STUDENTS' BELIEFS FOR FORMATIVE ASSESSMENT IN MATHEMATICS TEACHING AND LEARNING

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ABSTRACT

This paper is about the description of the purpose and actions of a European research program (FAMT&L) about the examination of formative assessment in the teaching and learning of mathematics. The focus is on presenting our first results about students' beliefs regarding the use of formative assessment in mathematics teaching and learning. Our first results reveal factors that appear to influence the construction of students' beliefs about the purpose and the role of formative assessment.

INTRODUCTION

The National Council of Teachers of Mathematics Assessment Standard (NCTM, 1995) define assessment as "the process of gathering evidence about a student's knowledge of, ability to use, and disposition towards mathematics and of making inferences from that evidence for a variety of purposes" (p.3). What is important, however, is that how we do this and why we do it varies tremendously (Dudley & Swaffield, 2008). Research shows that assessment must be formed for learning and not of learning, as "children have a role in assessment for this purpose since it is, after all, the children who do the learning" (Harlen, 2000, p.112). Thus, there is a need for reformation of traditional ways of assessment in education and teaching (Qassim, 2008). Our project aims at this reformation, focusing on the use of formative assessment, by providing teaching material for its effective implementation in teaching. Therefore, we try to carry out practice-based research from which schools will really benefit. Focusing at increasing the impact on educational practice, the design of this material will be based on the results of the examination of teachers' and students' beliefs, as the teachers' beliefs, as reflected in their practice, influence students' beliefs (Franke, Fennema, & Carpenter, 1997).

Furthermore, students' conceptions of assessment are very important because assessment has a significant impact on the quality of learning (Ramsden, 1997).

In fact, this contribution is about the description and discussion of the ongoing research program entitled *Formative assessment in mathematics for teaching and learning (FAMT&L)*[19]. The FAMT&L project proposes an innovative path that, starting from an investigation of the beliefs of the mathematics teachers (Michael – Chrysanthou, Gagatsis & Vannini, 2014) and students about formative assessment, will get to design a virtual environment (a web repository) for in-service teachers' training. This learning environment should provide a variety of tools and objects, including a guideline to be used in in-service secondary schools teachers training courses.

In this paper we mainly focus in the first part of the project, which consists of the study of the students' beliefs about the use and the role of formative assessment in the teaching and learning of mathematics. Our discussion will be based on the following research questions: (1) What are the students' beliefs for formative assessment in mathematics? (2) What are the factors influencing the students' beliefs for formative assessment in mathematics?

THEORETICAL FRAMEWORK

Definitions and Purpose of Formative Assessment

Researchers stress that assessment must be formed "for" learning and not "of" learning, as it is generally acknowledged that increased use of formative assessment (or assessment for learning) leads to higher quality learning (Wiliam, Lee, Harrison & Black, 2004). In accordance to this, Van De Walle, Karp and Bay-Williams (2013) define formative assessment as "an along the way evaluation that monitors who is learning and who is not and helps teachers to form the next lesson". A definition accepted by the Formative Assessment for Teachers and Students (FAST) group as the most accessible to educators is the one provided by Popham (2008, p.5), who characterize formative assessment as "a process used by teachers and students during instruction that provides feedback to adjust ongoing teaching and learning to improve students' achievement of intended instructional outcomes."

Techniques of formative assessment

Assessment practices and their outcomes on the students' learning, but also their affective domain has drawn the interest of different researchers in the last 30 years (i.e Crooks, 1988; Black & Wiliam, 1998).

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Cauley and McMillan (2010) provide particular techniques that should be used in teaching for the effective integration of formative assessment in instruction. Specifically, informal observations and oral questions posed to students while content is being taught or reviewed is a practice that allows ongoing formative assessment. Kyriakides and Campbell (1999) examined primary teachers' opinions about the appropriateness of particular techniques of assessment in mathematics. Performance test and structured observation were considered to be the most appropriate methods. On the other hand, unstructured observation and oral question-and-answer were seen to be the least appropriate techniques. Furthermore, Cauley and McMillan (2010) stress also the power of using the practice of providing clear learning targets to the students. They explain that formative assessment is more effective when students have a clear idea about their teachers' expectations of them, because providing clear expectations enables students to set realistic and attainable goals. Clark (2010) provides a richer list of sixteen formative assessment teaching techniques, suggesting that these techniques engage students in reflective thinking and problem solving. Among these sixteen techniques, higher order questioning techniques, feedback for students as comments and not grades, oral feedback to students, sharing assessment criteria with students, peer assessment and collaborative goal setting with and by students are included. It is obvious that the techniques suggested by Clark are also found in the previous suggestions that were discussed.

The effective use of formative assessment results

The use of feedback

Feedback is an important dimension of formative assessment, either as provided by teachers to students through questions peer-assessment practices. The power of feedback becomes evident in different definitions of formative assessment that highlight the importance of integrating feedback in instruction. According to such definitions, formative assessment refers to assessment that is specifically intended to provide feedback on performance for improving and accelerating learning (Sadler, 1998). Cauley and McMillan (2010) add to this by defining formative assessment as a process through which assessment elicited evidence of students' learning is gathered and instruction is modified in response to feedback. In the same sense, for Nicol and Macfarlane-Dick (2004) formative assessment, can generate feedback that can be used by students to enhance learning and achievement and by teachers for adjusting their teaching practices in order to correspond to their students' needs. However, Sadler (1998) raises an important issued regarding the use of feedback, turning the focus on the way the students can benefit from feedback. He actually claims that we cannot simply assume that when students are given feedback they will know what to do with it. Therefore, students should also be trained in how to interpret feedback, how to make connections between the feedback and the characteristics of the work they produce, and how they can improve their work in the future.

The formative use of mathematical errors

The use of students' errors is an important dimension of formative assessment, as it helps teachers modify their practices for helping their students correcting them, but also helps students in identifying their weaknesses and try overcoming them. Cauley and McMillan (2010) explain that by showing the students specific misunderstandings or errors that frequently occur in a content area or a skill set, and showing them how they can adjust their approach to the task, students can see what they need to do to maximize their performance. As a result, when feedback to students focuses on developing skills, understanding, and mastery, and treating mistakes as opportunities to learn, it is then particularly effective for their progress in learning and gives students hope and positive expectations for themselves. Therefore, the students' errors can have a formative use, as the teachers can exploit this information for modifying their future actions (Gagatsis & Kyriakides, 2000). Future decisions about the next learning steps follow from the formative identification of pupils' errors (Desforges, 1989). And this is particularly important, because a teaching plan which is organized in such a way, might help teachers to plan class and individual programs of work according to the different performance levels of the pupils (Gagatsis & Kyriakides, 2000).

METHODOLOGY

For the purpose of our study, a questionnaire for examining students' beliefs for formative assessment was developed. Based on our literature review, various authors' opinions and research results were transformed to statements to be included in our questionnaire. Previous relevant research instruments were also traced, parts of which were taken as examples for forming some of our statements. The questionnaire comprises of two parts. In the first part (Part A) the participants' demographics (gender, age-class and school) are asked. Part B includes 44 statements for which students had to express their agreement or disagreement on a 4-point Likert scale (1=strongly disagree, 4=strongly agree). In fact, these statements reflected not only beliefs about formative assessment, but also about particular assessment practices used by the teacher or/and the students. This structure allows not only tracing the students' beliefs for formative assessment, but also to examine the relations between particular practices and the formation of positive or negative beliefs. The 44 statements were grouped according to four dimensions of formative assessment, as defined based on the results of our literature review. In fact, in the first group there were 10 statements about the purpose (P) of formative assessment. The second group included 8 statements about the use of different formative assessment techniques (T). In the next group there are 6 statements regarding the use of the results (R) of formative assessment, emphasizing on the use of students' mathematical errors.

The last group includes 20 statements regarding the role of each stakeholder (S) in the formative assessment (students, teachers, parents). Representative examples of statements in each group are provided in the presentation of results.

The questionnaire was administered by all partner countries, after it was translated to the language of each country. However, the results presented in the next session are only about the data from the Cypriot students. The participants were 308 lower secondary school students, aged 12-15. The questionnaire was administered by their teachers for 30 minutes, during school time. For tracing the relations between the students' beliefs and the practices they or their teachers use, the implicative statistical analysis was performed using the software CHIC (Classification Hiérarchique, Implicative et Cohésitive) (Bodin, Coutourier, & Gras, 2000). The implicative statistical analysis (Gras, Régnier, Marinica & Guillet, 2013) aims at giving a statistical meaning to expressions like: *"if we observe variable A in a subject, then in general we observe variable B in the same subject".* Thus, the underlying principle of the implicative analysis is based on the quasi-implication: "*if A is true, then B is more or less true"*. An implicative diagram represents graphically the network of the quasi-implicative relations among the variables of the set V.

RESULTS

The implicative diagram (Figure 1) presents the implications between particular statements of the questionnaire, either expressing a belief or a practice. These relations provide indications about the way specific factors or practices influence the construction of students' beliefs about formative assessment. The relations between the variables in the diagram allow the identification of five distinguished implicative chains. Each chain is described separately. To shed more light in these results, the percentages of the students' answers in some of the statements are also provided.

Implicative chain 1

The first implicative chain starts with a statement relating to the involvement of parents in the assessment procedure. Actually, the statement refers to the teachers' practice of inviting the parents for discussing with them, either before (S10a: *My math teacher uses to call my parents to make a discussion before my assessment*) or after the students' assessment (S10b: *My math teacher uses to call my parents to make a discussion after my assessment*).

The parents' participation in such a discussion appears to motivate students for participating also in the assessment process, by defining a check list for assessing themselves (S19: *I usually create a personal check list in order to assess myself in math*) and by making comments on their own corrected work, for defining what they have succeeded (S3: *On my corrected work in math, I make comments that tell me what I have done well.*). Also, the involvement of parents through discussing with teachers, especially before the assessment (S10a), seems to influence the use of differentiated practices from the teacher after the students' assessment (T18: *After an assessment my teacher uses to give different mathematical activities at each student, in order to help us promote our good skills in math* / T19: *After an assessment my teacher differentiates the activities that he gives us according to our interests*). Therefore, we could say that the information that teachers collect from parents before they conduct an assessment can be used as a source for helping teachers differentiate their feed-forward practices according to their students' needs and characteristics. These relations end up with a statement, according to which the students discuss and get informed about their teachers' expectations before an assessment practices (S14: *I use to discuss with my teacher his/ her own expectations before an assessment in math*). We could thus claim that when students develop and use self –assessment they realize the importance of having a clear idea about their teachers' expectations. And this probably help students set new goal and define the direction of their future efforts.

Table 1

Percentages of students' answers to the statements of the 1st implicative chain

	No answer	Never	Rarely	Sometimes	Often
My math teacher uses to call my parents to make a discussion *before* my assessment.	5,5	50,3	21,1	14,6	8,4
My math teacher uses to call my parents to make a discussion *after* my assessment.	4,2	31,5	25	25,3	14
I usually create a personal check list in order to assess myself in math.	4,2	40,3	24	17,5	14
On my corrected work in math, I make comments that tell me what I have done well.	1,3	39,9	22,4	21,8	14,6
After an assessment my teacher uses to give different mathematical activities at each student, in order to help us promote our good skills in math.	3,2	46,4	22,1	20,8	7,5
After an assessment my teacher differentiates the activities that he gives us according to our interests.	3,6	45,8	25,6	17,2	7,8
I use to discuss with my teacher his/ her own expectations before an assessment in math.	2,9	26,3	31,8	23,7	15,3

The results of the students' answers (Table 1) provide more indications about the students' practices related to assessment. First of all, almost a third of the students appear to apply self-assessment techniques sometimes or often and this is encouraging. Also, the results show that teachers should also focus more on differentiation, as almost half of the students reply that their teaches never or rarely involve differentiation in their teaching. Almost half of the students reply also that their teachers never or rarely discuss with them their expectations, although it was found as an important practice in the implicative diagram. This is also the case for teachers discussing with parents before or after the assessment.

Implicative chain 2

What occurs from the second implicative chain is that having teachers discussing their criteria and expectations with their students before an assessment (S14: *I use to discuss with my teacher his/ her own expectations before an assessment in math*) and focussing on the formative use of errors (R5: *My math teacher wants to be with me while I am correcting my mistakes*) for planning their next lesson (R4: *My teacher uses our mistakes and interests to plan the next mathematics lesson*) and for helping students with their difficulties, are factors that can help teachers verify if their students have understood their mistakes (R3: *After an assessment in math, my teacher wants to verify if I have understood the mistakes that I have made*). This knowledge is important for helping the students who fail, as teachers have the chance to adjust their next lessons according to their students' needs (T15: *For improving students who fail in mathematics, the teacher explains again a mathematical topic*).

Complementary to these results, the percentages of the students' answers (Table 2) indicate that their teachers show interest for knowing whether their students understand their mistakes and thus try to explain again the lesson. However, almost two thirds of the students say that their teachers never or rarely use their mistakes or observe them during correcting their mistakes.

Table 2

Percentages of students' answers to the statements of the 2nd implicative chain

	No answer	**Never**	**Rarely**	**Sometimes**	**Often**
After an assessment in math, my teacher wants to verify if I have understood the mistakes that I have made.	3,2	15,6	24,4	32,8	24
My teacher uses our mistakes and interests to plan the next mathematics lesson.	2,9	32,8	28,6	24	11,7
My math teacher wants to be with me while I am correcting my mistakes.	3,6	35,7	30,5	21,1	9,1
For improving students who fail in mathematics, the teacher explains again a mathematical topic.	1,3	11	19,8	33,4	34,4

Implicative chain 3

At the left part of the implicative diagram most of the assessment techniques for which the students had to define their importance are related between them, creating a separate implicative chain. In this chain two groups of techniques can be distinguished. In fact, the techniques about assessment through tests are separated from other more open and less commonly used techniques (according to our experience from the Cypriot classes). Actually, at the top of the chain the group with the less commonly used assessment techniques is situated, such as individual interviews (T9), projects (T5), presentation of different works, reports etc. (T6) and mainly group works (T11), portfolio (T3), self-assessment (T8) and peer-assessment (T7). At the bottom of the implicative chain the second group of techniques is formed from the relations between the different types of tests, which are the tests with completion tasks (T1a), tests with multiple choice tasks (T1b), tests with true – false tasks (T1c) and tests with matching tasks (T1d).

The discrimination of the aforementioned assessment techniques into two groups indicate that the students are in position and do distinguish the different assessment techniques used by their teachers, attributing a differentiated significance for each of them. This is also evident from the results in table 3, which reveal that participation in class (T4) is the most important way for assessing them in mathematics. The importance of this way of assessment occurs also for the implicative diagram, in which all the relations of the first group of techniques end at. Furthermore, the fact that using tests are at the lower part of the chain shows that the tests are more important for the students, which is also indicated by the percentages in table 3. This can be attributed to the students' assessment experiences at school, as it is well known that test is a basic and very commonly used way for students' assessment in Cyprus. On the other hand, the group of less commonly used techniques is situated at the upper parts of the chain, indicating that these techniques are slightly less important for the students (as shown also in table 3). However, the placement of these techniques at this position reveals their influence of the students' beliefs about the use of tests.

According to the students' answers (Table 3), as mentioned test is the most important assessment technique for the students. The next most important technique is the participation in class. Homework is also among the techniques students consider as important. Portfolio and individual interviews are the less important for the students. Furthermore, near half of the students find important self-assessment and peer-assessment.

Table 3

Percentages of students' answers to the statements of the 3rd implicative chain

How important do you think are the following methods of assessment in math?	**No answer**	**1**	**2**	**3**	**4**
Test with Completion tasks	5,5	14,3	29,5	29,9	20,8
Test with Multiple choice tasks	4,2	13,6	24,7	30,5	26,9
Test with True – False tasks	3,9	8,4	25,6	27,6	34,4
Test with Matching tasks	7,1	14	28,6	27,3	23,1
Participation in class	1,3	8,8	12,3	33,8	43,8
Portfolio	10,1	28,9	29,5	17,2	14,3
Homework	3,9	8,4	20,8	38	28,9
Project	5,8	36,4	23,4	19,8	14,6
Presentation of works, reports etc	6,2	27,3	28,6	23,7	14,3
Peer-Feedback	7,5	18,5	26,9	30,5	16,6
Self- assessment	8,4	18,8	29,2	28,2	15,3
Individual interviews	8,4	40,9	24	14,9	11,7
Group activities	10,7	18,2	24,4	26,9	19,8

Note: 4 represents the highest degree of importance

Implicative chain 4

Related to the statement about the importance of self-assessment (T8), a new implicative chain begins from the statement about the benefits of continuous feedback (P5: *When feedback is continuous I feel I have a foundation that helps me to understand what I am learning in math*). The relations in this implicative chain indicate that continuous feedback (P5) and the students' knowledge about their teachers' expectations (S16: *When it is clear to me what and how to learn in a mathematics class, I become a more motivated and engaged learner*) enhances their intrinsic motivation and fosters their understanding in maths. Continuous feedback (P5) is also linked to a positive belief about the purpose of assessment (P1: *Assessment helps me identifying my good skills in math*), which relates to the identification of the students' strong points.

These statements are also related with statements indicating that continuous feedback increases students' self-confidence (P7: *I feel more confidence about myself when I have more frequent feedback about my progress in a mathematic subject*) and increase motivation and effort (P9: *When I am not satisfied about the grades that I have received for my working in math, I have to try harder*).

Implicative chain 5

The last implicative chain includes a group of statements indicating the students' positive perspective towards understanding and not grading (S18: *It's more important for me to understand the mathematical knowledge I am taught than to get high grade***)**. These beliefs are related to considering assessment as a mean for detecting the students' strong points (P1: *Assessment helps me identifying my good skills in math* / T2: *importance of participation in class*). This information seems to help the students set new goals (P8: *Assessment information motivates me to set new goals in learning math*). Students appear also to be positive about the use of errors, thus they are in favour of exploiting their mistakes in a formative way (R1: *Correcting my mistakes helps me to understand better a mathematical concept*). Also, having comments from their parents (S11: *My parents make comments about my corrected tests or works in math, even if I get low or high grades*) and knowing the criteria of their assessment (S15: *I prefer to know the criteria that my teacher uses for my assessment in math*) helps the students realize that they have to increase their effort (P9: *When I am not satisfied about the grades that I have received for my working in math, I have to try harder*).

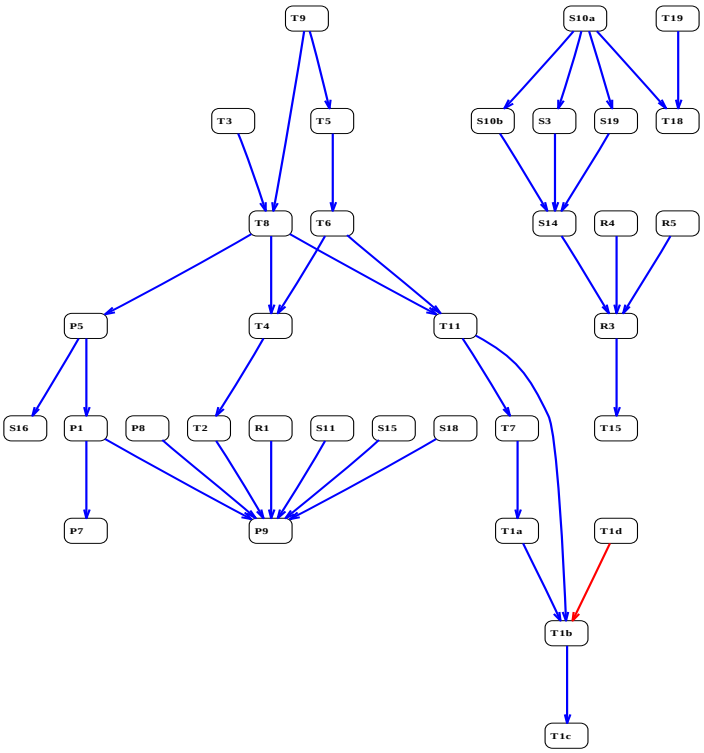

Figure 1. Implicative diagram

CONCLUSIONS – DISCUSSION

According to the implicative relations formed between the different statements of the questionnaire, several indications occur about factors that can have an important role in implementing formative assessment in the teaching and learning of mathematics. First of all, giving parents the chance to participate in their children assessment can have positive effects both on teachers and students. Actually, involving parents in assessment can benefit the students in developing self-assessment practices, but also the teachers in adopting feed-forward actions based on differentiation. Students appear to become more engaged assessors when they have their parents' comments, when they set their own assessment criteria and when they discuss about their teachers' expectations. These factors seem to help the students defining themselves as learners in a more complete way, by providing them the information for creating a more accurate self-image.

Continuous feedback has also a positive impact on the students' cognitive and affective domain, as it relates to the creation of positive beliefs about the purpose of assessment. Feedback provides students information about what they are expected to learn and how, and this knowledge seems to create them security and stability and thus to increased intrinsic motivation. This is in accordance to Nicol and Macfarlane-Dick (2004), who suggest that good feedback practice facilitates the development of self-assessment (reflection) in learning, encourages teacher and peer dialogue around learning, helps clarify what good performance is (goals, criteria, expected standards), provides opportunities to close the gap between current and desired performance, delivers high quality information to students about their learning, encourages positive motivational beliefs and self-esteem and provides information to teachers that can be used to help shape the teaching.

In relation to the above, self-assessment can also be considered as a source for feedback for students. Thus, if students develop their self-assessment abilities they will be able to provide themselves continuous feedback and benefit at a cognitive and an affective level. However, besides the focus on the positive effects of providing feedback to students, researchers emphasize also on gaining feedback from students about their learning and understanding. Actually, Hattie (2009) adds that a powerful influence of formative assessment on achievement is the meaningful feedback from students as to what they know and where they make errors or have misconceptions. Therefore, it is important to turn our attention towards gaining feedback form students and only providing them feedback.

Students express positive beliefs about assessment. They recognize the contribution of assessment in detecting their good skills and enhancing the effective use of their errors and their parents' comments for increasing their learning. As a result, students set new goals and try harder for succeeding them, especially when they are aware of the criteria by which they will be assessed. This is in line with Cauley and McMillan (2010) that explain that by showing the students specific misunderstandings or errors that frequently occur in a content area or a skill set, and showing them how they can adjust their approach to the task, students can see what they need to do to maximize their performance. Furthermore, according to the students' beliefs, teachers use the results of assessment for defining the degree at which their expectations are satisfied and according to the distance between expectations and results they take decisions about ways to help students overcome their difficulties.

The students' beliefs differentiate among the different assessment techniques. Their beliefs about the less commonly used but more open types of assessment may define their beliefs about the usual ways of assessment. We shall thus focus on the use of less "traditional" assessment techniques, and try to limit the use of tests, as it is extremely difficult to gain access to the students' solving procedure and strategies through asking them just to complete a task or just to choose an answer.

Therefore, more attention must be given on assessing students through ways that allow an interaction between teachers and students and provide more chances for understanding the students' cognitive processes, their knowledge, misconceptions and strategies. Such knowledge is powerful because students have a good understanding of what they are doing and why the teacher provides them feedback and these help them understand what they are learning, to set goals, and to self-assess (Cauley & McMillan, 2010).

In summarizing our conclusions, the following table (Table 6) includes factors that appear to be important for the effective implementation of formative assessment. The table indicates the way the students and can use these factors for improving themselves as learners or how they are benefited and how their teachers should use these factors when implementing formative assessment.

Table 6

Important factors for implementing formative assessment

STUDENTS	**TEACHERS**
Exploitation of parents' comments	
Use as a feedback source	• For organizing feed-forward actions • Differentiation
Expectations / assessment criteria	
Getting aware of teachers' expectations / criteria for • defining their own criteria • defining better self-image	• Make their expectations explicit • Discuss the assessment criteria they set with students
Self-assessment	
Self-assessment as feedback source	Develope students' self-assessment skills
Formative use of errors	
Increase understanding of mathematical concepts.	For adjusting next lessons based on students' needs
Techniques of assessment	
Focus on participation in class	Use of assessment techniques allowing active interaction with students.

These factors seem to influence the teachers' practices and the students' cognitive and affective domain. Therefore, practices appearing to influence positively the students' beliefs for formative assessment should be enhanced and will be used for designing the teachers' training model for implementing effectively formative assessment practices. Thereafter, gaining access to the students, but also the teachers' beliefs will give us the opportunity to design relevant teaching material, based on their needs, in order to have the chance to achieve a change in classroom practices towards the effective implementation of formative assessment. And this is important, as teachers have a remarkable influence on students' construction of their beliefs through the ways in which they present the subject matter, the kinds of task they set, assessment methods, procedures and criteria (Pehkonen, 1998). Thus, the development of our training model and web-repository will enhance the teachers' professional development.

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