

Article

# Enhancing Student Motivation in Secondary School Mathematics Courses: A Methodological Approach

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**Abstract:** In this paper, a teaching experience carried out within the framework of the subject of mathematics is presented. This subject is taught at several levels in secondary schools. In addition to some specific content related with mathematics (percentages, fractions, graphics, and bank interest), the methodology is designed in order to enhance the development of transversal skills (e.g., oral exposition, poster design and presentation, the analysis of social inequalities, etc.). Survey results based on the responses from over 110 students across four consecutive years, as well as the teacher's self-assessment, indicate that the proposed methodology enhanced the students' motivation and was helpful for developing mathematical content in a more pleasant way than in a conventional class based on a master class and problem-solving class.

**Keywords:** active methodology; secondary school students; 12–14-year-old students; mathematical skills; transversal skills

## 1. Introduction

In this paper, an active methodology is presented that helps students (from 12 to 14 years old) enrolled in the three first courses of Spanish compulsory secondary education to increase their motivation in the study of several mathematical concepts, such as percentages, fractions, graphics, bank interests, etc. The aim of this methodology is also to improve some transversal skills, such as oral exposition, poster design and presentation, analysis of social inequalities, etc. Taking into account the positive teaching experiences in mathematics associated with group working [1–3], the methodology presented in this paper is focused on this technique.

The main aim of this methodological statement is to motivate secondary level students to (i) study certain mathematical contents (percentages, fractions, charts, bank interest, etc.), and (ii) develop certain transversal skills (oral exposition, content organization, simplifying results, reflecting on social inequalities, etc.). The results of applying this methodology over four academic years (from 2011/2012 to 2014/2015) in different Spanish high schools are included in this paper, revealing the proposed methodology to be a simple way of improving both students' participation and motivation in the classroom.

## 2. Literature Review

By Spanish state law, education is compulsory until the age of sixteen. Thus, many students of the Spanish compulsory secondary education (12–16 years old) do not feel motivated by almost any subject, as reflected by both the school failure and school dropout rates at this education level (i.e., high school) [4]. One of the subjects that, in general terms, is often associated with lower interest levels and higher difficulties in students is mathematics [5–8]. Furthermore, in many cases mathematics

can provoke anxiety in students [9,10]. In fact, mathematics is one of the most requested subjects in private tuition, since the knowledge that students assimilate in their high school classes is often insufficient in many cases.

On the other hand, the habit of doing homework—which is essential in mathematics for assimilating and understanding the content correctly [11]—tends to be crucial for achieving good academic results [12]. In spite of that, in general terms, it can be assessed that many students do not feel motivated to do math homework [11] and, in many cases, they wonder about the real usefulness of this subject [13–15]. Although this demotivation may be due to the direct influence of the subject teacher [16], who may be demotivated him/herself [17,18], most math teachers are worried about improving the teaching–learning process and, hence, they try to find solutions and to use innovative methodologies that enhance the students' active participation during the classes and that reinforce the acquired knowledge in order to achieve better academic results [19].

This way, it is easy to find many research works related to new methodologies in mathematics at the high school level. Thus, according to recent studies [20], the use of tangible interfaces and virtual worlds for teaching geometry in secondary school seems to favor more meaningful learning. In the same way, another paper shows the success of a game-making teaching approach in enhancing students' understanding of geometric principles [21]. Other authors used practical geometry tasks as a method for teaching geometry in secondary school, corroborating a more active student participation [22]. Conversely, another research study in secondary schools pointed out that the control group learned significantly more than the experimental group (in which an active methodology was applied to improve students' ability to reason and argue using mathematics) [23].

Some teachers linked computer programming with mathematical content related to polynomial equations, and by doing so obtained better learning results than those obtained with traditional methodologies [24]. Another study dealt with solving mathematical problems in secondary education, analyzing the relationship between the learning strategies and the tendency to use algebraic procedures [25]. Another study at the secondary school level investigated the influence of formative assessment and assessment on learning in mathematics education [26]. In another paper, dealing with computer games in mathematics, it was concluded that educational computer games make lessons more enjoyable for the student body and, moreover, they help students to develop positive attitudes and motivation towards doing mathematics [27]. Similar results were found in a recent study where programming was used to improve the learning of mathematics [28].

On the other hand, another paper suggests using complexities of social justice contexts to encourage mathematical understanding in educational programs [29]. Finally, there is a need to increase the number of research works analyzing how teachers support active participation of students in mathematics classes [30]. In this sense, there are several proposals that suggest the use of the 'flipped classroom' for mathematics learning [31,32], which implies a more active participation of students in the teaching–learning process.

### 3. Methodology

According to previous experiences [33,34], reducing the size of work groups can enhance effective cooperative learning. For this reason, the proposed methodology is based on small work groups (up to 4 students). Before applying this methodology, each small group chooses a celebrity (one admired by them) and searches on the internet for information regarding his/her annual salary (in some cases this data is not easily found, so each group must consider several alternatives). The celebrity chosen by each group must be different from the rest of the groups. From this initial data, the teacher proposes a series of activities that students of each group must complete (Figure 1):

- (a) Students must calculate the total amount earned by the selected celebrity per year, per month, per day, per hour, per minute, and per second (taking into account the huge amounts earned by certain celebrities, these values are still big even for the two last cases, i.e., per minute or per second).

- (b) To compare, as a percentage, how much money the selected celebrity earns with the amount of money earned by the celebrities selected by other groups and with the average salary of a Spanish worker. This allows students to develop transversal skills, e.g., identifying social inequalities and social unfairness, which can help them to reflect on what is more important in life.
- (c) To establish bar and pie charts with the data obtained in the previous step. This aspect is especially important because all secondary school science textbooks contain many such diagrams [35]. In this way, the differences between each of the celebrities selected by all of the groups can be visually observed.
- (d) To evaluate the bank interest that each celebrity would receive from one year's salary by working with compound interest. This topic is covered in the third course of Spanish compulsory secondary education (14-year-old students). The results show that certain celebrities would earn more monthly from a fixed-term deposit in the bank than an average Spanish worker would from his/her work.
- (e) To design a poster (A1–A2 size) with an original organization of all of the content produced in the previous steps, selecting appropriate sizes of elements (letters, spaces, plots, etc.) that ensure everything can be correctly seen and aligning margins correctly. This task requires greater effort than students might think, and it represents an important challenge of learning the importance of measuring and estimating the size of each section in the poster. In Figure 2, an example of the posters made by secondary school students during the development of this methodology is shown.
- (f) Presentations and debate about the developed work, thereby developing oral and exposition skills (and reinforcing the mathematical learning at the same time [36]).

It is planned that the complete activity should be developed during five teaching hours plus five additional hours for working at home (a total of ten hours). Sections (a) and (b) are developed during a 50 min class. Taking into account the difficulty of the tasks that students have to complete (pie charts), a whole 50 min class is also devoted to Section (c). The next step, Section (d), is developed during half a class (25 min). The poster design is the more difficult task for students (Section (e)), especially for those groups more involved in the activities developed with this methodology. For this reason, it is estimated that in Section (e), the teacher must interact with the groups during one and a half classes. (Moreover, each group must dedicate extra time outside of school to finishing the poster.) Lastly, the defense of the activity (Section (f)) is developed during another full 50 min class.

Besides this, from the collected data, a discussion between students about social inequalities can be developed under teacher supervision. This discussion is developed mainly during the poster presentation and debate (Phase (f)) and/or in tutoring classes (at the secondary level, tutoring class in Spain is mainly dedicated to enhancing transversal skills in students). It is worth highlighting that in many cases, the celebrities chosen by students earn such a large amount of money that a Spanish worker on a median salary would need to work several years to earn an amount similar to what a celebrity earns daily. From this point, an analysis of the social differences between developed and underdeveloped countries is carried out by comparing common salaries in both types of countries. The revealed social differences are so huge that a debate arises in the classroom about how unfair the world distribution of richness is. In addition, this fact helps students to reflect on the privileges of living in a developed country and on the importance of solidarity with those who do not have such luck.

The mathematical content that is worked on in this new methodology (percentages, fractions, bank interest, charts, etc.) does not follow the sequence normally used in academic textbooks. Therefore, students must use diverse resources placed in different sections of the textbook. This fact strengthens in students the sensation of working in a different way to the one they are used to during a conventional class, i.e., usually following an academic book sequentially. In addition, this fact could help students to relate the different mathematical concepts, thereby promoting more meaningful learning (it must be

considered that both the order used for teaching mathematical concepts and the way in which the relationships between them are taught strongly affect the learning process [37]).

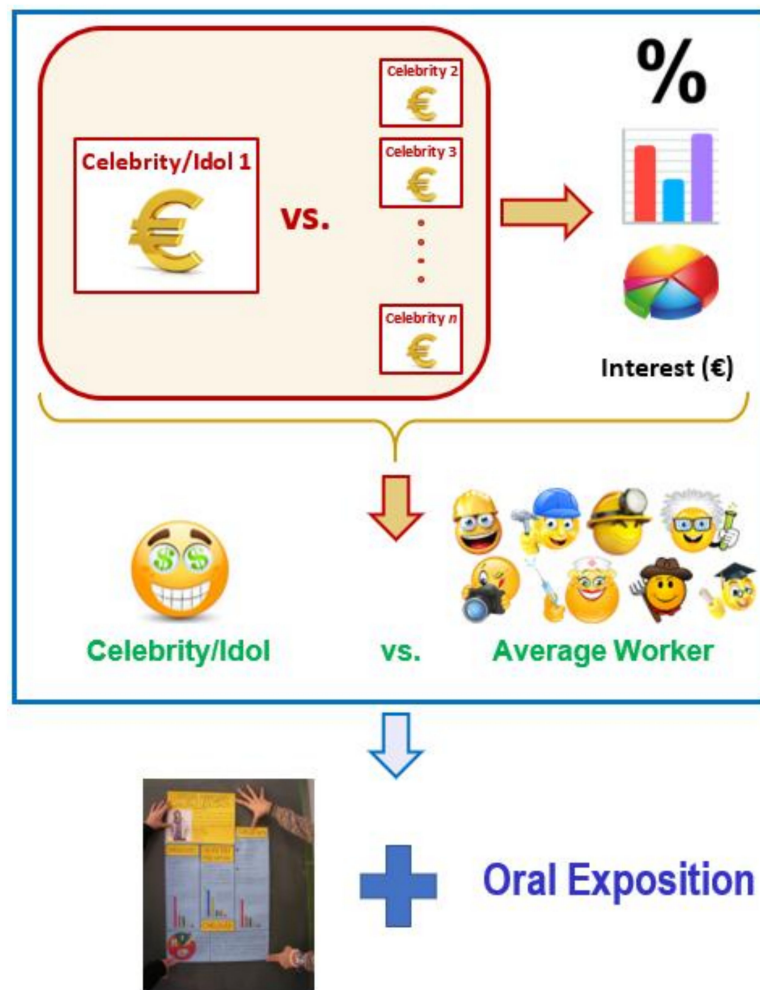


Figure 1. Scheme of the proposed methodology.

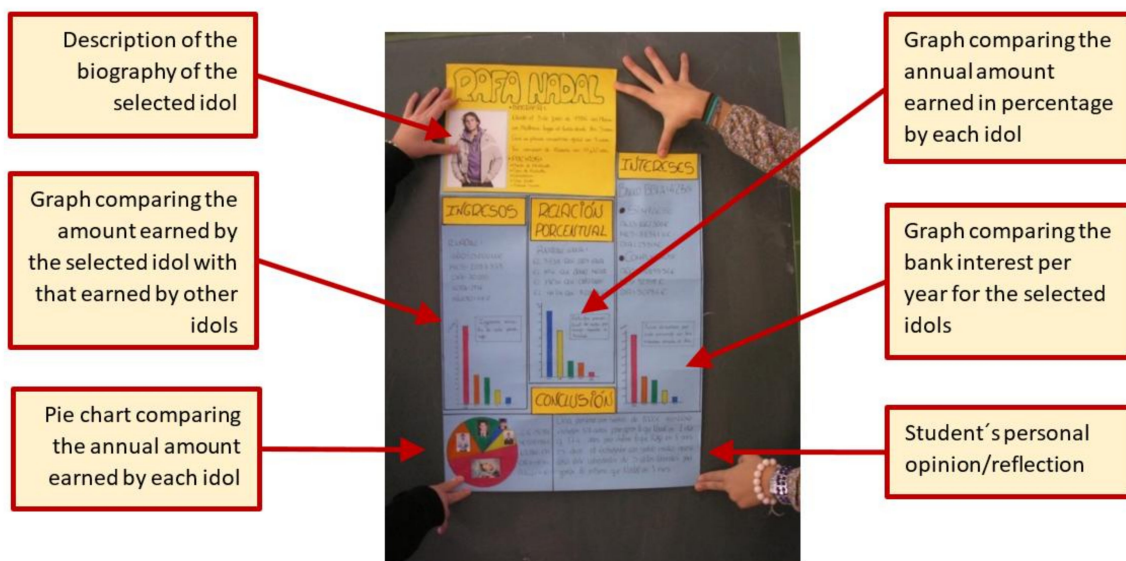


Figure 2. Example of a poster made by students.

Following is a brief description of the context of the experiment carried out by the authors:

- The methodology was applied during four academic courses (from 2011/2012 to 2014/2015) in different Spanish High Schools.
- The experimental group was composed of 134 students enrolled in the first three courses of Spanish compulsory secondary education (i.e., from 12 to 14 years old). At this education level, students have not decided yet their academic path (technical/science or social/humanities). Thus, students with a high variety of particular personal interests are together in the same classroom.
- All the Spanish High Schools where these educational experiences were applied were public centers. There, students of middle-class families attend classes (the annual gross income of the middle class in Spain is around 26,500 € [38]).

#### 4. Findings

To evaluate the educative efficiency of the proposed methodology, two sources of evaluation were considered: (i) the teacher, who through direct observation can appreciate both the learning level and the motivation that this methodology awakens in students; and (ii) the students, who by means of answering two surveys—one before the experience (pre-test) and another once the experience is completed (post-test)—help us to know their real opinion regarding this experience.

##### 4.1. Teaching Observations

By using this methodology, the teacher could test whether students were stunned after reflecting on the magnitude of the economic quantities involved. To highlight this aspect, it is important that the teacher asks questions that cause students to think about this point; otherwise, the educative experience may be not as efficient as it could be, mainly because it would not grasp the attention of the student body.

One of the more efficient questions to make students wonder about the content of the educational methodology is, “*What thing (or things) would you buy today if you had X € available?*”—X being the amount of money earned daily by their idols. It is advisable to highlight at this point that, in most cases, this value exceeds the yearly income of a middle-class worker in Spain. After the students’ answer, a new question is raised: “*If tomorrow you once again earned the same amount of money, what would you buy? And the following day? (etc.)*” All the students run out of ideas about which things to buy after a few days (no more than 7 days, i.e., a week in the celebrity’s life) since they are not used to handling such a large amount of money and, consequently, their actual needs are covered by a considerably lower amount of money than that corresponding to a celebrity salary.

Just in this moment in the classroom experiment—when students were aware of the amount of money involved—the teacher perceived that the whole group of students was enthusiastic about the activity as reflected by the signs of surprise in their faces. Some of them even expressed their illusion of earning such a large amount of money in the future by themselves. All this indicates that at that moment, the activity had hooked the students. At this point, it is worth highlighting that even some teachers were surprised when they saw the celebrity salaries included in the posters hung on the classroom walls.

With regard to solving conventional problems or exercises related to percentages or fractions, the teacher could see that students tended to raise fewer doubts than in previous courses when a conventional methodology was used. Furthermore, the way students solved the proposed exercises/problems was generally improved. Despite that, the final evaluation (learning outcomes) did not vary meaningfully from one academic year to another; this is logical since the final evaluation is based mainly on a final exam including more content than what is taught with this methodology.

According to all of these observations, this methodology enhances the active participation of the students in the teaching/learning process. This then leads to a higher level of motivation during the development of the mathematics classes and to a higher level of understanding of the basic

concepts than the students achieved with conventional classes (master classes and exercise–problem resolution classes).

#### 4.2. Students' Opinions

Surveys, composed of the questions shown in Table 1, were used to reveal the students' opinions. In the first year of this four-year didactic experience, no survey was performed, so the survey results shown in Figure 3 (average values and standard deviations) correspond to the following three years. In each one of them, students filled out a survey after the didactic experience was completed (post-test), but only in the last year was a pre-test performed after a 15 minute explanation of the activity stages. The survey population was 110 students for the post-test and 35 students for the pre-test (last year).

**Table 1.** Questions from the survey performed before and after the proposed methodology.

Question Number	Pre-Test	Post-Test
1	Do you believe that the Mathematics subject is useful in real life? <i>Rate from 1 to 10 your answer</i>	Do you believe that the Mathematics subject is useful in real life? <i>Rate from 1 to 10 your answer</i>
2	Do you like the Mathematics subject? <i>Rate from 1 to 10 your answer</i>	Do you like the Mathematics subject? <i>Rate from 1 to 10 your answer</i>
3	Do you think that you will like the new methodology? <i>Rate from 1 to 10 your answer</i>	Have you enjoyed the new methodology? <i>Rate from 1 to 10 your answer</i>
4	Do you consider that the methodology will help you to learn percentages and bar and pie charts? <i>Rate from 1 to 10 your answer</i>	Do you consider that the methodology helped you to learn percentages and bar and pie charts? <i>Rate from 1 to 10 your answer</i>
5	Do you consider that making an oral presentation will help you to better understand what is learnt? <i>Rate from 1 to 10 your answer</i>	Do you consider that making an oral presentation helped you to better understand what you learnt? <i>Rate from 1 to 10 your answer</i>
6	Do you prefer the new methodology or a conventional class?	Do you prefer the new methodology or a conventional class?

The first two questions of Table 1 serve to reveal the students' feelings about Mathematics. These two questions were asked in both the pre-test and post-test in order to provide unity with the rest of the survey. The first two questions can be useful to provide a better understanding of the responses to the remaining four questions since surveyed students (studying one of the three first courses of Spanish compulsory secondary education) have not chosen their academic path and are all together in the same group (science and humanities). As could be expected, the results revealed no remarkable changes in the way students consider the subject of Mathematics before and after using this methodology in class (Questions 1 and 2). It can be concluded that, in general terms, students that participated in the survey (i) understood that the Mathematics subject was useful for their daily life (Question 1, Figure 3) and (ii) did not like the subject very much (Question 2, Figure 3).

On the other hand, the remaining questions included in Table 1 (Questions 3–6) are focused on knowing the students' opinion about the applied methodology. The obtained results suggest that students liked this methodology (even a little more than what they initially thought (Question 3, pre-test vs. post-test, Figure 3)). Regarding the educative efficiency of this methodology (Question 4, Figure 3), students gave an average rating that was not very high (6 out of 10). In addition, no meaningful differences between the average ratings were found between the pre-test and post-test. However, the results of Question 4 (Figure 3) show a more remarkable dispersion in the post-test than in the pre-test.

Relating to Question 5 (Table 1), the students' perception of the educational utility of giving an oral presentation on the content worked upon in the classroom greatly improved. This was observed by comparing the average values collected in both the pre-test and the post-test (this value was increased by about 50%) and the dispersion in the results (which was considerably lower in the post-test (Question 5, Figure 3)). Lastly, the results of the sixth question (Table 1) were outstanding: 87% of the students responded in the pre-test that they preferred the new methodology instead of the conventional one (master classes and problem-solving classes). After the teaching experience this percentage increased (only 9% of the students preferred conventional classes). Furthermore, the reason this result was not improved further was that there was a minority of students who did not exhibit any interest in studying, and what they really wanted was to assume a passive role in the classroom. Therefore, it can be concluded that the proposed methodology is attractive for students.

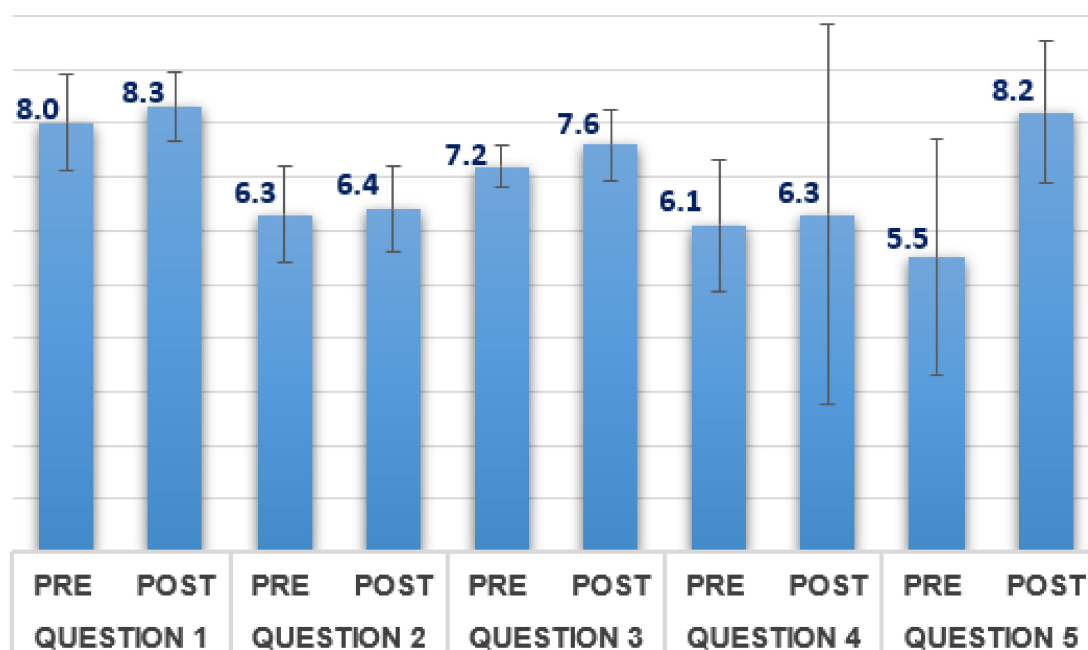


Figure 3. Results of the first five questions of the survey shown in Table 1.

## 5. Discussion

The surveyed students, in spite of being conscious of the usefulness of mathematics (as reflected by the rating of 8.0 out of 10 in Question 1), are not attracted to this subject (rating of 6.3 out of 10 in Question 2). This implies that most of them are demotivated during math classes and, hence, new alternatives to the traditional methodology (teaching the theory included in a math textbook and solving the exercises of such a book) are needed; this conclusion is consistent with the literature [3]. As previously commented in the literature section, demotivation and even anxiety are frequently present in Mathematics learning [5–10], so innovative methodological approaches such as the one presented herein are usually positively valued by the student body. In keeping with this, it was observed that, in general terms, the proposed methodology in this paper enhances students' motivation to learn (as reflected by the more active participation of students in the classroom). Furthermore, the teacher also feels motivated to teach since positive attitudes or behavior of students directly affect the teacher's feelings of encouragement [39]. A clear example of the active participation of students is the fact that each of them tends to compete against their peers for the idol who earns the most: "My idol earns X% more than yours". In this sense, the enthusiasm of the students is much higher than usual (in a traditional class).

The knowledge level of the worked content (percentages, fractions, charts, bank interest, etc.) improved with regard to previous years (when a conventional methodology was used based on an academic textbook). This affirmation is based on the lower number of students' expressions of doubt during the classes where exercises were solved and the high number of students that correctly solved those problems. Besides this, the proposed methodology favors the worked content being assimilated better than a conventional methodology and, consequently, students can remember it in the future (meaningful learning). This was checked during the classes of the following months when students worked with percentages, fractions, etc. The improvement observed in the acquired knowledge is in agreement with studies where a relation between motivation and academic performance was revealed [40,41]. Another aspect related to such an improvement could be the students' belief in their abilities, since, according to previous studies [42], this plays an important role in their motivation and learning. Despite that, a quantitative measurement of the improvement in their knowledge is not possible in this study since the final evaluation included more content than was worked on with this methodology.

The results of the questions related to student satisfaction with the presented methodology—Question 3 (Figure 3) and Question 6—reflect that students enjoyed the new methodology (a rating of 7.6 out of 10 in Question 3, and 91% preferred the new methodology in Question 6). The result of Question 4—with a lower rating than expected when compared with the rest of the questions (Figure 3)—can be explained as follows: (i) the lack of interest of some students in taking an active role in the classroom, (ii) the effort needed in daily work at home for preparing or finishing the different activities (some students do not want homework), and (iii) the work in groups (problems between peers arose in some work groups, which is consistent with the literature [43–45]). It is worth noting that some students thought—wrongly—that with our methodology they would experience “effortless” learning; hence, after the experience, they negatively rated the experience in the post-test. Finally, the results of Question 5 (Figure 3) confirm that the students considered that giving an oral presentation of their poster helped them to understand in a better way the mathematical content worked on with this methodology.

This experience reveals that a key point for motivating secondary-level students is a good methodological design that enhances the interest or curiosity of students. One of the more influential factors on good methodological design is the classroom group and the way in which small work groups are distributed. In certain cases, some students do not work in their group due to disagreements between peers. The teacher must deal with this issue very carefully to ensure the good development of the methodology. In addition, many students have difficulties meeting each other outside of high school in order to keep on working on the proposed activities, so teachers must also take this into account when they organize the small working groups.

## 6. Limitations of the Present Study and Suggestions for Future Research

The findings of the present study reflect an improvement in the level of knowledge acquired by students. Such an improvement was checked qualitatively, but not quantitatively, since the final evaluation included more than just the content developed by the proposed methodology. Thus, as in previous papers where the potential of a method is quantitatively demonstrated in the teaching–learning process of Mathematics [46], future research will be to quantitatively compare the levels of knowledge acquired by students by using the conventional methodology (following the textbook) and by using the present methodology.

In addition, the final product of this methodology (posters) can enhance other teachers' work on the specific content of other subjects (for instance, Economy, Ethics, Religion, etc.) or transversal skills (tutoring hours, etc.). The involvement of several teachers in such a multidisciplinary work could enhance the higher educative impact of the proposed methodology. As future work, we plan to improve the methodology by means of teaching collaboration between diverse departments.



## 7. Conclusions

An innovative methodological approach was presented in this paper that helps to teach mathematical content in an active way in secondary education (percentages, fractions, charts, bank interest, etc.). The results reveal that the proposed methodology does improve both students' participation and motivation in the classroom (when compared with a conventional or traditional methodology). Both aspects, active participation and motivation, are essential for properly developing the teaching–learning process, so this methodology is very interesting for Mathematics teachers at the secondary school level. Furthermore, taking into account that students expressed fewer doubts when completing exercises in class and they completed the exercises more easily, it can be concluded that our innovative methodology improves students' learning of the mathematical content. Likewise, the shown methodology strengthens some transversal skills such as oral exposition, poster planning, the analysis of social inequalities, etc. In particular, social inequality is one of the key points that make this methodology very interesting because it helps students to reflect on the privileges of living in a developed country and on the importance of solidarity with those who have not had such luck.

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