POSTERS: A TOOL TO FOSTER VISUAL AND COMMUNICATION SKILLS THROUGH MATHEMATICAL CHALLENGING TASKS USING A GALLERY WALK

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Abstract

The society is evolving posing continuous challenges that demand the development of a specific set of skills and knowledge of its citizens. These core competencies involve problem solving, creativity, communication, critical thinking, collaboration, that must be incorporated in the teachers' practice and developed by students. So, teachers must orchestrate productive discussions around the solution of tasks that allow multiple solutions (including visual ones). Students don't all have the same types of thinking, some are more analytical, others prefer visual approaches. This implies the use of strategies that meet the different types of thinking displayed by the students, confronting them with tasks that challenge them to see outside of the box. We introduced posters to foster students' learning as a tool that enable visualization and stimulate communication, through a Gallery Walk (GW), as an active learning instructional strategy. The GW allows students to solve a task, collaboratively, given them the opportunity to present, discuss and assess solutions in a poster placed around the classroom, in a similar perspective to that used by artists when they expose their works in a gallery. In this paper we share an ongoing study carried out with future elementary teachers (6-12 years old) where a GW was implemented that aims to characterize the strategies used by the students (future teachers) when solving tasks with multiple solutions, in particular to identify the visual solutions, and to characterize the reaction during their engagement in this GW strategy. An exploratory qualitative approach was adopted, collecting data through written productions (solutions, posters, comments to the posters), observations and a written report. The results showed that students enjoyed this experience, allowed to identify that students privileged visuals solutions of the tasks, and posters are a potential tool for assessment, through peer feedback, and allowed to verify the potentialities of the GW for a more effective teaching and learning of mathematics.

Keywords: Posters, gallery walk, visualization, multiple-solution tasks, pre-service teacher education.

1 INTRODUCTION

Nowadays we are experiencing deep changes in different areas of society, including education, and in particular in mathematics. So, school mathematics requires an effective teaching approach that implies adequate instructional strategies, where the orchestration of productive discussions take place, around different tasks, giving learners opportunities to communicate, reason, be creative, think critically, solve problems, make decisions and understand mathematical ideas (e.g. [1], [2]). In this perspective many educational organizations, e.g. [3], recommend that school must prepare students in the 21st century to be proficient in four skills known as the '4 Cs': critical thinking (including problem solving), to make informed decisions or judgements, to achieve the best solution; communication, to understand and share ideas, thoughts and solutions with others; collaboration, to work together to make decisions in favor of a common goal; creativity, to provide opportunities for express new and efficient approaches. In this context, the Gallery Walk (GW) [4] emerges as an active instructional strategy to contemplate in classroom practices which allows students, through collaborative work, to solve diverse mathematical tasks in a creative way, present and discuss their solutions in posters, with their peers, in a setting very similar to when we visit a gallery of art. This strategy perspectives learning in an active way and emerges from the experiences and interactions of the learners among their intellectual, social and physical dimensions [5], [6]. It is also important to highlight the importance of the posters, during a GW, which are tools that enable visualization to foster students' learning as a key component of cognition. This all makes sense through the nature of tasks and the quality of communication established in the classroom by the teacher. Stressing that we can communicate in different ways we highlight visual contexts as a strong support for the understanding and explanation of concepts and ideas. Thus, teachers should pursue practices that lead students to use different visual forms of representation to communicate and to reason mathematically and develop this ability through experiences that require such way of thinking [7].

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In this context, it is essential to develop practices which are sustainable and produce the desired learning outcomes for preservice teachers. This paper reports a study carried out with future elementary teachers (6-12 years old) where a GW was implemented that aims to characterize the strategies used by the students (future teachers) when solving tasks with multiple solutions, in particular to identify the visual solutions, and to characterize the reaction during their engagement in this GW strategy.

2 THE CLASSROOM, THE TEACHER AND THE TASKS

The mathematical activity developed during the teaching and learning process depends greatly on the knowledge of the teacher, the tasks he/she proposes to his/her students and the strategies used for promoting an effective teaching [2], [8]. In this way, teacher training should provide future teachers with different mathematical experiences, so that they can acquire a sounder knowledge to develop their mathematical ideas, reasoning and resolution strategies, in the exploration of mathematical tasks, which will provide them with knowledge and skills for an effective teaching with their own students.

2.1 An active learning approach

The traditional classroom, focused in teaching, where it is used what some refer to as 'Triple X' teaching: exposition, examples, exercises [9], doesn´t give students the tools to survive in this competitive and unexpected world we live in. We need an exploratory classroom where we use an inquiry-based learning approach, a term that refers to classroom practices in which students understand, pose questions, explore and discuss [10]. This classroom is focused on learning, where students learn by doing, understanding, analyzing, and discussing multiple approaches when solving a task. The role of the teacher is more demanding, where the instructional strategies and the tasks that teachers select are fundamental to attend that initial goal. In this context, active learning arises, generally defined as an instructional method that involves students in the learning process [5], [6]. It requires the engagement of students in meaningful activities that think about what they are doing. The focus is entirely on the student and the activity he/she develops, as opposed to the more traditional approach in which he/she is limited to passively accessing the information transmitted by the teacher.

Our primary goal as mathematics teachers is to implement practices in the classroom that get students intellectually engaged with the content. In this sense, different organizations and educators [2], [5], [6] have been promoting, for a long time, methodologies that require students intellectually engaged in the construction of new knowledge, investigating and discovering relationships of a different nature that lead to the construction of meanings, highlighting the importance of problem solving, and the emerging activity of questioning and inquiring. Examples of some instructional active that are grounded in inquiry-based learning approach, among others, are problem solving activities, inquiry activities, creating posters or multimedia presentations synthesizing what they learned, which go beyond the application of routine procedures, in which students must explain and justify their reasoning. However, in addition to the strategies of an intellectual (cognitive) nature are also important in the context of active learning those that arise from social and physical activities. That is, the intellectual involvement may not be enough, learning needs a social component where students confront ideas, so allowing students to work collaboratively is a significant aspect of classrooms where the role of communication and mathematical discussion stands out. Here, the students' involvement in active socially mediated learning is at stake, and it is undeniable that social interactions are considered as one of the best practices to be highlighted in the mathematics class [2]. Some examples of instructional active strategies to develop the social dimension, highlights the importance of active listening are the use of small group discussions and whole group discussions and also the use of small group projects. This type of collaboration facilitates the sharing and development of mathematical meanings, and it is up to the teacher to foster a sense of community so that students feel safe and confident to take risks and express their ideas, either between peers or with the teacher [5], [6], [11]. The other component to add to this discussion is the movement. Learning requires movement, as an active body incites the brain, making students more engaged, allowing students to be attentive, improve comprehension and memorization which contributes to a better performance [8]. Students, especially the youngest, need to be physically active in the classroom. This is explained not only because, in the most traditional approaches, they have long periods of inactivity and attention, but also for physiological reasons. This need for movement can be solved with the use of instructional active strategies as hands-on projects, lab experiments, manipulatives, building models, math trails or gallery walks, that also facilitate interactions.

Thus, the importance of those aspects mentioned above is perceived, and it can be assumed that learning emerges from experiences and interactions between the intellectual, social and physical dimensions [5], [6]. In this sense we must keeping students mentally, and desirably physically, active in their learning through activities that involve them in solving various tasks of different level of demand.

2.2 The tasks, the visualization and the styles of problem solving

Learning is strongly dependent on the teacher and the tasks proposed are an important mediator between knowledge and students in the process of the teaching and learning of mathematics [12]. So, the tasks are the starting point for students' mathematical activity and have a great influence on what students learn. The cognitive level that the tasks raise has a lot to do with their nature, but also with the exploration made by the teacher and the way they are carried out by the students. We privileged two features in the tasks: they should be challenging and with multiple solutions [12], [13]. A challenging task or situation in this sense, that provides an opportunity to think mathematically. A challenging task, may be defined as a question posed intentionally to attract students to attempt a resolution. It is interesting and perhaps enjoyable, but is not always easy to deal with or achieve, and that should actively engage students in building a diversity of ideas and learning styles [14]. An appropriate challenge is one for which the individual possesses the necessary mathematical knowledge and skills, but needs to use them in a no standardized or innovative way. When the teacher proposes tasks with multiple solutions, he/she is giving more opportunities for students to solve the task and to choose the way he/she wants to solve it. It is a strategy we use to discover original solutions and can contribute to identify a creative student. Furthermore, as we value visual solutions, having several solutions, we hope that students will also use them. Let's see why visualization is important in learning (and teaching).

It has come to be recognized that visualization is an important aspect of mathematical understanding, insight and reasoning. In particular, for certain kinds of tasks, the use of visual representations may have advantages over the use of other representations, facilitating problem solving [7], [15]. However visual representations have not always been recognized as important and worked on in the math class, with serious implications for students' learning [7], [16], [17]. Visualization is not only related to mere illustration, but it is recognized as a relevant component of reasoning - deeply involved with the conceptual rather than just the perceptual. It is sometimes easier to perceive or even explain a concept by creating an image, since it is quickly understood and retained longer than a sequence of words [7]. The visual characteristics of a task can help students overcome some difficulties with mathematical concepts and procedures, successfully solving a given problem. However, in a classroom, not all students understand the concepts and solve tasks in the same way. In accordance with [18] we can consider in students two styles of thinking: logical-verbal and visual-pictorial, and the balance between these two ways of thinking determines how mathematical ideas operate in an individual. Facing the solution of a task [8], [15], [18], [19], [20] we consider three types of students depending on their thinking preferences and methods used in mathematical problem solving: (a) *Non visuals*, Verbalizers (analytical) - those students who have a preference for the use of non-visual solution methods, preferring to use verbal-logical modes of thinking, which involve algebraic, numeric, and verbal representations, even with problems that would yield to a relatively simple way to solve through a visual approach; b) *Visuals,* Visualizers (geometric) - those students who have a preference for the use of visual solution methods, preferring the use of visual-pictorial schemes, which involve graphic representations (i.e., figures, diagrams, pictures), even when problems are easily solved by analytical means. They have preference for an extensive use of visual methods to solve a mathematical problem that can be solved either by visual or non-visual methods; and (c) *Harmonic* (mixed or integrated) - those students who have no specific preference by either verbal-logical or visual-pictorial thinking. They have an integrated thinking style because they combine analytical and visual reasoning.

Taking into consideration that students have different learning styles and also that they may present difficulties understanding mathematical ideas when the only form of communication is speech/verbal, (words, symbols) it is necessary to look beyond and integrate others forms of communication and representations, including the visual ones [7].

3 COMMUNICATING IDEAS: FROM POSTERS TO A GALLERY WALK

3.1 Mathematical communication

Communication is a fundamental component in any classroom, in particular in math class. It is a transversal ability to all mathematical activity that contributes to the construction of meanings, consolidation and dissemination of ideas. Fostering communication in the mathematics class, students have the opportunity to reflect, clarify and expand their knowledge about mathematical relationships.

However, communicating an idea to another, in a clear way, requires organizing and clarifying the thought. This objective is not always achieved, particularly when communication is restricted to its verbal form only, in terms of verbal discourse. To avoid this situation, teachers must use multiple sources of information, of a different nature, that may be related, in order to contribute to clarify a certain idea [21].

Mathematical communication uses different forms (verbal, visual, gestural and written) and representations, however these different ways of communicating are related to the way of learning that students prefer, some learn better if the information is verbal (with words, reading or listening) while others prefer the information to be more visual (graphics, diagrams, drawings). And on the other hand, related in the same sense to the way of communication that the teacher privileges. However, it is widely accepted that verbal communication (oral or written) is crucial in teaching and learning of mathematics and is the most used. The oral communication is more used in the interaction between students, with the teacher and in the collective discussion, while written communication is used when it is requested to carry out written records referring to the accomplishment of a given task or to the elaboration of justifications or small texts, on certain mathematical subjects. But not only; it is by seeing, listening, talking, manipulating, reading and writing about mathematics that students can organize, reorganize and consolidate their mathematical thinking, knowing about their own ideas, as well as analyzing and finally learning. Considering the different forms of mathematical communication, verbal communication is perhaps the most natural way for students to express emerging ideas. However, written communication is also of particular importance, as it provides students with a record of their own thinking, enabling reflection on the work performed [2].

In this sequence, we highlight as a privileged form of communication, the figurative or visual contexts with an indisputable relevance in all mathematical activity. The visual characteristics of an information or task can help students overcome some difficulties they may have with mathematical procedures concepts, successfully solving a certain problem. Thus, visual solutions are understood as the way in which mathematical information is presented and / or processed in the initial approach or during the resolution of a problem. Many mathematical concepts are best understood if students have access to some form of visual support. Writing in the math class can help students deepen their exploration of mathematics and reflect on their own mathematical processes and also helps them to organize their knowledge and understand the questions raised at a deeper level. When students communicate their thinking in this way, they tend to clarify their ideas and provide valuable information to the teacher, information that they would probably not otherwise have access to [21].

3.2 From posters to a gallery walk

Posters are connected with the nature of the knowledge used in our high-tech daily lives, based largely on images full of information. So, they can be an important tool to use in mathematics classes to improve learning. They offer a means that stimulates concise communication and discussion, encouraging students to reflect on their learning during their collaborative work, and enable them to show their learning and to learn from other students' ideas. Posters are very important in teaching and learning of all level of students and in particular in teacher training where teachers must be able to communicate in different forms to include the various learning styles of students in their classrooms. And it is also important because they offer the opportunity for teachers to communicate in forms which differ substantially from the dominant modes of communication [22].

When building a poster, you have to write math ideas, using words, images or mathematical language clearly for others, which can help students deepen their mathematics processes of exploration and reflect on their own mathematical processes. It also helps them to organize their knowledge and understand the questions raised at a deeper level. Posters require short and succinct statements expressed in the poster, so students have to select the most important ideas in their work, and display them in an appealing way to have an impact on students to become engaged in the active learning process. Similarly, visual learners are more likely to be stimulated by well-constructed posters, and hence, motivated to learn. All these ideas help to develop communication skills and to have synthetic reasoning [8], [22], [23], [24].

The use of posters in the mathematics classroom can have some main intentions. One is that through the poster construction students will develop skills, techniques and knowledge about poster construction and effective communication. The other, allows student demonstrates appropriate understanding of a concept or an idea or solve adequately a task, that must be displayed in a concise, innovative and friendly way. Another allows to evaluate students' knowledge. Finally, it gives students the opportunity to be creative not only in the way of solving the task but also in the presentation of the poster, allowing to develop their aesthetic sense not only in the form of presentation but also in the type of solutions presented, with some proposals being more elegant and simpler than others.

To improve posters as a powerful resource in mathematics classroom, we propose a Gallery Walk (GW) as an active learning strategy that can be used in the mathematics classroom, adapted from an idea of [4]. We consider a GW [1], [8] as an instructional strategy that allows students to solve multiple-solution tasks collaboratively, in small groups, displayed in posters around the classroom (or outside), in a similar perspective to that used by artists when they expose their works in a gallery. Students will have the opportunity to give and receive written/oral feedback about their posters in a "non-threatening" way, contributing for their learning. Finally, a collective discussion is promoted, mediated by the teacher, during which each group has the opportunity to show their poster again and clarify aspects of their work. The organization of a GW leads students to get out of their chairs and get them actively involved with the mathematical ideas of their colleagues. For many students, moving can help them feel more motivated to get involved in classroom work.

A GW is a powerful resource for learning because it connects students to each other and to the mathematical topics or skills in different, interesting and interactive ways, putting the emphasis on challenging tasks with multiple solutions. This means that it can readily be used to enhance conceptual and contextual skills, but not procedural and algorithmic skills. According with this idea we defend the use of multiple solution tasks, for the reason we said previously. When the teacher proposes multiple solution tasks he/she provides scaffolding to the students so that they can find their personal styles of thinking; provides an opportunity to choose the most efficient strategy for themselves to use, according to their knowledge and preferences; provides an opportunity for students to try something outside of their comfort area pushing them to learn more; and provides an opportunity for the students to enrich their personal repertoire of processes/strategies when they confront their strategy with those of their peers.

Thus, a GW is a strategy that falls within the scope of active learning as it promotes cognitive, social and physical engagement by students. Social interactions, reflected in collaborative work and collective discussions, facilitate sharing, the development of mathematical meanings and the construction of knowledge, and it is up to the teacher to foster this sense of community [1], [2]. On the other hand, the movement improves levels of attention and understanding of students, because they are active individuals, who build, modify and integrate ideas interacting with the physical world, materials and colleagues [8].

4 METHODOLOGY

In this manuscript we describe a particular study that aims to characterize the strategies used by the students (future teachers) when solving tasks with multiple solutions, in particular to identify if students used the visual ones, and to characterize the reaction during their engagement in the GW strategy. The participants were fifteen students, future teachers of elementary education (6-12 years old) that attended a curricular unit of Didactics of Mathematics during an initial training course, who in which a GW was implemented as a teaching and learning strategy in solving problems that address rational number contents, privileging the visual solutions. We adopted a qualitative methodology, following an exploratory design [25]. Data was collected in a holistic, descriptive and interpretative way and included classroom observations, written productions about the proposed tasks (solutions, posters, comments of students to the posters) and a written report where these future teachers commented on the lived experience through a Gallery Walk, focusing in particular on the posters and the tasks. The GW used allows the development of the 4 C's skills where students were organized to think, speak, listen, write and move. We adopted the following steps and procedures during the GW [1], [8] (Figure 1) *Solving tasks* – students in group solve the same proposed tasks, with multiple solutions. In this GW they solved three problems; 2) *Construction of posters* – students discussed among themselves how to display their solutions in the poster, in this phase they pushed for their originality and aesthetic sense; 3) *Presentation and observation of posters* – posters were affixed in the walls of the classroom; 4) *Analysis and elaboration of comments* - Each student went through the different posters to analyze the different solutions and after their evaluation, wrote, in post-its, their personal comments, doubts, questions, possible errors, etc. While students discuss their colleagues' solutions, we circulate around the classroom, evaluating students' observations and discussions; 5) *Group discussion*– After this round, the students take their own poster and analyze the contents of the post-its, making a small report; 6) *Collective discussion* –with all the posters fixed again in the wall, the groups orally present the solutions and respond to the comments of their peers. This moment serves for us to highlight some of the ideas expressed, making connections between the different approaches, making syntheses, clarifying doubts and errors and provoking. This provides also an excellent opportunity to give feedback to the content of each poster, that all students already knew, grounded on the work displayed, commented and discussed and through what we saw and heard.

Figure 1. Steps of the used GW

5 THE PARTICIPANTS ALONG THE GW

In this item, we characterize the participation of the students, describing some results along the GW having as starting point one of the three tasks used (Figure 2). We intentionally chose a task, a problem, in the context of rational numbers, with no visual context.

In a school there are 18 less male teachers than female teachers. If 45% of the teachers are men, how many teachers are there in the school. Present more than one solution.

Figure 2. One of the proposed tasks during the GW

Students solved the problem in small groups (six groups), of 2/3 elements. They started by solving them individually, and when they reached a solution or had doubts, they began to discuss their work to clarify doubts. Solutions with different representations and mathematical knowledge emerged and then they choose the adequate solution for elementary students and also the most interesting (Figure 3). The fact that they worked collaboratively facilitated the exchange of ideas and decision-making. After solving the tasks, they started to discuss what would be the best way to present their work to their colleagues, so they started to plan the organization of the poster to display in the room. As a group, they decided which strategy to present, which were the most appropriate representations, how to write the text, among other features. There was some concern on the part of the students with the content of the poster and if it would be clear to those who consulted it, realizing the relevance of written communication in mathematics and also the representations used. They also expressed care of aesthetic nature (Figure 3).

Figure 3. Students solving the tasks and constructing the posters

After the posters' construction, they were displayed in the wall around the classroom, similar to what happens in an art gallery. Each student freely walked around the space, carefully observing the content of each posters. Individually and autonomously, they made the comments that they considered relevant and also asked questions about information that raised doubts. This feedback, in the form of comments and questions, was written in anonymous post-its that were associated with each of the posters (Figure 4). This step was followed by the analysis of the comments and questions associated with each poster. After, the groups collected their poster, with their post-its, and analyze the feedback given by colleagues. They discussed among themselves the relevance of the comments, what they could improve in their work, how to improve the explanation of their reasoning and, in some cases, they detected errors that had gone unnoticed (of one group). The feedback given by the peers was a positive contribution to promote reflection on the work done (Figure 4). Finally, after the discussion in each group the collective discussion began. The posters were placed in a central area of the classroom, and each group at a time had the opportunity to resume their work, to present their solution(s) and answer to the different previous comments. And a discussion was established between the various students and the presenters, explained some aspects that had become less clear and correct some errors. In some cases, a strong discussing appeared when trying to convince each other of something in the processes that was not clear. Although in this phase the role of the teacher was more interventionist, in the previous phases the action was limited to observing all the work, guarantee the engagement of the students and support whenever requested. During the collective discussion phase the discussions were mediated by the teacher responsible for the unit course, who summarized the different ideas and doubts. (Figure 4).

Figure 4. Analysis and comments of the posters

All the tasks used in the GW can be used with their own future elementary pupils. These students didn't present any difficulties, only one group made a little confusion with the statement of the problem. The word "teacher" in Portuguese can refer to all teachers, men and women, as well as only male teachers, which led to an incorrect response at the end of a group solution, that generated a lively discussion. Also some language inaccuracies appeared, such as 10% = 18. They used different approaches: visual, analytical and mixed solutions. In Figure 5, the first solution was analytical (two), the second is a visual solution and it was the only one. The last one we considered to be mixed because it combines visual representations with symbolic and was the most common (three). Only two groups didn't use the bar model. We can say that, throughout the didactic classes where we emphasized the power of visual solutions, because it is not a common way of solve a problem, there was an appropriation of the more visual models of solution, alternative to the more traditional ones that are usually manipulation of numbers, which constitutes a learning indicator, even in the case of students with more analytical learning styles. Some of the solutions surprised some students who, because they found it simpler and more elegant.

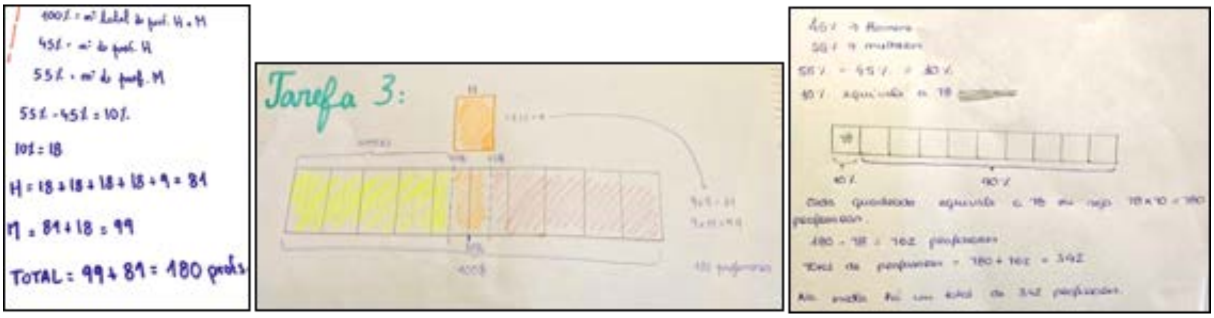

Figure 5. Types of solutions to the proposed task

According to our observations and their ideas in the written report we can conclude that: All of these students liked to experiment a GW strategy that was completely knew e them, and they reacted positively to this experience, showing interest and motivation; In personal terms, they recognized the contribution of a GW to their own learning and, as future teachers, to mathematical learning at the levels of education at which they will teach. The opinion on what they liked best about GW varied between "Working as a team"; "Share solutions" "Learn different solution strategies and ways of reasoning", "Make the poster"; One of their difficulties was how to organize the solutions in the poster (phase 2) so that their colleagues understood it, since they had never made a poster in mathematics. After some attempts and group discussions they got a well-organized poster and easy to follow; The phase of the GW in which they had the most difficulty was unanimously stated to be the 4th one, in which they had to analyze and comment on the work of their colleagues, saying that "it is difficult to give feedback". Because they say that giving an opinion on the work of colleagues was not easy, as they often did not understand the processes used to solve the task, because in some cases some indications were missing and giving feedback to their peer work is an activity that they are not familiar with; They also had some difficulties in phase 5, when they had to analyze in group the comments of the post-its, because they didn't understand what their peers wanted with some of the comments. This can be justified because post-it has not so much space to write and consequently to pose the question in a complete and comprehensive way. Anyway, this issue was overcome during the collective discussion.

6 SOME CONCLUDING REMARKS

Throughout this manuscript we intended to highlight the potentialities of a GW as an active learning strategy where the posters and the multiple solutions tasks are crucial for mathematical understanding of the students with different styles of thinking, where the visual is privileged [2], [5], [6], [8], [9], [12], [13], [15], [18], [20].

The students' productions allowed to identify the strategies used by the participants and to verify that they solve the tasks privileging visual solutions, that they explained being easier to use, although some students continued to use more analytical representations. The GW allowed students to be engaged in peer resolutions and classroom discussions, clarifying doubts and increasing the individual repertoire of resolution strategies. Students reacted positively to the GW by expressing interest, motivation and recognition of its importance in mathematical learning at any level and it was an enjoyable and rewarding experience for all of them. They also valued this strategy because, by solving the same task, they were able to engage in the analysis and discussions of the solutions presented by their colleagues more in-depth. We can conclude that the GW allowed to identify different types of engagement by the participants: intellectual (e.g. solving the tasks), social (e.g. interactions in small and large groups) and physical (free movement in the classroom and poster construction). Preparing posters and a GW was a different and novel experience for these students, future mathematics teachers, and thus provided a motivation to their learning but we could verify that they recognize the potential of GW as an opportunity to contact with other (teaching) learning contexts and also an opportunity to work together. The GW was new for these students, in particular the preparation of a mathematical poster which has compelled students to become more critical and reflective about their construction and about the content to be addressed in the posters. Although feedback requires further study, the collected data allowed to observe that despite students expressed that the GW step they liked less was to give feedback on the work of their colleagues, it was a support for critical thinking. It allowed them to gain more knowledge due to the imposed need to reflect and evaluate their peers' work; it also helped them with regard to learning with specify orientation for improvement. Furthermore, we observed and they also stated that they were more comfortable to discuss their work in this setting, that the GW provides, than in a more formal one.

To close, the results of this study are in accordance with the results of a similar study [1] that the GW enhances communication skills and provides opportunities for a collaborative learning and discussions, being exposed to a variety of mathematical and pedagogical knowledge which will be valuable in their future careers, mainly with peer and self-peer assessment, despite that this last aspect needs more research. So, teacher education programs should provide opportunities, living didactic experiences during the instruction that stimulate preservice teachers' knowledge, solving the same tasks and using the same teaching and learning principles that they are expected to use with their own future students.

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REFERENCES

[1] I., Vale, A. Barbosa, "Movement & learning: the gallery walk strategy." In *Improving children's learning and well-being* (G.S. Carvalho, P. Palhares, F. Azevedo, C. Parente Coords.), 7-22, Braga: UM- CIEC, 2020.

[2] National Council of Teachers of Mathematics, *Principles to actions: ensuring mathematical success for all.* Reston/VA: NCTM, 2014.

[3] WEF (2016). *New Vision for Education: Fostering Social and Emotional Learning through Technology*. Available in http://www3.weforum.org/docs/WEF_New_Vision_for_Education.pdf

[4] C. Fosnot, B. Jacob, B., *Young mathematicians at work: Constructing Algebra*. Portsmouth/NH: Heinemann, 2010.

[5] S. Edwards, “Active learning in the middle grades,” *Middle School Journal,* vol. 46, nº 5, 26-32, 2015.

[6] G. Nesin, Active Learning. This we believe in action: Implementing successful middle level schools. Westerville/OH: Association for Middle Level Education, 2012.

[7] I. Vale, A. Barbosa,“The Importance of Seeing in Mathematics Communication,” *Journal of the European Teacher Education Network,* vol. 12, 49-63, 2017.

[8] I. Vale, A. Barbosa, “Promoting Mathematical Knowledge and Skills in a Mathematical Classroom Using a Gallery Walk.” In *Proceedings of ICEMST 2021- International Conference on Education in Mathematics, Science and Technology* (M. Shelley, W. Admiraal Eds.), ,Antalya/Turkey: ISTES Organization, in press.

[9] S. Evans, M. Swan, “Developing Students’ Strategies for Problem Solving,” *Educational Designer,* vol. 2, nº 7, 1-34, 2014.

[10] K. Maaß, M. Doorman, “A model for a widespread implementation of inquiry-based learning,” *ZDM Mathematics Education*, vol. 45, 887–899, 2013.

[11] A. Barbosa & I. Vale, “As dobragens como uma estratégia de aprendizagem ativa”. Em *Atas da VII Conferência Internacional Investigação Práticas e Contextos em Educação (*D. Alves, H. Pinto, I. Dias, M. Abreu & R. Muñoz, Orgs.), 83-91. Leiria, Escola Superior de Educação e Ciências Sociais Instituto Politécnico de Leiria. 2018.

[12] M. S. Smith, M. K. Stein, “Selecting and Creating Mathematical Tasks: From Research to Practice,” *Mathematics Teaching in the Middle School*, vol. *3, nº* 5, 344 – 349, 1998.

[13] R. Leikin, Exploring mathematical creativity using multiple solution tasks. In Creativity in mathematics and the education of gifted students (R. Leikin, A. Berman,B. Koichu Eds.), 129-145, Rotterdam/ Netherlands: Sense Publishers, 2009.

[14] D. Holton, K. Cheung, S. Kesianye, M. Losada, R. Leikin, G. Makrides, H. Meissner, L. Sheffield, B. Yeap, “Teacher development and mathematical challenge”. In *Challenging Mathematics In and Beyond the Classroom – New ICMI Study Series 12* (E. J. Barbeau & P. J. Taylor, Eds.), 205-242. New York: Springer, 2009.

[15] N. Presmeg, Creative advantages of visual solutions to some non-routine mathematical problems. In *Proceedings of the Problem@Web International Conference: Technology, Creativity and Affect in mathematical problem solving* (S. Carreira, N. Amado, K. Jones,H. Jacinto Eds.), 156-167, Faro/ Portugal: Universidade do Algarve, 2014.

[16] A., Barbosa, I. Vale, P. Palhares, “Pattern tasks: Thinking processes used by 6th grade students,” *Revista Latinoamericana de Investigación en Matemática Educativa,* vol. 15, nº 3, 273-293, 2012.

[17] I. Vale, A. Barbosa, “Mathematical problems: the advantages of visual strategies,” *Journal of the European Teacher Education Network,* vol. 13, 23-33, 2018.

[18] V.A. Krutetskii, *The psychology of mathematical abilities in schoolchildren.* Chicago: University of Chicago Press, 1976.

[19] R. Borromeo Ferri, “Mathematical Thinking styles and their influence on teaching and learning mathematics”. Paper presented at the 12th International Congress on Mathematical Education, Seul, Korea, 2012. Retrieved in march, 5 2015 from http://www.icme12.org/upload/submission/1905_F.pdf

[20] I. Vale, T. Pimentel, A. Barbosa, The power of seeing in problem solving and creativity: an issue under discussion. In N. Amado, S. Carreira, & K. Jones (Eds.), *Broadening the scope of research on mathematical problem solving: A focus on technology, creativity and affect* (pp. 243-272). Cham, CH: Springer.

[21] A. Barbosa & I. Vale, “Tens correio! A comunicação escrita e o feedback na aula de matemática”. *Interacções,* vol.15, nº 50, 109-123, 2019.

[22] R. Zevenbergen, “Peer assessment of student constructed posters: assessment alternatives in preservice mathematics education,” *Journal of Mathematics Teacher Education,* vol. 4, 95–113, 2001.

[23] J. Berry, K. Houston, “Students using posters as a means of communication and assessment,” *Educational Studies in Mathematics*, vol. *29*, 21-27, 1995. https://www.questia.com/library/journal/1G1-153041072/promoting-discussion-in-the-science-classroom-using

[24] M. Francek, “Promoting Discussion in the Science Classroom Using Gallery Walks,” *Journal of College Science Teaching,* vol. 36, nº 1, 27-31, 2006.

[25] R.K. Yin, *Case study research: Design and methods (4th edition).* Newbury Park/ CA: Sage, 2009.