Chapter

Transforming Elementary Mathematics Classroom Practice: Ideas and Innovation from a Leader's Perspective

Karim Medico Letwinsky and Michael Berry

Abstract

The purpose of this chapter is to highlight common challenges that school leaders encounter when seeking to implement change in the teaching and learning of mathematics at their schools. Specifically, the chapter will offer innovative ways that international elementary principals successfully have influenced systemic change in K-5 mathematics classroom practice. The challenges highlighted are not unique to international educators, but the context from which we speak is situated in the international educational environment. We offer practical, but theoretically based guidance for school leaders looking to implement, support, and sustain authentic change in the culture and practice surrounding the math development of students. The first half of the chapter will provide context and a situational perspective relative to the complex relationship between principals, as instructional leaders, and their ability to influence classroom change. Key events that have made conversations about the teaching and learning of mathematics prominent in schools around the world also are highlighted. The second half of the chapter details actionable ideas grounded in research that elementary principals or curriculum leaders can implement to help shift classroom teaching and learning at the elementary level. Ultimately, these shifts are designed to enable higher levels of mathematics achievement for all K-5 students.

Keywords: elementary mathematics, teacher education, pedagogy, leadership, professional development

1. Introduction

The process of leading change in a school, or any complex system, can be an elusive task. In fact, many theorists suggested that the vast majority of change efforts, despite the type of organization, end in failure [1–4]. In international schools, uniting a wide range of cultural beliefs about educational practice can be especially challenging. For instance, current best practice in teaching methods can clash with older, more traditional approaches experienced by parents or caregivers—a dilemma not unique to international schools. This places a natural divide between students' learning process at school and the type of support students receive from caregivers at home—particularly related to mathematics [5]. Some cultures may continue to place significant value in more traditional teaching approaches including drill, practice, direct teaching style, timed testing, or memorization. Several of these methods have not only been proven ineffective or damaging for students, but they also are incongruent with the pedagogical practices required to shift mathematical understanding in a way that best prepares learners for the current global society. These complexities are not exclusive to international schools, but are a challenge for educational leadership teams in all environments.

One of the greatest challenges for school principals today may be supporting and sustaining teaching practices at the classroom level that demonstrate improved student learning, particularly in mathematics. The variables that contribute to influencing classroom practice are vast and include: the student, the teacher, curriculum, assessment, and student caregivers, just to name a few. The role of teacher and student beliefs about mathematics, past experiences, and potential anxiety are also prominent factors in determining classroom experiences [6]. What has become clear in the most innovative educational systems, however, is that the power to improve learning does not exist with an individual, but rather that a collective effort from whole school communities working together is required for successful change to happen [7].

This chapter will further explore the pressing need to change the way that elementary students engage with and use mathematics in the classroom. From the perspective of a primary school leader in Southeast Asia and a mathematics specialist working in both U.S. and international contexts, we offer innovative ideas that instructional leaders can implement in their efforts to transform the elementary mathematics teaching approach in their schools. The overall process is highly complex and interconnected with other influences not addressed in this work, such as curriculum or other external resources that support classroom practices. The focus here is on creative ways to unite the stakeholders of education and to bridge research and practice in support of transforming classroom pedagogy and learning experiences for elementary mathematics.

2. Time for change

The need for a transformation in how educators teach and students learn mathematics has been well established. Instructional leaders now are tasked with bringing a new vision of learning to life through the classroom experiences created for students. Since 1989, the National Council of Teachers of Mathematics (NCTM), an organization that the world looks to for research and guidance dedicated to improving mathematics education, has articulated a clear and comprehensive vision for mathematics in K-12 classrooms. Specifically, the organization has advocated for mathematical learning focused on an exploration of concepts rather than a more traditional learning environment that was teacher led, formula focused, and process driven [8, 9].

Another push for changes in mathematics teaching came from the extensive work of Professor J. Boaler [10]. Boaler heightened the debate for reformed teaching methods in her role as a Professor of Mathematics Education at Stanford University and the faculty director of Youcubed, an online platform of resources for parents and teachers focused on new and unique approaches to learning mathematics [11]. Boaler's work highlighted the ineffective results of passive learning experiences in mathematics classrooms and the traumatic outcome for students who were taught mathematics as a series of disconnected methods and formulas to be memorized. Boaler's influence grew in 2016 with the book, "Mathematical Mindsets: Unleashing Students' Potential through Creative Math, Inspiring Messages, and Innovative Teaching." This time, Boaler drew attention to the dismal dispositions, inaccurate myths, and faulty perspectives that have long been associated with mathematics. This included topics like the influence of anxiety on student learning, the beliefs of teachers and students about their potential to learn mathematics at higher levels, student ability tracking, and the value of mindset and mistakes in the classroom.

A final urgency for change in mathematics teaching comes directly from the global community and society, at large. Reports regularly flood the news about the need for students with STEM (science, technology, engineering, and mathematics) specialty and interest [12]. The expanded availability of employment opportunities related to these areas of study is well represented in popular media and some researchers insist that mathematics in the context of STEM education demands focused attention in conversations and in classrooms [13, 14]. Reconceptualizing mathematics education is essential as the need to perform basic math skills is diminished with increased automation and technology capabilities [14].

General agreement exists about how little value a purely procedural approach to mathematics offers for today's highly complex world. In a school system at the core of instructional change is the role of the leader (i.e. elementary principal or curriculum leader) to inform and influence teaching at the classroom level. What any principal quickly learns in this effort, however, is that the process of implementing and sustaining change in teacher practice is anything but simple—especially for elementary mathematics.

2.1 Teaching mathematics

"Please take out a piece of paper and fold it in half hotdog style (vertically), rip it in half and give the other piece to a friend." Forty years ago, this is how our math class began each day. Once the paper was shared with a partner, each student numbered the paper 1–10. The teacher then called out multiplication fact questions at lightning speed as the students rushed to write down the answers. Once completed and corrected, the teacher read the list of student names and when your name was called, you reported aloud the number of questions answered correctly out of 10. Classes were filled with directives to memorize procedures using mnemonic devices such as Dracula's Mother Sucks Cold Blood (DMSCB—Divide, Multiply, Subtract, Check, and then Bring Down) for long division or Please Excuse My Dear Aunt Sally (PEMDAS) for the order of operations. Seldom, if at all, did mathematics lessons teach at the conceptual level. Rather, there was an abundance of worksheets for students to practice these mindless steps over and over again.

In many classrooms today, much of the same can be seen. Once, while visiting classrooms at an international school, we entered the room as the mathematics lesson was about to start. It began with students completing a multiplication fact worksheet as quickly as possible—now called "mad minutes" or some other anxiety provoking name. As we entered the class, one student immediately shrunk into his seat and stopped working. When students finished the worksheet, they were to call out "done" and the teacher would reply with their time which was then recorded. Students calling out "done" one after the other began sounding like popcorn popping—the calls of "done… done… done" became more and more rapid each moment. As more students shouted out "done", the further the boy slid into his chair. Not different from many years ago, students then had to call out how many correct answers they had when the teacher called their name.

A teacher's approach to teaching mathematics is formed by range of influences. As a start, one might gain significant insight simply by asking a teacher some of the following questions: How did you learn mathematics in elementary school? Did your teacher encourage you to memorize facts and formulas or were you taught to seek understanding in the connections between mathematical concepts? Did you engage in math fact races that made you feel slow or not as good at math as your classmates? Perhaps you were taught that there is only one right way to solve a problem, often using a formula that you memorized so you could solve the next problem. This only worked, of course, if the *next* problem was exactly like the one you memorized.

These questions highlight some of the approaches that many teachers were exposed to as learners. Unfortunately, as research in teaching and learning continues to emerge, these very approaches are deemed some of the most ineffective and damaging ways for students to engage with mathematics. Yet, they remain familiar and comfortable for teachers who once endured them. If not adjusted in the elementary learning years, ineffective teaching methods will continue to turn students away from learning mathematics with more discouraged students sinking in their seats and dreading the moment their name is called. Such methods also will perpetuate gross misconceptions about what learning and exploring mathematics is about. For instance, these methods send messages to students that mathematics is about being right or wrong and solving problems fast, rather than thinking deeply, even slowly, about meaningful problems with multiple creative solutions.

Because elementary school is where foundational concepts, understandings, and attitudes are formed for students, we argue it is the most critical time in the learning continuum to examine practice continuously. Certainly, we do not suggest that a classroom teacher does not make every effort to offer the best possible learning opportunities for students. The reality is, however, that many teachers may have experienced learning in the manner described above—traditional, procedural, and disconnected from conceptual understanding. This incongruence in the way teachers learned and the way in which we are asking them to teach today can be a challenge to overcome [15, 16].

Necessary changes in mathematics teaching approaches are driven by societal needs for individuals who can apply creative mathematical thinking and current brain or educational research [10, 14]. None of these changes are simple and a comprehensive approach is necessary. Advancements in research related to the effective teaching of mathematics clearly point to the need for a balanced math class that incorporates both procedural and conceptual learning opportunities, presenting mathematics as a creative subject that requires reasoning and flexible thinking with interconnected concepts to be understood, not memorized. More specifically, students also need time to communicate mathematical understandings, explore concepts through inquiry, seek justification, and apply reasoning [8]. Often, this is contrary to the mostly procedural experiences many classroom teachers had as learners themselves, and therefore can be an unintended obstacle to their current classroom practice. Compounding this challenge is the reality that many parents and caregivers also have had traditional learning experiences with mathematics, and so they do not see the benefits to the desired classroom changes.

3. Taking action to transform mathematics teaching

Taking action in a way that can influence how teachers teach mathematics in their classrooms requires a sustained and integrated approach for change. In general, we identify three key areas that an instructional leader must attend to in order to have a positive and lasting influence on classroom practice. We broadly identify these areas as: (a) teacher development through external support, (b) informational and experiential parent development, (c) educating the whole math student. The process when executed is not linear, but rather each action occurs in a fluid and ongoing manner as the work progresses.

3.1 Teacher development through external support

The first step an instructional leader can take to influence a teacher's approach to teaching mathematics is to ensure targeted professional development. Critical to the success of the process is an authentic re-learning of elementary mathematics for teachers. The professional development, however, must be unlike traditional, less effective approaches, which may include a one-time trip to a conference or a brief visit by an outside professional consultant. The design and delivery must do more than demonstrate new classroom practices and strategies. Implementing a change in teacher practice requires a more comprehensive process than a momentary demonstration of a new method that a teacher then is expected to implement with success in their classroom.

3.1.1 Professional development models

When considering the use of professional development as a vehicle to influence teaching approach for mathematics, consideration of both content and delivery model is necessary. There are three common paths we have found international schools take when considering professional development delivery models. The first is teacher-directed model, sometimes in consultation with administration (curriculum coordinator or principal). This typically entails locating and attending a conference that presents information of interest. One issue with this brief injection approach, however, is that these topics often are fleeting ideas for practice and the desired change at the classroom level is not sustainable much past conference attendance. With this experience, a teacher's long-standing beliefs and experiences with mathematics remain the same.

The second model of professional development is more of an integrated and intentional approach to teacher improvement. In consultation with the administration, an identified area for improvement is noted for the teacher after numerous formal and informal observations. The opportunities for growth are addressed by having the teacher attend workshops or conferences with topics to improve the identified areas. We strongly recommend including the identified areas for growth as goals in the teacher's annual appraisal for consistency and clarity between the teacher and principal. This focused approach may help accentuate the desire to change, but often times the teacher's beliefs and past experiences with mathematics will once again overcome classroom practice.

A third approach to professional development most intended for a systemic change across the school is to employ an external professional consultant who will come to the school and work with both the administrators and teachers. Typically, the goal of this model is to change a specific practice across the school (i.e. Grades K-5), rather than in one classroom only. Often, this will mandate a change in the school's teaching and learning philosophy, as well. The idea of redefining a collective philosophy is essential to achieve sustainable change because a school cannot focus on changing teaching practice only. The entire ethos of how the school believes students learn mathematics must evolve through this process. If this deeper philosophical change does not occur, once the key change agents within a school depart for other international jobs (a common phenomenon as international education is built upon a transient population), the change will not remain embedded within the school culture. A transformation in the overall school learning philosophy ensures that the teachers who come and go will have a clear vision of how the school engages in the teaching and learning of mathematics thereby promoting continuity even with turnover. This approach extends well beyond the decision to have an outside expert deliver lessons to teachers and administrators. Rather, the work with an external professional is only one piece of a multi-year, dynamic change process.

There are several benefits to deciding to have an external consultant work with the school community. The first is that by designating funds to an external resource, administrative teams convey messages of importance and value to the teachers. This is a rather strong message given the scarce nature of both time and money in most educational systems. Second, having all teachers and administrators in the building hear and experience the same learning opportunity together when the training occurs promotes consistency across the school. The conversations in the staffroom, classrooms, and offices around learning math now have a united purpose and focus because each individual experienced the same training as his or her colleagues. Third, although the consultant often is selected by the school's administrative team, ensuring that leadership teams (i.e. assistant principals, curriculum coordinators, grade level leaders, etc.) are involved in the selection process helps to gain buy in from all staff. Early conversations between all leadership teams and the external consultant makes it possible to customize the professional development experience. For example, asking the consultant to be aware of the school's mission, vision, and value statements help ensure that the content resonates with the teachers and is in alignment with the school's core philosophy.

3.2 Informational and experiential parent development

The triangular relationship between the student, parent, and teacher has long been proven valuable in promoting student achievement, in addition to positively influencing other variables such as student engagement or dropout rates [17, 18]. In classrooms, some educators refer to this as the triangular relationship that is essential for educators to effectively do their jobs. Others call it the triangle of trust or strength, noting the triangle as the strongest geometric shape, thereby creating the strongest potential for learning. Parent involvement can take many forms and may include activities such as attendance at school events like back to school night, parent-teacher meetings, volunteering in classrooms, or general school networking opportunities.

Most recently, research supports the benefits of including parents specifically and intentionally in their child's elementary mathematics education [19]. This is the dimension of parental involvement that we believe is critical to support classroom changes for mathematics. Unique to the new, desired learning environment for elementary mathematics are the significant differences in how students are taught math concepts as compared to how their parents or care givers were taught. For example, the approach to teaching should emphasize strategic thinking and flexibility to support deep understanding of mathematical concepts, rather than repetitive practice or drills. This would allow students to use different strategies when adding, subtracting, multiplying or dividing, rather than a traditional algorithm. When asked to add 18 + 5, a student might choose to decompose the 5 into 2 + 3 as a first step. Then, by adding 2 to 18, the student makes the problem 20 + 3, summing to 23. In absence of proper communication with caregivers, this method can be unlearned if the student has work to complete at home and the parent reteaches a traditional algorithm. The next day, the student might now be saying, "to solve this problem I can drop a three and carry the one." Ironically, this is exactly what a teacher does not want to teach or reinforce, as it is strewn with misunderstandings of basic math concepts.

Creating and nurturing the relationships with parents to support these changes is not always easy. In any school, especially in international school systems, parent communication tends to be an area in need of continuous improvement. Some schools are trying to overcome parent-school communication challenges by inviting parents to campus to participate in a more engaging exchange about math teaching and learning, sometimes called Parent Coffee Mornings or the Parent Cafe. These are informational sessions designed to provide parents first-hand knowledge about a specific topic, and the leader of these parent sessions often is the elementary principal, curriculum coordinator, or an instructional coach. This personal exchange can be more effective than a newsletter to relay essential curricular information, but is limiting in its ability to support classroom change.

Adding more parental/caregiver engagement to these sessions can make them both informational and experiential, which we have found much more influential to support classroom change. In an interactive-station based model, teachers and/or students lead the sessions rather than being facilitated lecture style by the administration. This transforms the Parent Cafe from a passive listening session into an interactive and more experiential learning exchange. The interactive-station based model invites parents to actively participate in the sessions. Similar to the first information-only model, this design includes a keynote or general overview of the topics. This information then is followed by an activity that circulates parents through various stations led by students and teachers. Each station demonstrates an authentic example of the information shared where parents are not only observing the math activity, but are taking part. For instance, one station might be focused on games that support number sense, another for hands on activities to learn geometry concepts, and another using manipulatives to enhance the understanding of fractions.

An alternative informational and experiential model expands upon the station-based model by connecting the parent engagement directly to the classroom environment. This type of parent session lasts longer because there are deeper levels of interaction embedded into the experience. Similar to the previously described station-based model, the classroom-based interactive session includes an overview of the key ideas. This can take 30–45 min, during which time the curriculum leader can set the stage for the purpose of the school visit. Here, the theory behind the topic can be explored. For example, in a session focused on teaching mathematics through inquiry, the presenter would highlight how this learning strategy may look and feel nothing like how the parent community learned mathematics when growing up. The value of collaboration between students, a de-emphasis on rote and procedural teaching, and the detrimental effect that timed tests can have on children would be common topics discussed during the opening session. Describing to parents what inquiry mathematics looks like, feels like, and sounds like also would be essential topics.

The second half of the interactive classroom-based model includes parents visiting classrooms to see inquiry mathematics teaching in action. Empowered with some foundational knowledge about teaching mathematics through inquiry shared during the opening session, the parents have an opportunity to build a schema of inquiry mathematics teaching and then connect new learning in the context of the mathematics classroom. During classroom visits which last about 30–45 min, parents can note their key observations.

Finally, the parents reconvene with the session leader to reflect on the visit to the classrooms—a key step in the experiential learning process. This collective reflection allows parents to both reflect upon and regulate their prior beliefs about how learning mathematics should look and feel. Research has promoted such reflection as a means to support critical analysis in experiential learning [20]. Other studies also suggested that "Reflection can be as simple as asking questions such as, 'What just happened?' [21, 22]." When prompting parents to reflect on the classroom experience, we find parents genuinely excited by their observations. Statements such as, "I wish I was taught math like this!" and "It looked as if the students were having fun!" are common responses from the parent community.

A final, innovative way elementary principals engage parents in support of mathematics classroom transformation is to include parents in a new and unique learning experience in an effort to build collective efficacy. Almost 50 years ago, A. Bandura noted that if a group had great confidence in its abilities, the group also experienced great success [23]. Collective efficacy has been defined as "the perceptions of teachers in a school that the efforts of the faculty as a whole will have a positive effect on students [24]." In the educational setting, research on the concept of collective efficacy has examined the relationships between teachers' collective efficacy and student achievement, finding that collective efficacy can be more important in explaining school achievement than socioeconomic status [25].

Extending the potential reach of collective efficacy, Bandura suggested that collective teacher efficacy can also have a positive influence on parent-teacher relationships [23]. In this final experiential model for parent development, the principal capitalizes on the powerful concepts of experiential learning, collective efficacy, and reflection. If we suggest that a strong triangular relationship is beneficial to student achievement, why not incorporate a process to build collective efficacy between the critical stakeholders to classroom learning: teachers, parents, and students? This model also removes the administrators, teachers, or students as the messengers for new information, and connects parents directly to mathematics teaching experts and research.

J. Boaler, the professor previously mentioned from Stanford University and director of the webpage, Youcubed, has created a number of online courses to support both teachers and parents. One self-paced course entitled, "How to Learn Math for Teachers" requires participants to, "Explore the new research ideas on mathematics learning and student mindsets that can transform students' experiences with math [11]." The website further explains that, "Whether you are a teacher preparing to implement the new State Standards, a parent wanting to give your children the best math start in life, an administrator wanting to know ways to encourage math teachers or another helper of math learners, this course will help you [11]."

Believing in the potential for a broader sense of collective efficacy, one school we encountered used Boaler's online course to create a more extensive but inclusive learning community to support a comprehensive transformation in mathematics teaching. The process began by encouraging elementary teachers, administrators, and parents to enroll in the online course offered by Youcubed. When the course began, 35 teachers and administrators and more than 50 parents embarked on the learning journey together. Upon conclusion of the online course, the principal hosted reflection meetings for all participants to discuss the learning experience and the influence it had on their beliefs about how to teach mathematics, how to help students persist with learning mathematics, and what a meaningful demonstration of understanding mathematics should include.

Elementary principals who have used this approach reported that the knowledge gained during the online course was highly impactful for all participants. The course material provided classroom teachers the motivation to persist with the implementation of new strategies for teaching elementary mathematics from previous professional development sessions. The information provided parents the explanations and demonstrations needed to reduce resistance from home to classroom changes in learning mathematics. The experience also afforded parents a new understanding for how to support their children from home in their math learning journey by not only sending positive learning messages, but also by resisting the urge to regress students back to the traditional or procedural methods learned by parents in the past. The online course experience also helped administrators understand how to best support teachers in the effort to shift the teaching and learning trajectory for elementary mathematics throughout the school.

3.3 Educating the whole math student

Familiar phrases that teachers hear often in their mathematics classes are, "I'm not good at math" or "I'm not a math person." These phrases have provided excuses for decades to students who have decided to disengage with this subject [26]. Sadly, when this sentiment is expressed in the presence of a parent, longstanding math anxiety for parents may result in a response such as, "Don't worry, I was never very good at math either" [27]. For some reason, this statement is accepted as opposed to, "I was never very good at reading," something seldom heard among adults or children. Our willingness to accept these excuses for mathematics over the years has contributed to the low achievement of students in this subject, as well as the perpetuation of negative attitudes that surround mathematics.

An individual's attitudes about learning mathematics are formed by prior experiences which often included damaging teaching methods like drill, speed, and practice without purpose. If teaching focuses on the procedures of mathematics but is vacant of deeper conceptual understandings, the results are superficial understandings of topics. These limited understandings allow students to conclude that they are not very good at math, when really what they lack is deeper understanding. The reality is that students never actually learned the content in the first place. The pervasive avoidance of engaging deeply with mathematics prevents adults and students, alike, from seeing mathematics as a subject of value to be understood, rather than avoided. To counteract the "I'm not good at math" syndrome, we believe it is essential for teachers to attend to not only the conceptual learning process of mathematics, but also to break the cycle of bad math attitudes by cultivating the necessary habits of mind for success.

Some of the essential habits of mind that teachers must develop with students include the value of making mistakes and willingness to engage in a productive struggle in mathematics class. The process of learning math is messy and unpredictable [28]. Students should expect to engage in trial and error that includes making mistakes and then trying again… and again. If this mindset is considered the norm, then learning mathematics becomes more like a stream that flows naturally from mistake to mistake [29], and less like a final destination with one right answer. Teaching methods that focus on speed or right answers only send messages to students that make them feel incompetent when a solution is incorrect or when the student needs to work slowly. There are many students we have encountered like the young boy in the previous example who could not work as quickly as peers, and so they slowly shut down to the possibility of feeling accomplished with mathematics. When teachers ask questions that allow for multiple pathways and creative thinking, students have a chance to engage with the class and with the content. At the same time, teachers must give ample time for students to contemplate questions deeply, rather than answer quickly from memory. In doing this, teachers also send messages that thinking, wondering, and persisting is valued in mathematics, not answering correctly or quickly.

Closely related to welcoming mistakes as a part of learning mathematics and not a part of failing to excel in mathematics, is the value of productive struggle. Piaget noted the essential role of disequilibrium or cognitive conflict in order to advance in levels of cognitive sophistication [30]. This struggle or imbalance plays an important role in the learning process during mathematics class. Misconceptions about how easy or difficult learning mathematics should be may increase a student's negative response to struggling. Teachers must actively inform children that struggling is not unique to students who do not excel in math, but more importantly, that struggling is an essential part of the process for all who learn math. This important shift in how students perceive the struggle in mathematics class is another way that teachers can be sure to educate the whole student in math class. The educational process must not only focus on the mathematics content, but also on the students' beliefs and attitudes about what learning mathematics should be. At times, learning will feel difficult and mistakes will happen. These are no longer exceptions that apply to less capable students, but rather *expectations* for all students.

4. Finding success by understanding change

Designing, initiating, and implementing change in any institution is difficult. Anyone who has tried also knows that sustaining change over time is even more challenging. Schools extend large amounts of money, time, and energy to initiate change processes throughout a school system. Often times when the effort is intended to influence teacher practice, it is not long before teachers revert back to the way things were done before the implemented change took hold. This is not an act of defiance or even intentional resistance, but the reality is that teachers feel most comfortable teaching the same way they were taught. Breaking this cycle is an intricate and involved process. Even the most accomplished teachers who have successfully transformed their approach to mathematics teaching report that they must continuously challenge themselves and reflect upon their lessons to ensure fidelity with the new desired appraoch.

In the United States over the past 20 years, ongoing public awareness campaigns have encouraged parents to read to their children, increase access to books, or revise classroom learning to promote literacy. At the same time, mathematics initiatives have not had the ability to gain the same traction [31]. Global assessment statistics would support a similar phenomenon in mathematics throughout the world. When examining the influences related to our understanding of and interaction with mathematics, however, one quickly realizes how complex affecting change can be. Compounding these challenges, a nationwide survey conducted in the United States also found that parents generally find math and science less important in their children's lives than reading [32].

The question that remains is: what can school leaders do to ensure that a desired change is institutionalized? Elementary principals who have found success in this process take time to revisit the effort and the progress continuously. In their book Implementing Change: Patterns, Principles, and Potholes, G. E. Hall and S.M. Hord remind us that change is a process, not an event [7]. Effective instructional leaders take time to remind themselves and their stakeholders why a change was important. Revisiting an initiative with this mindset allows for the cycle of continuous improvement to occur, as leaders re-evaluate the "why" of this work.

Some elementary principals claim that success requires making time for staff meetings every 6–8 weeks to discuss what has gone well and what challenges continue to exist. Continuous reflection contributes positively to the effort over time, and assigning a small task or challenge in between meetings can keep teachers active in the change process. Examples of this might include: conducting a lesson using one of the new classroom strategies and reflecting on the successes or difficulties of the lesson; conducting a peer observation and then reflecting together on the lesson's outcomes; or inviting someone to observe your class to offer perspective on your application of a new classroom strategy.

Teachers have reported that when making efforts to change their classroom practice, having time to observe and collaborate with their peers is extremely helpful. This can pose an additional challenge for leaders because organizing class coverage for teachers to visit other rooms during the day can be challenging, as resources for this purpose are scarce in many buildings. Principals or curriculum leaders who are willing to cover classes for teachers or hire substitutes teachers to enable peer observations and collaboration demonstrate a strong commitment to teacher success in the change effort. As an alternative, some teachers choose to video themselves teaching a lesson which allows for personal reflection and self-assessment.

Elementary principals warn: do not forget to celebrate the small successes. Recognition and celebration of progress is a key part of the change movement's momentum. This positive energy may also help shift lingering resistance. There will be times when teachers may not be successful in achieving the desired changes, however positive reinforcement for their attempts is important. A truly innovative process includes both success and failure as we learn important information from each of these experiences. Elementary principals also warn that there will be some teachers who may never feel comfortable with changing their math classroom practice. They can be found in almost every school in the world—plan for these teachers. They will need more support and encouragement to be successful. Facilitating change must be viewed as a continuous, supportive cycle grounded in a team approach.

4.1 A model for change

A final trait we attribute to the most innovative instructional leaders is a keen awareness of the essential elements to a successful change process. Framing the approach to influence classroom practice in a way that aligns with general principles for change significantly increases the potential for success. For example, one principal reported that maintaining focus on Kotter's 8-Step Change Model helped in the overall effort to create and sustain authentic change in math classroom practice [1]. These eight stages include:

- Establish Sense of Urgency
- Form a Powerful Guiding Coalition
- Create a Vision
- Communicate the Vision
- Empower Others to Act on the Vision
- Plan for and Create Short-Term Wins
- Consolidate Improvements and Produce More Change
- Institutionalize New Approaches

When reviewing the practices detailed in this chapter, alignment to these stages articulated by Kotter are apparent, as the goal of our work has been to unite theory and practice in new and meaningful ways. The execution of the strategies described in this chapter offer multiple entry points for leaders to infuse the stages of Kotter's model into the change process of classroom teaching. Essential to the overall process is to identify and measure key variables along the way in order to demonstrate success with authentic data. This information offers the opportunity to celebrate demonstrated success and keep the process moving forward. Principals who use this strategy found that data revealing success along the way provides motivation for teachers, parents, and administrators to keep going. Although discussing the systems that gather data will not be addressed in this chapter, it is important to note that quantitative data (including external and internal benchmarks or assessment) as well as qualitative data (observations, anecdotal notes, etc.) are all valid examples of collected data.

5. Discussion

The overarching goal of this work was to reimagine the concept of professional development and to present a new model for achieving classroom level change in elementary mathematics practice. This work evolved over 6 years and within the walls of over a dozen international schools seeking ways to provide the best learning opportunities for students in mathematics, while recognizing changes in instruction at the classroom level were necessary. A leader's primary role in any school and in every context is to work within the school community to elevate the achievement of students. Supporting a reform in classroom instruction is key to changing the success trajectory for students in mathematics. By taking a leadership lens in an international school environment, this work provides multiple creative solutions for a range of obstacles not unique to the international environment.

In international schools, the complexity of implementing change can be considerably more difficult because of some environmental and situational realities of these schools. For instance, teachers and leaders in international schools are often expatriates of the host country and move on to different schools in different countries within 3–5 years. This transience is an expected part of the international school community, yet the impact on the stability of the schools, and specifically the consistency of educational delivery, can make consistent year to year operations a challenge. Given this dynamic, sustainable change can be difficult when the initiators of the process may not have a role in the implementation or institutionalization of the desired change.

For a school principal whose primary responsibility is the oversight of instructional practice, these obstacles are concerning because they can directly interfere with student learning. At one time, the principal served predominantly as an administrator focused mostly on managerial duties. In recent years, however, the role of the principal has shifted to more of an instructional leader where the principal is deeply involved in setting learning goals, evaluating teachers, identifying and allocating instructional resources, and managing the curriculum that guides classroom learning [33]. Most international school principals seek a balance between their manager-administrator duties and their role as an instructional leader. As an instructional leader, the principal places the highest priority on instructional quality and works directly with teachers to bring to life a vision excellence in every classroom.

Effective principals who make student learning the nucleus of their work recognize the tremendous push for improving student math outcomes within their schools. Rapid changes in our global society require educators to reconsider how we design and deliver the most relevant learning experiences for students. Reports on international student assessments such the Organization for Economic Cooperation and Development's (OECD) Programme for International Student Assessment (PISA), allow the world to internationally compare educational achievement. This has placed a new focus on the quality of education across systems, cultures, and countries. The reports have spot-lighted educational quality for all who are watching to determine which countries are successful in this pursuit of learning excellence, and which ones are not. The range of differences revealed in these reports has made educational reform a high priority for almost every country in the world.

Proficiency and literacy in mathematics now extends beyond correct answers or a cursory understanding of mathematical concepts. Today's world demands the creative use of these ideas and the ability to communicate mathematical thoughts clearly to others. Rather than providing one right answer produced by a learned formula, a true demonstration of mathematics literacy requires the ability to provide several different pathways to a right answer or at times, several different possible answers. This requires command of traditional mathematics, a sophisticated use of the language of mathematics, and a deeper understanding of concepts. These necessary skills turn the mathematics learning process into something much different from the passive classrooms of the past where mathematics was procedurally driven and memorized for success.

6. Conclusions

It has been our privilege over the years to work with teachers and leaders to help influence change in how students engage with elementary mathematics. We have found the process of change to unpredictable and nonlinear. Despite the challenges, we insist that the time to change is now. The most successful and innovative curriculum leaders have applied the ideas shared in this chapter or some combination that is most suited to each school's unique culture and climate. Seldom is success achieved without attending to the overarching theme—instructional practice reform is more complex than an expressed desire to make changes in day-to-day teaching.

As illustrated here, the effort to transform mathematics classroom teaching is complex and multifaceted. Facilitating and sustaining such change is a team effort supported by an engaged community.

To achieve sustainable change in classroom practice, we further suggest that leaders maintain a keen awareness of the stages of change. Many professional development models that schools employ are not successful for various reasons including poor planning, not obtaining buy-in from stakeholders, or not following through with important steps to ensure that a lasting change takes hold. However, by implementing a PD model that is targeted and purposeful, such as the one described here, change initiatives can be successful. We recommend that a comprehensive plan must include: (a) teacher development through external support, (b) informational and experiential parent development, and (c) educating the whole math student. At the same time, leaders must be mindful of the stages of change and a reliable change model. Through this process, we have found that elementary teachers can realize they did not have to be "good math students" in their youth to become great math teachers today. Similarly, parents and administrators can learn actionable ways to support our children in becoming engaged and enthusiastic math learners for life.

Notes/thanks/other declarations

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Author details

Karim Medico Letwinsky[1]* and Michael Berry[2]

1 Wilkes University, Wilkes-Barre, Pennsylvania, United States

2 Bandung Independent School, Bandung, West Java, Indonesia

*Address all correspondence to: karim.letwinsky@wilkes.edu

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