hundred graduates, many of whom have played a leadership role in their schools. In both these programmes, central place was given to enhancing the mathematical knowledge that teachers needed to teach effectively.

Adler was part of the movement in mathematics education research that brought the issue of teachers' mathematical knowledge into central focus. This strand of work stems largely from Lee Shulman's work in the 1980s, in which he pointed out the neglect of subject matter (or content) knowledge in teacher education. Shulman introduced the now popular term "Pedagogical content knowledge" or PCK to signify "that special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of understanding" (Schulman, 1987). The majority of school (and college) teachers are

subject teachers, typically teaching one of these subjects – science, mathematics, social science or language. Teacher education programmes usually assume that their student-teachers already have the required subject knowledge, since they have done a Bachelor's or Master's degree in the subject, and hence only focus on the pedagogical aspects. As a result, pre-service teachers, who specialize in mathematics as the subject, have little opportunity to revisit and strengthen their understanding of mathematics itself. The emphasis on teachers' subject matter knowledge, developed through the work of Shulman and many others including Adler, seeks to correct this trend. A good analysis of what is meant by deep understanding of school mathematics is presented in the famous book by Liping Ma, Knowing and Teaching Elementary Mathematics (Ma, 1999).

Adler's work takes a grounded approach, seeking to identify and describe mathematical aspects of classroom interaction, both in teacher education classrooms and school classrooms. What knowledge resources does the teacher draw upon and how does it shape the mathematics that emerges in the classroom? A central insight that underlies her analysis of classroom interaction is the understanding that pedagogic discourse involves the transmission of criteria. Teachers are continuously striving to pass on to students criteria for what is acceptable as a valid response, for what counts as mathematics, for what is acceptable as a justification for a given response and so on. The teacher's own judgement underlies the criteria that she chooses to transmit implicitly or explicitly to the students. Adler observed that teachers draw on four broad domains of knowledge to support their judgements: mathematical knowledge, everyday knowledge, professional knowledge and curriculum knowledge (Adler, 2012). She cautioned that when extra-mathematical domains are used to support judgements, the integrity of the mathematical idea must not be compromised.

In her recent work, Jill Adler has revisited the question of mathematical discourse in the classroom. In typical style, she has combined this research with intervention. She is leading a project aimed at improving the mathematics teaching and learning in an identified group of schools serving traditionally disadvantaged communities. In 2009, Adler was awarded a prestigious grant to carry out this project. The intervention was at multiple levels – providing opportunities to the teachers to strengthen their mathematical knowledge, evolving tools to track changes in teaching and learning gains, and developing a community of researchers and teachers engaged with the project.

In this work, Adler, along with a group of colleagues, is shaping the tools and the framework to capture the mathematics in classroom interaction and discourse. Our own work at the Homi Bhabha Centre has shown that teachers do not simply repeat what is stated in the textbook; they do not merely articulate definitions, procedures or theorems in the classroom. Mere telling is generally ineffective in producing learning. Teachers should present examples, interpret the mathematical idea or concept using situations or contexts, design and assign tasks for students to complete, ask questions, design and use representations, moderate discussion, respond to students' utterances or writing, push certain lines of thinking, etc. In the course of doing this, the teacher unpacks the mathematics that is presented in the textbook, in a manner that is appropriate for her/his group of learners. If one examines the transcript (a text version usually prepared from a video recording) of an actual lesson, where there is a reasonable level of interaction between teachers and students, one gets an idea of the complexity of the activity of classroom teaching and learning. The more one pores over the transcript, the more one discovers of what may be going on in the lesson in terms of the teachers' goals, the students' thinking, the teachers' responses to this thinking and the dynamically evolving classroom context. Is there a systematic way of analysing the transcript for an understanding of what is occurring in the lesson? Can this understanding lead to a judgement of the mathematical quality of the lesson? Answering these questions calls for not only an adequate description of what is said, but also a principled interpretation of what remains implicit. Because what is implicit is important in understanding the teacher's and the students' utterances and actions. Adler's work is

aimed at developing a framework for precisely such purposes, to understand the "mathematical discourse in instruction" (Adler & Ronda, 2015).

Like in her previous work, Adler brings powerful theoretical resources to this research. Using an eclectic approach, she combines perspectives from the Russian social psychologist, Lev Vygotsky, and the British sociologist of education, Basil Bernstein. This ongoing work promises to yield insights and tools that serve to better understand classroom teaching of mathematics and thereby design more effective professional development for teachers.

Adler's contributions to mathematics education go well beyond those of a researcher. I have already described her interventions in teacher education. She has contributed significantly to building the mathematics education community not only in South Africa but also in the Southern African countries. She chaired the programme committee of the 22nd Psychology of Mathematics Education (PME) conference in 1998. This is one of the most important annual conferences in mathematics education research and it was hosted in Africa for the first time in 1998. In South Africa, she has developed and guided teams of researchers – PhD students and post-docs, who have gone on to become established researchers making major contributions of their own. She oversaw the activities of ICMI as Vice-President for two terms. In this period, she initiated the African Congress in Mathematics Education (AFRICME), which is now held every four years and is emerging as a nucleating point for mathematics education research in Southern and East Africa. Adler has visited India several times, interacting with mathematics education researchers from the country. She was an invited speaker in the mathematics education section of the International Congress of Mathematicians (ICM) in Hyderabad in 2010. She has visited the Homi Bhabha Centre three times and has supported the research work at the Centre. She played an important role as a member of the committee that comprehensively reviewed the work of the Homi Bhabha Centre. To quote the award citation again, "she has played an outstanding leadership role in growing mathematics education research in South Africa, Africa, and beyond."

References

1. Adler, J. (2001). Teaching mathematics in multilingual classrooms. Kluwer Academic Publishers, Dordrecht.
2. Adler, J. (2012). Knowledge resources in and for school mathematics teaching. In G Gueudet, B., Pepin, B., and Trouche, L. (Eds.) Mathematics Curriculum Materials and Teacher Development: From text to 'lived resources' (pp. 3--22). Springer, The Netherlands.
3. Adler, J. & Ronda, E. (2015). A framework for describing Mathematics Discourse in Instruction and interpreting differences in teaching. African Journal for Research in Mathematics Science and Technology Education (AJRMSTE), 19(3), 237--254.
4. Ma, L. (1999). Knowing and teaching elementary mathematics: Teachers' understanding of fundamental mathematics in China and the United States. Lawrence Erlbaum Associates Inc., Mahwah, NJ.
5. Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1–23.

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