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Methodology for teaching programming: Integrating best practices in the teaching and learning process with undergraduate students

Metodología para la enseñanza de la programación: Integrando las mejores prácticas en el proceso de enseñanza y aprendizaje con estudiantes universitarios

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Abstract

There is a wide variety of methodological proposals for teaching programming. In general, the purpose of each of them is to improve students' academic results. However, at the higher level, there is not one that integrates several of them in a methodology that includes some of the best practices that have had successful results in the academic and professional environment. This study aims to apply a methodology called CAAIPP that integrates the inverted classroom model, pair programming and an online support course, to measure its effect on the learning of students in the Software Development and Management Engineering program. The methodological approach used was mixed and the design was experimental. The results show that the group that received the treatment obtained the best academic performance; likewise, the students expressed that the methodology was beneficial for understanding concepts, preparing their internships, and programming their final project.

Methodology, Teaching, Programming

Resumen

Existe una gran variedad de propuestas metodológicas para la enseñanza de la programación. En general el propósito de cada una de ellas es mejorar los resultados académicos de los estudiantes. Sin embargo, en el nivel superior, no se encuentra una que integre varias de ellas en una metodología que incluyan algunas de las mejores prácticas que han tenido resultados exitosos en el ámbito académico y profesional. Este estudio tiene como objetivo aplicar una metodología denominada CAAIPP que integra el modelo de aula invertida, la programación en parejas y un curso de apoyo en línea, para medir su efecto en el aprendizaje de los alumnos del programa de Ingeniería en Desarrollo y Gestión de Software. El enfoque metodológico utilizado fue de tipo mixto y el diseño de tipo experimental. Los resultados reflejan que el grupo que recibió el tratamiento obtuvo el mejor desempeño académico, así mismo, los alumnos expresaron que la metodología fue de beneficio para comprender conceptos, elaborar sus prácticas y programar su proyecto final.

Metodología, Enseñanza, Programaciónn

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Introduction

Numerous studies agree that the teaching of programming has been a recurring problem in recent years. It is common to find demotivation and frustration among students; it is also frequent that courses are reduced only to syntactic structures (Villalobos, 2009). Using a compiler of a specific company forces to write certain codes in its own way or limits the use of others; in this way, one learns directly to program on the language, but without orienting the student towards creativity, problem-solving and logical abstract reasoning (Pérez, 2015). These ways of teaching programming often contribute to rejection, demotivation and difficulty in achieving learning. Unfortunately, students often experience fear and intimidation regarding introductory programming language courses (Sun, 2018). Likewise, (Adu, Arthur & Amoako, 2013), they cite that in the face of this problem, teaching, methods and strategies cannot be ignored as important factors that contribute to the high rate of failure or dropout in programming students.

There are also various investigations on the teaching of programming, some of them with successful results, however, much is limited to analyzing each of the methods or tools separately and not to the development of a methodology that could use and combine some of the best practices of these works. Therefore, this study proposes the use of a methodology based on successful teaching elements used in the teaching of programming, which integrates the use of an online support course to the face-to-face course, the flipped classroom model and the pair programming technique, as an interesting element to reduce the failure rate of programming students.

Currently, there is a wide variety of online learning platforms, some of which are aimed at offering MOOC courses (Massive Online Open Courses), which are developed by the main and most prestigious universities in the world for free. There are also other platforms that offer courses developed by professionals in their fields at very low costs. This type of platforms and their courses can be used as a support to face-to-face classes, especially in public institutions which do not have the budget, financial and human resources to produce materials and multimedia products with the quality that characterizes these courses. Some learning experiences have been carried out using virtuality as a tool to face-to-face teaching at the higher level, with the result that students perceive this strategy as an excellent, dynamic and innovative way to carry out the teaching-learning process at the university. (Varguillas & Bravo, 2020).

Likewise, it is of interest to mention that in a study carried out at Prince of Songkla University, using the flipped classroom model for teaching programming, it had the result, according to (Pattanaphanchai, 2019), that the students who took their courses in this model showed higher programming ability than that of students in the previous year's traditional teaching class environment. Another study done by Pontificia Universidad Católica de Valparaíso yielded results showing that the model can improve students' grades and achievement of learning outcomes. In addition, students had a positive opinion of the model in relation to the fact that it improved their learning and performance, and increased their motivation and interest in the course (Griffiths et. al, 2016). One of the techniques in software development is pair programming:

> Pair programming is a common practice where two programmers work together on the same task using a computer. One of the programmers (the driver) writes the code and the other (the observer) actively reviews the work done by the driver. Essentially, the observer reviews the work to detect possible defects, takes notes or defines strategies to solve any problems that may arise in the task they are working on (Gomez, et al).

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Applying this method in the process of teaching programming greatly improves students' performance (Lewis, 2011), they can complete tasks faster and with higher quality, communication is improved, they are happier and less frustrated (Williams & Upchurch, 2011).

Methodology

The development of this study was carried out taking into account the following aspects:

A. Type of research

The methodological approach of this study is of mixed type because it aims to collect statistical data on the study variables, as well as the perceptions, problems and good practices of teachers and students on the process of teaching programming. Therefore, the design employed will be experimental, since an emergent teaching-learning methodology (independent variable) will be applied to a sample of students to subsequently analyze the participants' academic performance results (dependent variable).

In summary, the methodological approach used will be mixed and the design employed will be experimental, contrasting the data by means of descriptive and correlational studies.

B. Resources

For the development of the research, four professors who are members of the academic staff of the ICT program participated as human resources. As well as professors and first year students of Information Technology Engineering at the Technological University of Southern Sonora. Additionally, three experts in teaching programming were integrated. The population of participants in this research consisted of 64 first-year students. Divided into three groups (A, B and C), where only group A, 20 students made up of 16 males and 5 females between 17 and 19 years of age from the morning shift, received the treatment designed in this research since this sample is where the scope for the teaching of the class was taken. This population is defined because it takes a sample of the three groups by the scope of the teacher as support for this research.

Likewise, as a material resource, the program of the subject, the didactic guide, the work plan of the research, the intervention plan of the methodology used and various evaluation instruments such as the Ceneval exam were considered; applied to students before entering their first four-month period in order to detect the initial skills of analytical thinking, a fundamental aspect to achieve skills currently required in programming. Also, two other questionnaires were used for the development of the research, which consist of two evaluations applied to students to obtain their performance in programming skills and an interview instrument for expert teachers who teach this type of subjects, as well as content analysis of some materials for the presentation of results.

C. Procedure

For the application of each of the tasks in this study, first and as mentioned in the previous paragraphs, the type of research and the elements that integrate it are defined; as well as the human and material resources necessary for the orderly execution of this study. Subsequently, the planning of the educational intervention was used to prepare the courses of programming methodology, programming and development of web applications of the Information Technology Engineering program. This planning was based on the integration of a methodology called, for this study, as CAAIPP which is composed of the flipped classroom model (AI), the paired programming method (PP) and as support to the face-to-face classes an online course (CA) according to the contents of the subjects. As can be seen in Figure 1.

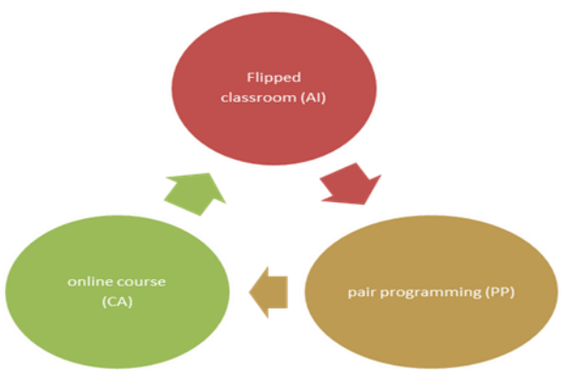

Figure 1 CAAIPP: ICT-based emerging methodology for teaching programming
Source: Own elaboration

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As for the support courses used during the first four-month period, we worked with the programming logic course, which is available on the Get trained for employment platform. This course served mainly to provide the videos, readings and materials that were used for the flipped classroom sessions. Subsequently, for the second quarter, we opted to acquire a low-cost course on initial programming on the Udemy platform, considering as part of the methodology to receive an online course to support the subject and to have quality multimedia materials. The course selected for this is called "Learn to program in c# and build a point of sale".

Finally, moodle was used to store evidence of the course activities, also as an institutional requirement for the follow-up and progress of the course contents. Subsequently, after 6 months of treatment using the CAAIPP methodology, the face-to-face classes were interrupted due to the Covid-19 contingency. One of the most important elements that were affected were the flipped classroom sessions in the face-to-face part of the methodology and the evaluation practices through observation, continuing only with the pair programming and the online support course. At the end of the course, the evaluation instrument was applied online to the control group and the other 2 remaining experimental groups. Three interviews were conducted with teachers of the program who have the most experience in teaching subjects related to programming. The results obtained can be seen in the corresponding section.

Results

After the methodology was applied for 4 months to the control group throughout the initial four-month period of study. First: a diagnostic instrument was applied at the beginning of the second quarter to the entire population of students participating in this study. This instrument consisted of the development of programming logic exercises, which included sequential control statements, decision statements and cycles. If they so desired, a tool for the development of pseudocode was used. The results of skills reflect that the group that received the treatment had the highest academic performance.

Results of the control group:

Points	Performance level
15	Excellent
14 - 12	Satisfactory
11	Under development
Between 10-6	Attention
<=5	Insufficient

Table 1 Performance levels for measurement
Source: Own elaboration

No.	Registration	Points earned
1	5319100019	15
2	5319100042	14
3	5319100071	0
4	5319100074	15
5	5319100341	15
6	5319100088	15
7	5319100370	5
8	5319100369	15
9	5319100128	4
10	5319100388	15
11	5319100177	13
12	5319100190	14
13	5319100229	8
14	5319100233	14
15	5319100246	13
Total group over 15 points.		11.666

Table 2 Diagnosis to Control Group: TIDSM2A. Group A-Scale 1-10 = **7.77**
Source: self made

The results of experimental groups 1 and 2 are shown below:

- Application of the Diagnostic Programming Logic Exam.

No.	Registration	Points earned
1	5319100637	5
2	5319100274	11
3	5319100560	15
4	5319100097	12
5	5319100564	4
6	5319100584	10
7	5319100411	7
8	5319100423	11
9	5319100429	11
10	5319100440	11
11	5319100458	13
12	5319100218	13
13	5319100619	15
14	5319100235	11
15	5319100626	14
16	5319100502	10
17	5319100245	11
	Total group over 15 points.	10.823

Table 3 Diagnosis of Experimental Group 1 TIDSM2B. Group B-Scale 1-10 = **7.21**
Source: Own elaboration

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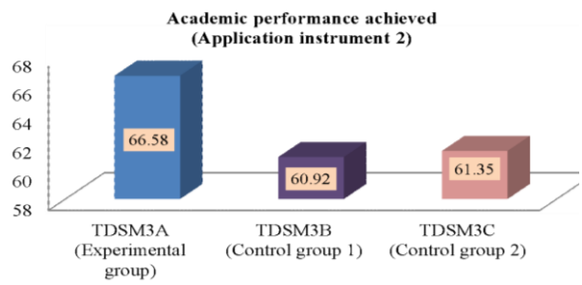
No.	Registration	Points earned
1	5319200001	3
2	5316100061	15
3	5319100535	15
4	5319100030	8
5	5319100293	6
6	5319100544	15
7	5314100515	0
8	5315100437	13
9	5319100559	11
10	5319100350	13
11	5319100353	7
12	5319100645	1
13	5319100571	10
14	5319100118	6
15	5319100176	0
	Total group over 15 points.	8.2

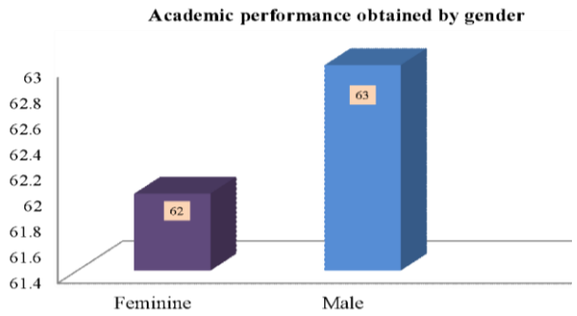
Table 4 Diagnosis of Experimental Group 2 TIDSM2C. Group C-Scale 1-10 = **5.46**
Source: Own elaboration

Subsequently, after 6 months of treatment using the CAAIPP methodology, the face-to-face classes were interrupted due to the Covid-19 contingency, which was mentioned earlier in this document. One of the most important elements that were affected were the flipped classroom sessions in the face-to-face part of the methodology and the evaluation practices through observation, continuing only with the pair programming and the online support course.

The second step was to apply the evaluation instrument to the control group and the other 2 remaining experimental groups at the end of the second four-month study period. The following results were obtained:



Graphic 1 Performance of groups of third TIDSM program in OOP
Source: Own elaboration



Graphic 2 Performance of groups of third TIDSM program in OOP
Source: self made

It can be seen in the first graph that the experimental group performed better than the control groups. Likewise, in the second application of the evaluation tool, the control group again outperformed the experimental groups by 6 percentage points.

Thirdly, interviews were conducted with teachers, where a huge area of opportunity for teacher training in the didactic and pedagogical area was observed. It was detected that there is a lack of best practices of innovation in the classroom, which could improve the academic results of the students. The academics, despite having a wide experience in their engineering discipline, in terms of their work method, their classes are closer to traditional teaching.

This study addressed the integration and use of three of the best practices in programming through the development of a methodology called CAAIPP, where we found that through its application the performance of students who received the treatment was higher than those who did not receive it.

The results coincide with other research mentioned in this work, where the application of innovative methodologies and tools in the teaching of programming have improved the performance results of the skills in programming students. The students expressed that the methodology was beneficial for their achievements, especially the online course based on videos was useful for them to understand concepts, elaborate their practices and program the final project. They consider that working in pairs helps them to provide feedback to each other.

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In terms of teaching practice, it is advisable to experiment with the inverted classroom model, pair programming and the use of online support courses for teaching programming, trying to integrate in class those that provide the best results.

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Conclusions

Through this research it was possible to understand and apply a combination of best practices, discovering new alternatives to traditional teaching, using as a medium information technologies, communication networks, approaches or theories of knowledge that establish how we should teach today. We were able to explore some training platforms that have excellent quality courses, all based on the production of content through audiovisual materials (videos, images, graphics and animations), resulting in the taste of students and offered for free or at a very affordable price. This makes it possible to have materials that could not be produced by some institutions due to university budgets and teachers' time availability. It was also proven that innovative methods such as the inverted classroom can have a beneficial impact on students, as well as the collaborative construction of knowledge through pair programming.

This project, being based on current methods and technologies, can be perfectly implemented in a distance modality and solve the problems and limitations that could continue to exist regarding the prevalence of this COVID-19 contingency.

It is recommended the use of innovative methodologies in the teaching of programming, it is very useful for students to have online courses based on videos as it allows them to reinforce the topics that have not been clear to them, the availability of the material at any time is one of the great advantages.

The research applied using the CAAIPP methodology should be expanded due to the limitations that were had for its correct and complete execution, since due to the COVID-19 contingency some characteristics of inverse classroom and pair programming were not applied, as well as the implementation in totally remote modality to complement the results of this work.

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