Aplicación de software matemático en carreras de ingeniería

Application of Mathematical Software in Engineering Careers

Aplicação de software matemático em carreiras de engenharia

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Resumen

Con el objetivo de encontrar vías que puedan conducir a solucionar el problema del aprendizaje de las ciencias exactas e involucrar al estudiante universitario de manera participativa y activa durante el periodo semestral con ayuda de las nuevas tecnologías, se desarrolló la siguiente metodología: *a)* se buscaron aplicaciones (*apps*) para *smartphones* que permitan cálculos; *b)* seleccionadas las *apps*, se identificaron las características para el *software*; *c)* se seleccionaron grupos en los que se pudiera probar el nuevo método; *d)* se desarrolló un banco de problemas para que los participantes los resolvieran, y *e)* se aplicó una encuesta a los estudiantes al concluir los cursos. Como resultado de esta búsqueda, se encontró que existen paquetes de *software* que pueden ser utilizados para las materias de física y que, además, cumplen con el requisito de no tener costo (por lo menos en su versión básica). Después de haber aplicado el nuevo método en tres grupos, en dos periodos semestrales diferentes y en cursos distintos, es halagüeño ver que los alumnos se interesaron por realmente aprender las ciencias exactas, e incluso por gestionar su autoaprendizaje. Los participantes fueron capaces de desarrollar una cantidad de problemas superior a la que se suele resolver con el método convencional.

Abstract

With the aim of finding ways that can lead to solving the problem of learning the exact sciences and involving the university student in a participatory and active way during the semester period with the help of new technologies, the following methodology was developed: *a)* applications (apps) for smartphones that allow calculations were sought; *b)* selected the apps, the characteristics for the software were identified; *c)* groups were selected in which the new method could be tested; *d)* a bank of problems was developed for the participants to solve, and *e)* a survey was applied to the students at the end of the courses. As a result of this search, it was found that there are software packages that can be used for physics subjects and that, in addition, meet the requirement of being free (at least in their basic version). After having applied the new method in three groups, in two different semester periods and in different courses, it is gratifying to see that the students were interested in really learning the exact sciences, and even in managing their self-study. The participants were able to develop a higher number of problems than is usually solved with the conventional method.

Resumo

A fim de encontrar caminhos que possam levar à solução do problema de aprendizagem das ciências exatas e envolver o universitário de forma participativa e ativa durante o semestre com o auxílio das novas tecnologias, foi desenvolvida a seguinte metodologia: a) buscou-se aplicativos (apps) para smartphones que permitem cálculos; b) selecionados os aplicativos, foram identificadas as características do software; c) foram selecionados grupos nos quais o novo método poderia ser testado; d) foi desenvolvido um banco de problemas para os participantes resolverem; ee) foi aplicada uma pesquisa aos alunos ao final dos cursos. Como resultado dessa pesquisa, constatou-se que existem pacotes de software que podem ser utilizados para disciplinas de física e que, além disso, atendem ao requisito de serem gratuitos (pelo menos em sua versão básica). Depois de ter aplicado o novo método em três turmas, em dois períodos semestrais distintos e em diferentes cursos, é gratificante constatar que os

alunos se interessaram por realmente aprender as ciências exatas e até mesmo gerir o seu auto-estudo. Os participantes foram capazes de desenvolver um maior número de problemas do que normalmente é resolvido com o método convencional.

Palavras-chave: aplicações, ciências exatas, dispositivo inteligente, professores.

Introduction

All the educational tools that have at some point made it possible to make improvements in higher education institutions have evolved or have been replaced by new, even more effective technologies. Currently, as a result of the vertiginous technological development of recent years, we are faced with the challenge of updating the practices and teaching-learning methods that have been used for a long time.

The educational field has not only benefited from technological developments in this digital age, but there have been several inventions throughout history that have facilitated learning within the classroom. Cajori (1909), for example, documents the use of the slide rule in engineering schools, institutes, and colleges over time. Indeed, this tool has been changing over the decades, and with it the students themselves. Thus, for example, until before the 1970s, it was common to identify an engineering student for carrying the slide rule; Later, with the appearance of electronic calculators, starting in the 1980s, two types of engineering students began to be distinguished: those who had to acquire an electronic calculator (who were normally students of upper-middle and upper classes) and those who continued to use the slide rule (generally lower-middle and lower class).

Calculators became more sophisticated as they included more and more functions, but above all they did so when they included screens (displays) through which several lines could be seen simultaneously and even the results could be plotted. For this reason, the more affluent students were able to far outperform those who could not acquire these devices to solve problems of the exact sciences at the higher and postgraduate levels.

Fortunately, the electronic calculators known as scientific calculators entered a mass production stage and the basic type (which are actually quite complete) became accessible to any pocket.

The problem of teaching exact sciences became more acute due to the fact that there was a voice in the class that said what had to be done to solve the problems that competed for the corresponding session. However, the students were not progressing as desired; teaching practice was reduced to "teaching" using chalk and a blackboard. Teaching the student to use these mathematics outside the classroom or explaining what they would be practically useful for was set aside, possibly due to lack of time.

According to Muente (2019), in recent years, there are groups of teachers who have sought, through formal and informal meetings, to establish methodologies that make exact sciences attractive to students. They have used computers that, through some software package, help them better "explain" the content of the subjects. Unfortunately, the student who does not have a computer at hand can only take note of the method used by the teacher and, with good luck, will be able to reproduce what they have been shown in class at another time.

Another very important fact is that, nowadays, students are always connected to their social networks through their smartphone. In fact, much of their time is spent on these types of social platforms (approximately 15% of their time, according to Kemp [2020]). Undoubtedly, it is a medium that can be used to attract the interest of the student to learn, understand and apply the exact sciences like never before. And with this, increase learning rates and decrease dropouts due to career change.

Theoretical framework

Since the 16th century, scientists have used devices with scales. The most emblematic figure is Galileo Galilei, who used them to calculate trigonometric formulas.

Roldán and Sampayo (2015) describe the history of logarithms before and shortly after the discovery of the American continent and point out that its inventor was the mathematician Edmund Wingate, in the mid-16th century, while others assign it to William Oughtred, in 1636 For their part, Ruiza, Fernández and Tamaro (2004) mention that concepts such as logarithmic numbers, by John Napier, would still have to arrive, whose advances were included in the slide rule for trigonometric calculations. Without ignoring that Newton himself used it to solve cubic equations, so he suggested incorporating a cursor to facilitate readings. Thus, the various contributions and suggestions of various scientists who worked various calculations shaped the slide rule. In this regard, Calvert (January 19, 2001) clarifies

that some scientists and mathematicians developed scales or standardization systems for certain types of calculations, which is why there were slide rule builders who came to have their own patents, including They find Post, Keuffel and Esser and Dietzgen in the United States and in Europe that of Dennert and Pape (constructors of the Aristo rule) and Faber, whose surname was positioned thanks to the Faber-Castell brand.

Until the early 1980s, it was very easy to recognize an engineering student because he was usually accompanied by his slide rule. But in 1972, according to Russo (February 20, 2020), two Stanford University graduates invented the first pocket calculator, which was identified by the name HP-35 (see figure 1). Initially, the HP-35 had a cost of 390 US dollars, a cost not very accessible to the average student's pocket, so it was only accessible to the wealthiest students, in addition to consuming batteries. Apart from this drawback, technological advance made it possible to have an auxiliary, very easy to use, to perform trigonometric, exponential and logarithmic calculations. Their popularity increased as their costs fell rapidly and soon cost almost the same as some slide rules, making them accessible to a large number of people. At present, it is possible to buy a scientific calculator for less than 20 pesos and the calculation rules no longer accompany the engineering student.

Figura 1. Imagen de la primer calculadora electrónica Modelo HP-35

Fuente: HP (s. f.)

On the other hand, in 1972, the patent for the first wireless cell phone was granted to Bell Laboratories, who also had the patent for the first modem, following Britos (2010) here. However, the first prototype was presented by Motorola in 1973, and until 1984 the DynaTAC 8000X model began to be marketed, which was a large, one-kilo "brick" and its battery lasted only one hour. This is the member who inaugurated the so-called first generation of cell phones. Uriarte (2020) describes that in 1990 the second generation arrived.

These cell phones opened the doors to future digital communication systems. From there came generation 2.5, which was characterized by allowing text messages and multimedia messaging.

Later, at the beginning of this century, the third generation arrived, characterized by a great diversity of advances and brands. The cell phone boom reached all countries with this generation, which included the first smartphones. At this point, communication increased at speeds never before achieved, as well as the development of very diverse applications for different types of users and their needs.

Another determining factor in the technological advances of worldwide impact was the discovery of the information super highway, which began in 1958. Castromil (March 26, 2016) attributes this advance to the AT&T telephone company, which created the Bell 101 dataset. , the first commercial modem capable of transmitting digital data over a conventional telephone line. From then on, says Uriarte (2020), there was participation of many institutions that little by little developed different technological applications: communication between computer equipment was achieved, viruses arrived, confirmation of the information super highway (World Wide Web) and the number of computers connected to the Internet grew in an incredible way.

Over time, all the technologies came together and came to form a system that users access through a mobile device (smartphone) and internet connection. Now there are approximately 3 billion mobile devices, and this number is expected to continue growing, as seen by Fernández (September 16, 2020). Figure 2 shows the number of users projected for 2021.

Figura 2. Cantidad de *smartphones* en el mundo
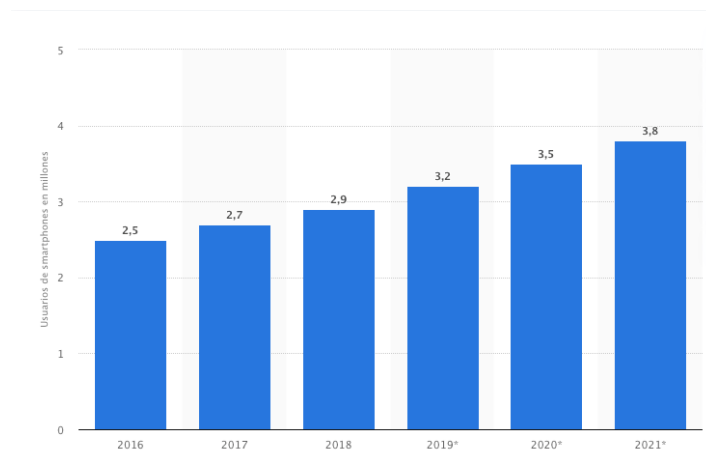
Fuente: Statista (2021)

Another determining factor that continues to impact the use of information and communication technologies (ICT) worldwide has been the development of applications, which have grown incredibly in recent years, including social networks, which group the largest numbers of users to post or view publications, to share information. A case that should also be mentioned separately from all the other developments that have taken place in the ICT universe is the large number of applications created to facilitate education (distance or face-to-face). The smart phone is not only a means to access social platforms, it is an extremely powerful educational tool for students. It facilitates the process of acquiring knowledge that in the future will be part of your profession.

Developing

To find ways that can lead to solving the problem of learning exact sciences and involve the student in a participatory and active way in the sessions of the subject during the semester period, the following methodology was developed.

  a) Find applications (apps) for smartphones that allow calculations.
  b) Once the apps have been selected, identify the characteristics for the software.
  c) Select or take the groups in which the new method will be tested.
  d) Make a bank of problems solved by the students of the course.
  e) Apply a survey to students at the end of the courses.

As the first part of this new process, apps were searched that met the following criteria: 1) that can be used during the course and 2) that are free to use so as not to cause expenses to the student.

As a result of this search, it was found that there are software packages that can be used for the subject of Physics and that, in addition, meet the requirement of being free (at least in their basic version).

Among the findings is the Squid app, which has the following functions:

  • Take notes naturally with the pencil and erase with your finger.
  • Convert graphics to vectors.
  • Supports different styles and sizes of sheet.
  • Do / undo, select, move and resize.
  • Change color and thickness of selected objects.
  • Cut, copy and paste between notes.

- Organize notes in notebooks.

- Import, cut and resize images.

- Export in PDF, PNG or JPEG to print, save or share.

- Allows you to share notes by email.

- Direct access to new notes and open notebooks.

- Toolkit: mark text, real draft of lines and figures.

- Cloud services: backup / restore and export PDF notes to the cloud (Enrique MP, 20 de octubre de 2016).

Another app that can be used to solve problems involving the hard sciences is handyCalc (Cummins, March 24, 2011). This tool is suggested for students who have difficulties when entering information in traditional calculators, that is, those students who have difficulties to visualize the mathematical algorithm that must be used to solve a specific operation or a simple or complex equation.

One more application that covers the necessary requirements to be used in the subjects where the new teaching method has to be tested is ChampCalc (MDF-XL Pages, 2018). It is very similar to traditional scientific calculators (physical), however, being an app, the power it provides for problem solving goes beyond physical calculators, which, combined with handyCalc, is a learning tool that allows you to go beyond what could be done with just one.

Regarding the characteristics that the smartphone should have, the manufacturer of each of the apps was consulted and it was found as recommendations that the device work with the Android operating system and have a minimum of 32 gigabytes.

The new method was worked with several groups. The initial group was 40 students from the 1st semester of the engineering career in Business Management and the subject of Introduction to Physics during the period August-December 2018.

The next period in which the method was put into operation was August-December 2019. A group from the 3rd semester with 30 students from the Public Accounting career in the field of Basic Statistics participated here. In the same period, there was another group of 35 students from the 5th semester of the engineering career in Business Management and the subject of Inferential Statistics.

Process to facilitate the understanding of mathematics using the smartphone and apps

Because in professional educational institutions the teacher is encouraged to use tools that make the subjects to be taught each semester more interesting, and because, in general, mathematics with its own name represents a problem for the teacher. student in general, a way was sought to make the teaching of these less tedious and for the student to be interested in them, seeing that they are really a simple way not only to meet academic credits, but that they are the basis of many of the jobs that they will be able to face in their life as professionals. Thus, a first attempt was made to make the courses that involve knowledge that have always been difficult to understand more interesting and attractive.

At the beginning of this procedure, there were no statistical references of the knowledge that the first semester students have, since they come from the upper secondary level and different educational institutions, so it was considered that each of the students gathered different knowledge and the objective was that at the end of the course they would have a homogeneous knowledge.

As part of the course, the students were explained how the course would be conducted and their consent was requested to proceed in this manner, which was achieved immediately.

Next, they were asked about the qualities of the smartphone that they use continuously. Here I was interested to know if they had the necessary hardware characteristics so that the software could run without any problem.

The responses they expressed were impressive: only two of them had a smartphone with a minimum capacity of 32 gigabytes and the rest had 64 and 128 gigabyte memories, that is, they were equipped with better equipment than the teacher.

On the second occasion (in each of the courses in which the new method was put into practice), the conditions were the same. It seems that the student in general has high-end devices and thus can do any query on the Internet with speed.

Students in the 3rd and 5th semester groups were asked to see their previous grades in the subjects where the exact sciences appear. The grades they obtained in general terms ranged between 72 and 87, for which the goal was to increase this average, in addition to giving them a taste for the subjects of the degree.

It should be clarified that, due to the fact that currently higher education institutions have an internet link that sometimes works very well and sometimes does not, students

sometimes had to go to use the data from their smartphones, without this having an impact on obtaining the results of the problems that were solved as part of the course.

The course

After everyone downloaded the apps and installed them on their cell phones, in the second session, the first test of the software that was going to be used during the semester was carried out. Using the classroom video projection system, the first equation was introduced to the teacher's tablet and the students were seeing how it was written, reproducing the event as the teacher did. The first example that was presented through the video projector was the 2nd grade feature, as shown in Figure 3.

**Figura 3**. Función de 2.º grado con la que se dio inicio el curso
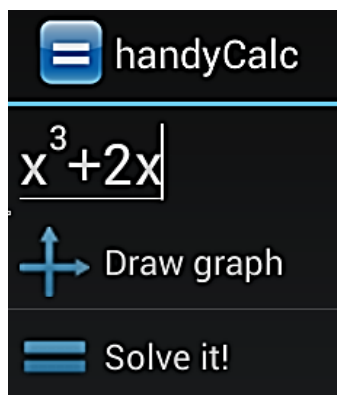
Fuente: Elaboración propia

The students immediately realized that it was easier to solve the problems using the new method, since from now on they would not have to bring with them the scientific calculator that most of them had acquired.

Figure 4 shows the result of the entered function (which is the one shown in figure 3), and with both the meaning was explained and they were shown how to interpret the data, which they did to verify that any function to be solved in a simple way and thus for the first time they related an equation to the results.

Figura 4. Gráfica que se desplegó de la función que se introdujo
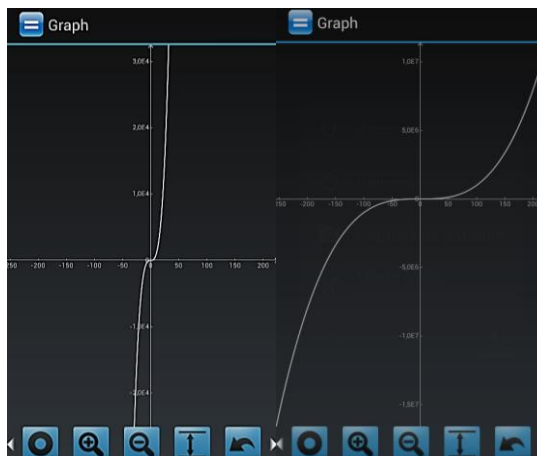
Fuente: Elaboración propia

Figure 5 shows the group of students doing the process shown by the teacher. The students used their smartphones in the subjects they were taking without using a traditional scientific calculator.

Figura 5. Estudiantes introduciendo la misma ecuación y viendo sus resultados

Fuente: Elaboración propia

As can be seen in figure 5, the students distributed themselves in the way that was most appropriate for them and shared the results they obtained, something that could not be done when they used the scientific calculator, which they forgot from day one.

Figura 6. Estudiantes sustentando una evaluación

Fuente: Elaboración propia

Figure 6 shows that, when supporting an exam, the seating arrangement is the one that has always been had in all educational institutions, that is, in rows. In both figures (5 and 6) it can be seen that there is not a single student who is using a laptop, only his smartphone.

It should also be mentioned that the students commented that they had the habit of listening to the teacher when he was writing on the blackboard and explaining what he was doing and they only dedicated themselves to copying and, on some occasions, doing some calculation on their calculator, in addition to copying what that was being written on the blackboard.

With this method more problems of the matter could be solved; They understood most of the concepts and above all they were able to relate the theories to their possible applications, that is, they began to learn exact sciences without using a scientific calculator.

During the course of the semester, the level of difficulty of the problems increased, as it is specified in the study program of the subject.

Therefore, the results obtained with the software installed on the smartphone were linked with the spreadsheets, so they were shown the design of the sets of instructions that can be executed sequentially in the spreadsheet and which are known as macros. As is known, a macro has the great advantage that it can invoke another and this one to another, so they can be implemented separately and stored to be used in the problem that requires it. Through this practice, they were able to explain how to design their own equations to solve the problems that they considered the most difficult within each topic.

And in order to get the most out of the functions that can be developed in Excel through the use of macros, Visual Basic was also used, which allows the creation or maintenance of

the macros that have been created, but, above all, that once stored they can be invoked from any other macro that they are instrumented.

Thus, for example, the student is provided with a data set like the one shown in table 1, and he is asked to perform the calculation of the trend measurements with his smartphone, using handyCalc and a macro.
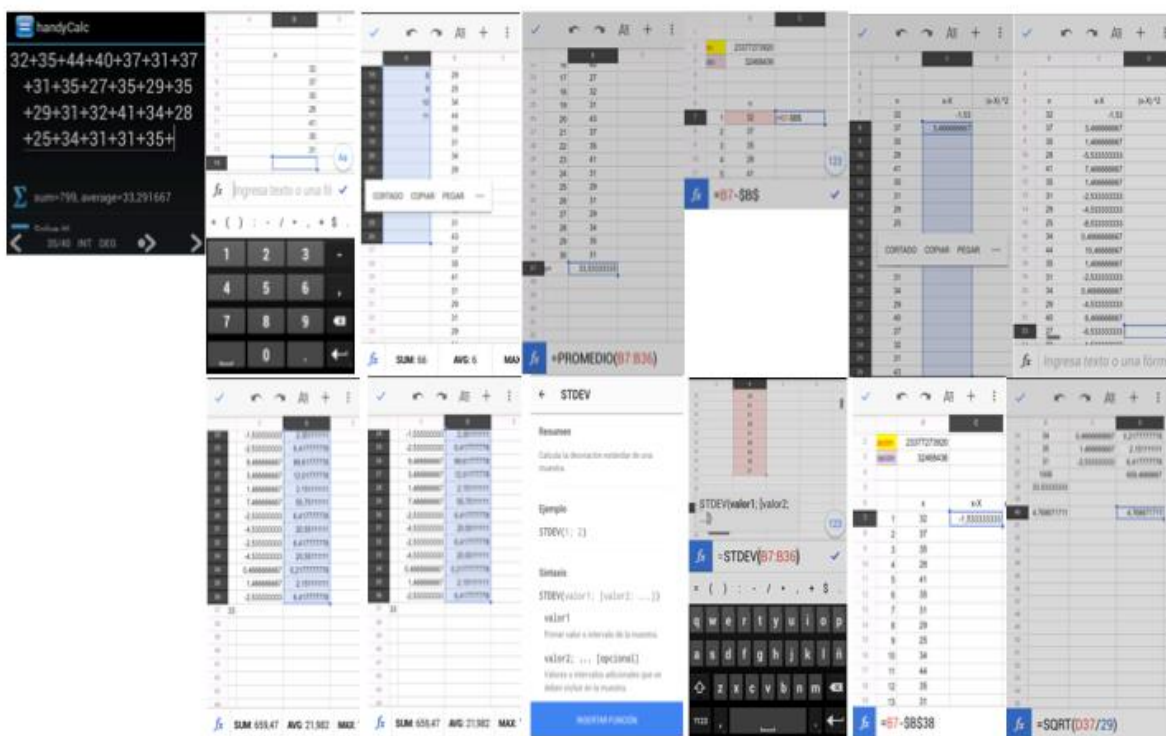
Tabla 1. Conjunto de datos iniciales

32	35	44	40	37	31
37	31	35	27	35	29
35	29	31	32	41	34
28	25	34	31	31	35
41	34	29	43	29	31

Fuente: Elaboración propia

The result provided by the student is shown in figure 7, where the data that is being introduced and transformed until the final result is obtained.

Figura 7. Secuencia de pasos para solucionar el problema propuesto en la tabla 1

Fuente: Elaboración propia

At the same time that the method was applied for the second time, a course was structured for teachers in the area of exact sciences. The main purpose of this course was to show you that the era of using the new tools has arrived. The 40-hour course was taught during the inter-monthly period, in January 2018. Throughout this, they were told about the benefits of using the smartphone to teach and apply exact sciences in the classroom. Directly with students and thus encourage them to join in not only using the smartphone to enter social networks, but also to make the most of it in their courses.

At the beginning, the teachers who studied using the slide rule and those who used the calculator (the majority being the latter, many of whom were those with whom the "new teachers" took their classes when they studied engineering at the same institution , so it was a very delicate situation to address, that they did not feel that it was about displacing them, much less showing them that it was time for them to retire, nor for them to show a negative reaction to change the new for what gave results for a very long period of time) initially they believed that it was one more course to fill the preparation space that all teachers must have in their educational institutions.

Therefore, they came with their calculators, which have a large number of functions and have used for many years. The content of the course was explained, they were asked to take out their smartphone and download the required applications (the same ones that were used with the students), and the explanations began as it happened in the first group of students. Some took their calculator because they did not believe that the results were being obtained with a greater number of approximation digits and began to be interested in being updated in the use of these applications and with the aim of obtaining better results in the teaching of exact sciences.

Unfortunately, we could not verify this, that is, that they have put it into practice in the period August-December 2018; And if they took it very seriously, then they discovered an excellent tool to apply it in current conditions, that is, at a distance.

At the end of the three courses that were taught using the new method, a survey was applied, which was made up as follows:

1)   What is your opinion now of mathematics?

◊   I don't know

◊   Easier

◊   They are the same

2) How are your results with this method?

    ◊ Best

    ◊ Worst

    ◊ Equal

3) Would you recommend the method for your other courses?

    ◊ Yes

    ◊ No

    ◊ It will depend on the teacher

4) Did you have trouble understanding the course?

    ◊ Yes

    ◊ No

It should be noted the fact that it was always applied at the end of the course, with the intention that, already knowing their qualifications, they could answer in the most honest way possible.

Results

The surveys applied to the students show how the courses were perceived among the three groups. It is worth mentioning that it has been a very satisfactory professional experience. Having started with an experimental type of work in favor of learning is giving rise to the beginning of an era (using applications through smartphones instead of expensive calculators) and the end of another (that expensive calculators become obsolete).

As part of the results obtained by the students, it must be said that there were no failures.

The responses to question one of the survey, which was "What is the student's opinion about mathematics after taking the course with this method?", Are shown in Figure 8.

Figura 8. En la pregunta uno se refleja que la aplicación del método facilitó la comprensión de la materia

	Grupo 1	Grupo 2	Grupo 3
NO SÉ	2	0	0
MÁS FÁCIL	35	26	33
SON IGUAL	3	4	2
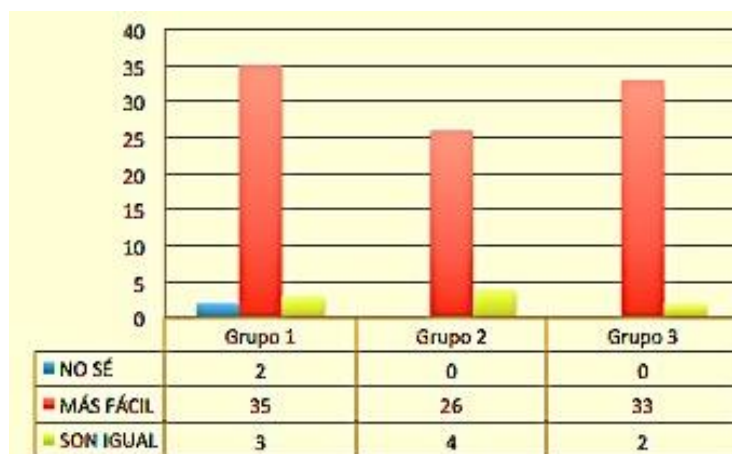
Fuente: Elaboración propia

From this it is concluded that the vast majority of the participants were greatly facilitated with the way of taking the course and found that they can not only use the smartphone for social networks, but also to acquire the knowledge that will be of great benefit and help in his professional life. However, it can also be observed that in the three groups there are students who continue to consider that the result with any method would be the same, and there were also the clueless who do not know what could be better for them.

The results of question two, which was "How do you think the results you obtained when using this new teaching method are?" Are shown in figure 9. The answers obtained are in favor of using the new method, leaving behind the expensive calculators, just as most students put it.

There were also responses that indicate that there is no change between the traditional method (exposure-explanation-exercises-task-calculator) and the one used here. It stands out that the first group had two students who claim that the results were worse.

Figura 9. En la pregunta dos se les cuestionó cómo fueron los resultados que
obtuvieron con este método

	Grupo 1	Grupo 2	Grupo 3
■ MEJORES	37	28	31
■ PEORES	0	0	2
■ IGUALES	3	2	2

Fuente: Elaboración propia

Question three, which consisted in knowing if the students would be willing for the same method to be followed in their other courses where the exact sciences appear (see figure 10), showed that many students would agree that the teachers who cover these Subjects will be trained to be able to teach courses using the new method, which is because it is simpler and more attractive, and highlights the fact that they cover a greater amount of material, which makes their course more complete and interactive.

Figura 10. En la pregunta tres se muestra que la mayoría de los estudiantes está dispuesto a continuar con el método en sus demás cursos

	Grupo 1	Grupo 2	Grupo 3
■ SI	33	27	30
■ NO	1	1	1
■ DEPENDERÁ DEL DOCENTE	6	2	4
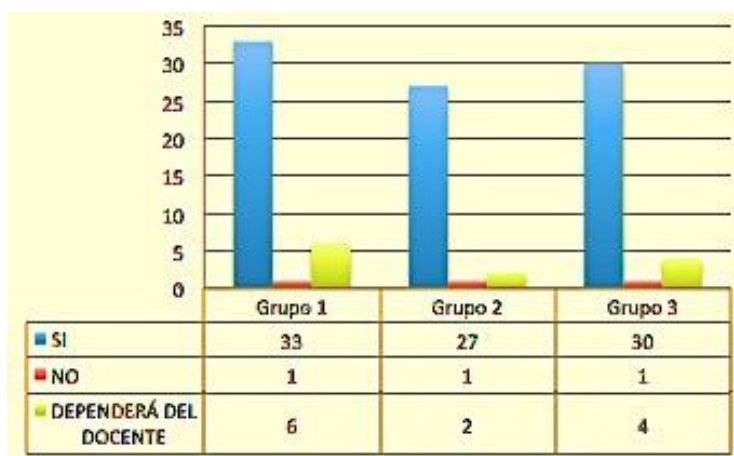
Fuente: Elaboración propia

Unfortunately, there were some students who, regardless of having obtained higher grades and better and more knowledge, insist on returning to the traditional method.

Figura 11. Resultados de la pregunta cuatro sobre la cantidad de conocimientos que
adquirió durante el curso

	Grupo 1	Grupo 2	Grupo 3
SI	39	29	33
NO	1	1	2
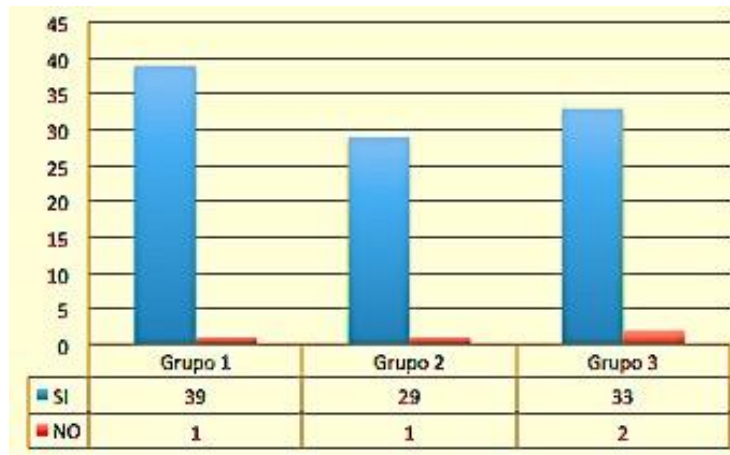
Fuente: Elaboración propia

Finally, Figure 11 shows the results regarding question four, which revolves around understanding the course. After having applied the new method in three groups, in two different semester periods in different courses, it is gratifying to see that the students have taken an interest in really learning not only the exact sciences, but also in managing self-learning. Participants were able to develop a higher number of problems (250 different problems and not from the class) than is done with the old method (28 different problems and not from class) in the group of 35 students from 5th grade. semester of engineering in Business Management and the subject of Inferential Statistics.

There were also negative responses that lead us to make continuous improvements to the method, in such a way that it is an adaptive method to changes in the devices used, the software and the plans and curricula that are part of the grid.

Now, on the side of the course that was taught to 20 teachers in the area of exact sciences, we still do not know whether or not they have applied what they have learned in their groups. We hope and trust that this is the case, especially because in this time when education is being carried out at a distance, it would be a tool that would give the optimal performance to them and their students.

Discussion

Having started a new professional experience in an experimental way using the new information and communication technologies can be seen as a starting point for the now student (professional of the near future) to lose the fear of exploring new opportunities in the that may or may not test their knowledge, as has happened with the teachers who started this new way of teaching mathematics.

It may not have been the best of the possible ways that could exist for them to understand mathematics, but it was the first step (true or not) for the teacher to shed traditional ways, of being the only person who speaks during the entire semester period when a mathematics course is being taught.

Perhaps many students will have woken up and others will not, perhaps many other teachers will not agree with the content and tools that have been used in these courses, but everything done here can be improved, and with the participation of many other teachers and a greater number of students will be able to do specialized teaching jobs that allow to benefit a greater number of participants.

Conclusions

Participating students were willing to use the smartphone with the intention of learning more easily and improving their grades. The teacher, in general, is used to teaching his subjects in a certain way, without experimenting with new methods, often replicating the method applied when he was a student. However, many of us had the opportunity to learn with teachers who were always innovative in their field and dared to improve the learning conditions of their students. In the present case, we try not to be static in the teaching and learning methods, like some teachers with whom we had contact during the career.

It is also necessary to mention that there are other teachers who still refuse to change their way of imparting their teachings and put us in predicaments by trying to involve them in setting up new scenarios that favor the student.

Future Research Lines

The procedure that was used, the way it was developed and the results that were obtained have been disseminated in different educational institutions. Many of the teachers found it very interesting to be able to participate in making improvements and carrying them out in their courses, while others are still incredulous about the procedure and the application of technology in the classroom and therefore refrain from participating .

Due to all the above, exclusive courses have been designed to show teachers the benefits of this procedure, based on the fact that some of them will have to be given explanations from the use of the smartphone they have so that they can participate actively .

Courses have been designed using the smartphone, tablet and computer to be applied online and remotely.

In each of the cases, the participants are expected to make suggestions that allow us to enrich the chosen process and thus have continuous improvement.

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