The potential of a task for professional development across national contexts -

M. Doorman, J. Garcia, D. Potari, G. Zsombori, S. András

Utrecht University, Netherlands; University of Jaén, Spain; University of Athens, Greece; Sapientia Hungarian University of Transilvania, Romania; Babeş-Bolyai University, Romania

1 Introduction

One of the challenges for professional development is to connect the learning of new teaching strategies or pedagogies with teachers' practices within the classroom. Teachers should feel the need and have the resources to adopt new ideas and to implement them in their daily practice. Classroom materials, like tasks for students, can play a crucial role in this implementation process. Tasks have the potential to reflect innovative aims, like inquiry-based learning (IBL) or using workplace contexts, and to inspire and support teachers in implementing these aims. However, whether a teacher recognizes and exploits this potential of a task and how she/he transforms it into her/his teaching is a complex process and highly depends on the adaptability of the task to his or her practice (Remillard, 2005). This seems especially the case when a task is developed for use across various European countries. We will present one task that is used for investigating the possibilities for implementing IBL in workplace contexts (the aim of the Mascil project) in four countries, Greece, Spain, the Netherlands and Romania. In Greece the adaptation and use of this task in the classroom took place in a master's course in Mathematics Education with prospective teachers. In Spain a group of researchers and one teacher worked together for optimizing and implementing the task. In the Netherlands an experienced teacher implemented the task to experiment with inquiry based-learning in connection with the world of work. In Romania the task was first introduced at a professional development course, where teachers had to solve the problem and then discuss the solutions and possible teaching strategies. Next, these teachers took the task and implemented it on levels varying from primary school to a master's course in Mathematics Education. We sketch these national contexts and provide rich descriptions of the cycle of designing, implementing and reflecting on the task and its use in actual lessons. With these experiences we reflect on possibilities and limitations of using one task across countries for in-service and pre-service professional development on a European level.

2 Mascil-tasks for IBL in workplace contexts

The aim of the Mascil project is to support science and mathematics teachers in extending their teaching repertoire towards inquiry-based learning (IBL) in workplace contexts. Both IBL and the connection to the world of work will make mathematics and science more meaningful and relevant to students. In a classroom where inquiry-based learning occurs, students take an active role, pose questions, explore situations, find their path to solutions and communicate their reflection. IBL approaches aim to promote students' curiosity, engagement and learning in-depth (Maas & Artigue, 2013). In order to implement inquiry-based teaching and to connect mathematics and science education to the world of work, classroom materials and resources for professional development are designed. To achieve these aims Mascil collected and published examples of classroom materials, i.e. tasks for students and example lesson plans, for inquiry in rich vocational contexts in close collaboration with all Mascil partners (see: www.mascil-project.eu). In order to support IBL and connect to workplace contexts, these tasks have specific characteristics. Traditional textbook tasks that are cast in a context, often explicitly state the problem that needs to be solved and give exactly the information needed to solve it (e.g. Figure 1). The goal of such a task is to give students the opportunity to apply a specific formula or calculation.

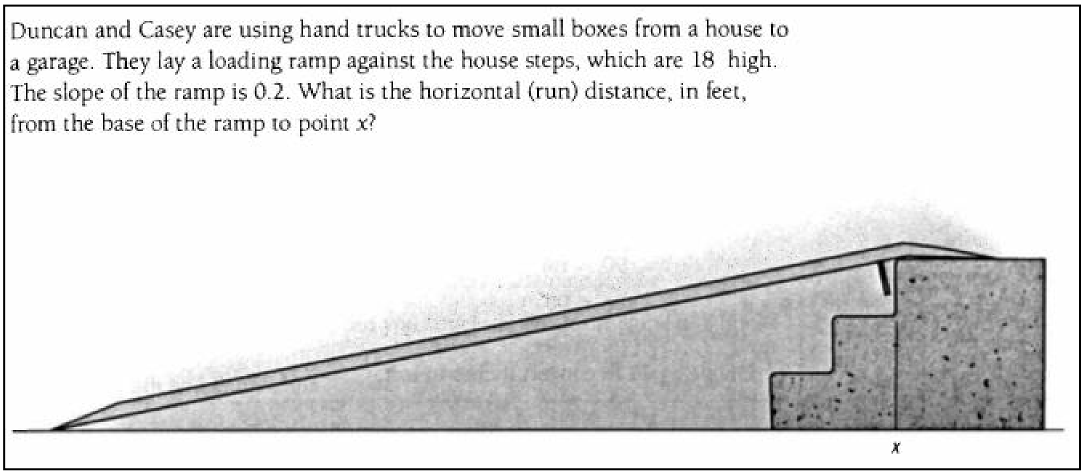

Figure 1: An example of a traditional textbook task

On the contrary, tasks that can be used for an IBL-lesson are open, do not provide a solution plan for the students, and have the potential to evoke a variety of solution strategies. However, the level of IBL supported by the task can vary. A task can include the main question to be solved and provide all information needed, but a task can also only sketch a situation that naturally incorporates one or more problems, without providing all information needed to solve one of these problems. The level of inquiry depends on the lesson created by the teacher with the task and the provided lesson plan that includes a possible pathway for scaffolding the inquiry process of the students. Consequently, learning to inquire in mathematics implies being able to deal with missing or superfluous data, being mathematical creative, and being able to use mathematics in non-routine situations.

Moreover, tasks that connect to world of work (WoW) use workplace contexts that provide a clear purpose and a need to know. The activities students do in the task are related to authentic practices from the WoW. If students’ activities are very similar to typical problems in textbooks for mathematics and science, the connection between activities and WoW is weak. Ideally, within the task students are placed in a professional role fitting the context of the task. The outcome of the task is a product made by the students in their role as professionals, meant for an appropriate audience. The product is similar to real products from the WoW. These task-characteristics are supposed to give students a sense of purpose and utility, and involve them in a ‘real’ research and design process.

Tasks can be an important resource for professional development. Mascil-tasks are framed by the above mentioned characteristics related to IBL and WoW. The use of the tasks in daily practice asks for specific teaching pedagogies. For instance, when a task provides less structure for students to solve it, the teacher needs to be able to scaffold their solution process in cases they get lost. Moreover, when a task is closely related to a workplace context, the teacher must be able to introduce the context for the students in such a way that role and product are taken seriously. By experimenting with a Mascil-task (prospective) teachers can experiment with new pedagogies related to IBL in workplace contexts.

We argue that these example tasks are crucial in supporting teachers involved in innovative processes, like the one supported by Mascil. However, we assume that the potential of a task depends, on the one hand, on its adaptability and, on the other hand, also on teacher’s ability to make it fit to his/her needs and context. In this paper we want to explore both aspects in the case of a specific task used in four different countries and in four different professional development contexts. Further on, also to reflect on a wider question: *Is a Mascil approach, based upon the use of innovative classroom resources for supporting teacher professional development, possible across various European countries?*

3 An example task: Designing a parking lot

The design of a building is a complex task involving many variables. Architects have to think about the structure, the distribution of the space (staircase, corridors, rooms, entrance hall), orientation of the building, etcetera. Often, decisions taken in prior steps affect what it is possible to do in the next ones. This task is supposed to give students the role of an architect in the design of a parking lot in the basement of a building. The structure of the building and the distribution of the pillars have already been decided and cannot be changed (see Figure 1). In order to build a parking-lot in the basement, students will work on a good distribution of the parking spaces and the entrance ramp.

Working as an architect: parking in the basement

In designing a block of apartments the architect has to work out how to distribute parking places in the design of the basement car-park.

The diagram shows a plan drawn to scale of the area available. All measurements are in metres.

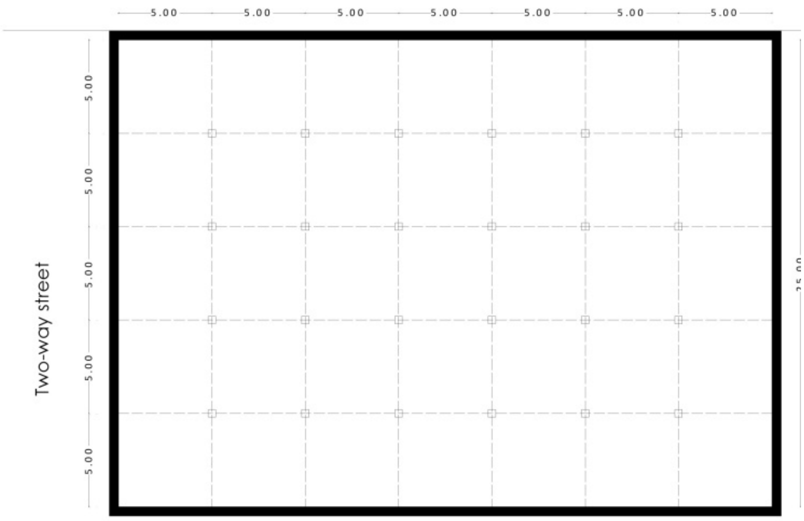

Figure 1: Worksheet for the Parking lot task

The worksheet for the task shows a plan of the area available. All measurements are in metres. The task has been designed by an architect, mirroring her work in the professional context. Constraints for the design have also been taken from existing regulations. Some constraints are that there need to be parking places for disabled people, parking places for motorbikes, a stairwell and a ramp by which cars enter and exit with a maximum gradient of 25%. The task leaves a lot of decisions that need to be made by the students (e.g. the size of a parking place for a car), is clearly situated in the context of the world of an architect and positions students in the role of an architect. The kind of activity they will be involved in mirrors the activity of an architect (e.g. creative design under constraints and working with scale models). And finally, the task does not ask for the one and only solution, but for a product that needs to be delivered by the students. Deciding about what makes a solution better than others is an intrinsic dimension of the task.

4 The task in Spain, Greece, the Netherlands and Romania

In Spain, a group formed by researchers and one teacher worked together in the implementation of the task. The initial aim was the piloting and optimization of the task. Previous to the implementation, a meeting took place. This helped the team to understand students' background and to organise the use of the task accordingly.

The task was used with twenty-five grade 9 students. Initially, three 50 minutes sessions were planed: session 1, guided by a researcher with the aim of introducing the task and initiate students' exploration of the situation; session 2, guided by the teacher, in which students should work in groups, designing their parking lot; session 3, altogether, where students will present their work, and argue about their designs. Finally, an extra session was needed in between. Students were used to work collaboratively, but not with an open-ended task like this. Groups were organised in advance and students were very engaged in the task from the very beginning. According to the description of the task, students' work was mainly focused in two issues: (1) spatial reasoning, optimising the distribution of the parking places and other parts of the parking; (2) geometry, calculating the dimension of the ramp so that the gradient is less than 25%.

We noticed that students had difficulties to interpret ramp's gradient in terms of percentages. They had some previous knowledge about gradients, but interpreted as the tangent of the angle. This made that most of the groups were stuck. Instead of a problem, this was perceived by the teacher as an opportunity to (re)visit the mathematics of trigonometry and triangles (see Figure 2).

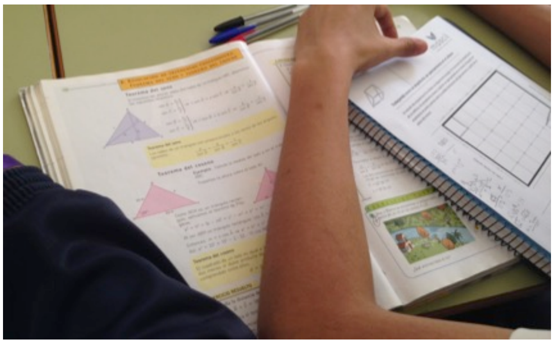

Figure 2: Students connecting the task with their trigonometry chapter

After the intervention of the teacher, most of the groups could translate the ramp's problem into a math problem, solve it, and interpret the solution in terms of the real situation, although the diagram of the parking conditioned their solutions. However, it was not clear if students made a deep understanding of the concept. Indeed, we observed that most of the groups draw the ramp they wanted first, calculating the gradient afterwards. Consequently, in most of the cases the percentage was higher than the 25% limit. Later reflections within the team lead us to identify the existence of a curricular gap. Indeed, in the Secondary Education, gradients are normally studied within the topic of linear functions, and associated with their algebraic expression. In geometry, when trigonometry is studied, the notion of the tangent of an angle is weekly connected with the notion of gradient. Therefore, students find it difficult to interrelate notions that are embedded in different mathematical domains and related to different kinds of mathematical activity. We interpret this as the manifestation of a didactical phenomenon, that we called elsewhere *the phenomenon of the disconnection and atomization of school mathematics* (García, Bosch, Gascón & Ruiz-Higueras, 2006).

Finally, all the groups could translate the ramp's problem into a math problem, solve it, and interpret the solution in terms of the real situation, although the diagram of the parking conditioned their solutions. At the end, students were asked about their experience with the task. According to their feedback, they really enjoyed the task. They liked both the open-ended nature of the task, and doing mathematics like professionals do outside school.

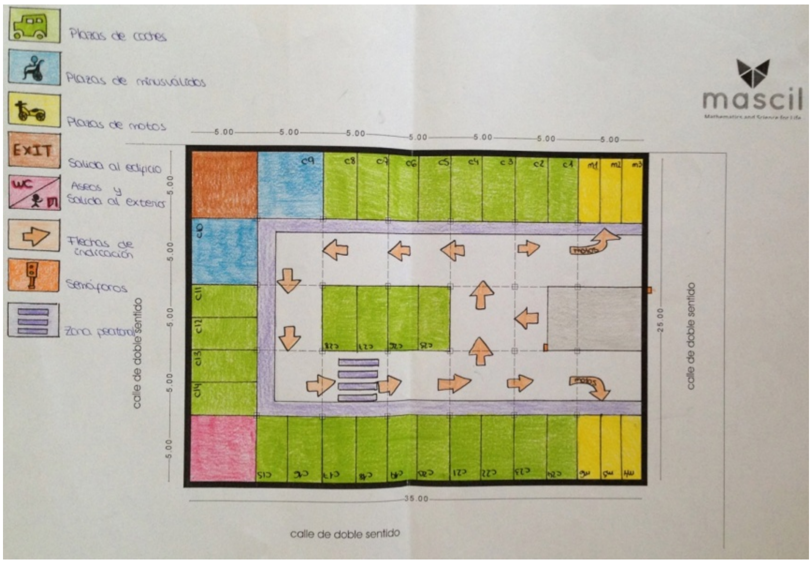

Figure 3: A result from Spanish students

In Greece, the task was adapted and used in the context of a master's course aiming to link research and theory in mathematics education to the practice of mathematics teaching. A group of three prospective teachers chose the parking problem task to investigate how this would work in an 8th grade mathematics classroom. Initially, they read about IBL in learning and teaching mathematics and they linked the characteristics of IBL with the task. Then, they posed their own goals and questions to explore, provided a plan of a building to familiarize the pupils with the work of an architect and materials to use. The students worked in small groups and by adopting the role of an architect they constructed their own plans and argued about their appropriateness. The prospective teachers identified students' solution strategies, their arguments and realized pupils' difficulties with the mathematisation process and the understanding of the underlying concepts. They also reflected on their own teaching and realized on one hand the potential of the tasks in promoting students' motivation and mathematical meaning but on the other hand the difficulties to manage these tasks in the classroom. The following extracts from the journals of three prospective teachers illustrate their realisation of the role of these tasks in learning and teaching mathematics: “The students were really involved in the tasks and they were keen to express their opinions and to argue for them … We could have managed better the time allowing students to provide more arguments for supporting their claims”; “I was surprised that students who were not considered as good students by the classroom teacher were really engaged in the task.”; “The students seemed to link the problem with the reality. They were checking whether their calculations provided realistic results. In one case they discovered an error in calculating the covering area, as their result was larger from the parking area. Visualization seemed also very important in the tackling the task.”

In the Netherlands, the task was used by an experienced mathematics teacher in two 8th grade classes. Her experiment with the task was part of a pilot for the Mascil project. This pilot was intended to create opportunities to explore whether and how a Dutch teacher can adapt such a task to her teaching practice. Moreover, we used the pilot to investigate what task characteristics and what pedagogies support the inquiry process of the students and how the teacher and her students experience the task characteristics related to the world of work. Initially, the teacher was a bit sceptical about the possibility of using the task as it is rather open and students need to deal with quite some missing information. After discussing the lesson plan that scaffolds the students’ activities (see Figure 4), she was willing to try out the task. She adapted the lesson plan to her time frame (one lesson of 70 minutes) and added a Dutch video of architects presenting their design for a parking lot.

She started the lesson with introducing the task, watching the video and a short discussion about the task situation. She asked what further information the students would need to start designing. Some students, for instance, asked for the size of an average car. She rephrased the question and asked how you could solve such a question. Students suggested to go outside and measure cars or to browse the internet. Both possibilities were rewarded and after dealing with all the questions the students started working on the task. Also in her case, they worked in small groups, adopted the role of an architect seriously and designed their own plans for a parking lot. Afterwards, the teacher was amazed by the enthusiasm of her students and of their work. In a quite natural way they worked with scale and ratio and created beautiful models with accompanying information to ‘sell’ their design (this was organized at the beginning of the following lesson). In retrospection, we reflected on the importance of discussing the lesson plan in advance, the openness of the task that stimulated the students’ inquiry and creativity, and the motivational role of the explicit workplace characteristics offered by the task.

5 minutes	**Create groups of 4 and introduce the problem**
10 minutes	**Students work in groups and identify what further information is needed**
5 minutes	**whole class discussion to share questions and sources or strategies for answers,** **to distribute responsibilities and to give feedback on the final product**
25 minutes	**Students continue and finalize their designs and underpinning**
10 minutes	**Presentations of (some of the) groups**
5 minutes	**Reflection**

Figure 4: The lesson plan of the Dutch teacher

In Romania, the Mascil team was convinced that an IBL task – especially when connected to the world of work – has the most success in being implemented if it is solved first by the teachers themselves. This is why the task was introduced at a professional development course, where 23 teachers had to solve the problem and then discuss about the different solutions. Teachers worked in small groups and were left to work entirely by themselves within a time limit. Due to the openness of the problem and all missing data, teachers spent almost an hour documenting and calculating. When time was up and a tentative solution was presented by each group, every group got five minutes to optimize their solution. The presentation of different solutions was followed by a brief discussion and all teachers were convinced that this task should be implemented in classroom practice. The task was used by primary school students (grade 3), secondary school students (grade 8), mathematics education master's course students, and by a high school class (grade 10). On different levels the quality of solutions was almost the same while the main focus of the discussions, the main difficulties and the possible lessons learned were quite different. Since the task was initially proposed for secondary school and high school students, implementing it in primary school was a great challenge.

It was clear from the beginning that young children can learn a lot from this task by simply trying to understand the problems and going through a solution process. However, it was a real challenge to guide them through this process and to emphasize links to mathematics without controlling too many aspects. Special preparations were needed: the parking lot plans were considerably enlarged, paper cars were printed out, already made stairwells (see Figure 5) were used and also some tools (like measuring-tapes) were brought in. More than half an hour was spent on having the students understand the task and all its details. For example, when the printed plan was shown, they thought they had to design a multilevel parking house. The cards (cars, stairwell) were only given to a group once the children in the group understood the task at hand. This was absolutely necessary in order to ensure the necessary contextual knowledge. Once they started though, the groups came up with a solution very quickly. After some optimizations and corrections done with the help of the attending teachers, these solutions were on par with the solutions given by teachers at the PD course.

Figure 5: Third grade student working with pre-printed paper cars and stairwell (the red square) and master students voting the best designs and identifying criteria for evaluation

Working with the same task on several levels offered a unique perspective about the undergoing processes, the typical reactions that came up in the activities. A striking difference was in the time management and in the use of tools. While teachers understood the task quite quickly, they spent a lot of time on gathering the missing information and in creating their first design, the younger students spent more time on understanding the task and only a small amount of time with the first design. The process of optimization needed teacher intervention (in most cases just a few well-chosen questions for each group) and a longer time period with the young students, while the group of teachers wanted to design an optimal plan from the very beginning. Young students got artefacts (printed cars, stairwell, ramp) from the teacher and they relied on these during the design process while older students and teachers had the opportunity to make their own artefacts (with paper, scissors, etc.) and they knew that they have to construct a model for their presentation, but first they made a paper-pencil design. It was also interesting to discuss with the master students and the teachers how to evaluate the activity, the work of the groups, the work of individual students and the differences with evaluating usual textbook exercises.

A central question for the Romanian team was: on what level could this task be implemented? Especially in Romania, with a strongly content focused curricula and a tight time frame for teaching mathematics? During the activities it became clear that the task can be used on all levels. In primary school, to help understand the concept of areas, scaling, multiple solutions, optimizations; in secondary school as application of trigonometry to real-world problems like the length of the ramp, the maximum slope of the ramp or in high school as an optimization problem. However, the success of the implementation highly depends on the teacher.

5 The potential of tasks for professional development across countries

One task was used by teachers from four different countries. In each country the task was not used in an average classroom but under specific and different constraints. In Spain, researchers and a teacher worked together to try-out and optimize the parking task.

In Greece, the task was used in a rather exploratory way and the focus of prospective teachers was to investigate pupils' thinking and solution strategies while being engaged in the task. In the Netherlands, the task was used by an experienced teacher to investigate its potential for inquiry-based learning and connections with workplace practices in the Dutch context while in Romania the task was used with several age groups in order to fit the task within the existing curricula and to experiment typical reactions/difficulties in connection with the task and more generally in connection with IBL and WoW oriented tasks.

In all four countries the teachers acknowledged the enthusiasm of their students taking the role of an architect, the activities that reflected the work of an architect and the creativity in and ownership of their products. The task also created opportunities to apply and deepen mathematics, to deal with missing information, to solve an open problem, and they experienced ways to communicate about their results. The teachers in each country recognized the potential of the task, the value of task-characteristics like the openness, the 'taking a role', creating a product collaboratively, the use of workplace artefacts, and an introducing workplace video (see Figure 6). They highly appreciated this way of working.

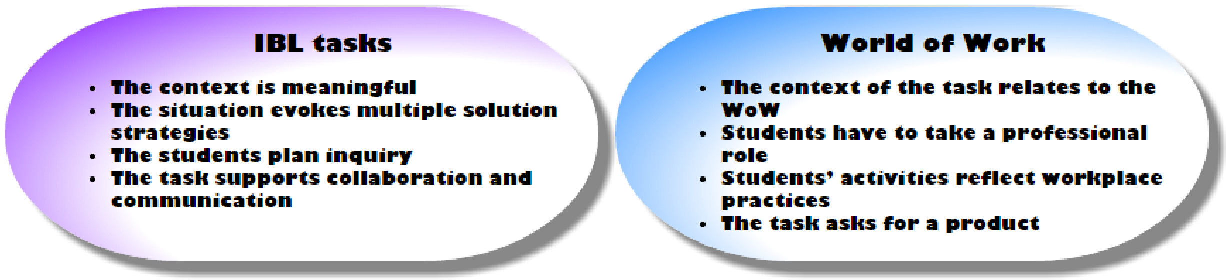

Figure 6: Task characteristics in the Mascil-framework (Doorman & Jonker, 2014)

The task appeared to be a potential resource for these teachers to get experience with and reflect on IBL in workplace contexts. The teaching experiments created opportunities to reflect on scaffolding students' inquiry with an initial exploration of the situation and a whole class discussion of emerging issues before starting group work. However, switching between a creative process and the discussion of mathematical issues that arise during that process asks for a careful planning of the lesson.

The experiences with this task in these four countries are promising for using the task in professional development of (prospective) teachers. Further experiments might provide us with the role of the different educational realities in the development of mathematics teaching and teacher education in integrating such tasks confirming that they are powerful resources for teacher education in each of these countries, and consequently, for scaling up professional development in Europe.

Acknowledgements

The research leading to these results/MASCIL has received funding from the European Union Seventh Framework Programme (FP7/2013–2016) under Grant Agreement No. 320693. This paper reflects only the author's views and the European Union is not liable for any use that may be made of the information contained herein.

References

Abreu, G., 2000, "Relationships between macro and micro social-cultural contexts: Implications for the study of interactions in the mathematics classroom". Educational Studies in Mathematics, Vol. 41, pp. 1-29.

Ainley, J., 2011, "Developing purposeful mathematical thinking: A curious tale of apple trees". In B. Ubuz (Ed.), Proceedings of the 35th Conference of the International Group of the Psychology of Mathematics Education (PME), Vol. 1, pp. 1-16, Ankara: Turkey.

Doorman, M., Jonker, V., 2014, Final versions of the initial package of classroom materials and guidelines. Deliverable N° D.3.1 of the Mascil project.

(Retrieved at January 9th, 2015 from http://www.mascil-project.eu/images/pdf/deliverablemascilw3D31FinalVersion.pdf)

García, F.J., Bosch, M., Gascón, J. and Ruiz-Higueras, L., 2006, “Mathematical modelling as a tool for the connection of school mathematics”. ZDM-The International Journal on Mathematics Education, Vol. 38(3), 226-246.

Maas, K. and Artigue, M., 2013, “Implementation of inquiry-based learning in day to day teaching: a synthesis”. ZDM The International Journal on Mathematics Education. Vol. 45, pp. 779-795.

Remillard, J. T., 2005, “Examining key concepts in research on teachers’ use of mathematics curricula”. Review of Educational Research, Vol. 75, pp. 211-246.

Smith, M. S., & Stein, M. K., 2011, “Five practices for orchestrating productive mathematical discussions”. Reston VA: National Council of Teacher of Mathematics.