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Artículos científicos

Evaluando la efectividad del aula invertida y de un laboratorio virtual para alumnos de educación básica durante la pandemia

Evaluating the Effectiveness of a Flipped Classroom and a Virtual Laboratory for Elementary School Students During the Pandemic

Avaliando a eficácia da sala de aula invertida e de um laboratório virtual para alunos da educação básica durante a pandemia

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Resumen

La pandemia de covid-19 ha provocado la incorporación de novedosos métodos de enseñanza, tal es el caso de la estrategia del aula invertida, la cual, mediante la incorporación de elementos de videoconferencia y lecturas previas, permite transmitir el conocimiento con mayor flexibilidad y que el alumno se apropie de este. Este estudio investiga los efectos del aula invertida desde la percepción de estudiantes de educación básica durante la pandemia actual. La muestra estuvo compuesta por 16 estudiantes entre los 9 y 10 años de edad que cursaban el periodo académico 2020-2021 (Tolcayuca, Hidalgo, México). Se administraron y examinaron encuestas idénticas a través de estadísticas descriptivas y pruebas no paramétricas. Se encontraron diferencias estadísticamente significativas entre las pruebas previas y posteriores: los estudiantes mejoraron en las últimas. La mayoría de los estudiantes tuvo una percepción positiva sobre el aula invertida; se destaca la ventaja de las actividades prácticas en clase, así como una mayor autonomía en el aprendizaje.

Palabras clave: aprendizaje, aula invertida, enseñanza, pandemia.

Abstract

The covid-19 pandemic has led to the incorporation of novel teaching methods, such is the case of the flipped classroom strategy, which, through the incorporation of videoconferencing elements and previous readings, allows transmitting knowledge with greater flexibility and allows the student to appropriate it. This study investigates the effects of the inverted classroom on the perception of basic education students during the current pandemic. The sample consisted of 16 students between the ages of 9 and 10 years old in the 2020-2021 academic year (Tolcayuca, Hidalgo, Mexico). Identical surveys were administered and examined through descriptive statistics and nonparametric tests. Statistically significant differences were found between pre- and post-tests: students improved in the latter. Most students had a positive perception of the flipped classroom; the advantage of hands-on activities in class is highlighted, as well as greater autonomy in learning.

Keywords: learning, flipped classroom, teaching, pandemic.

Resumo

A pandemia de covid-19 tem levado à incorporação de novos métodos de ensino, como é o caso da estratégia de sala de aula invertida, que, ao incorporar elementos de videoconferência e leituras prévias, permite que o conhecimento seja transmitido com maior agilidade e que o aluno se aproprie dele. Este estudo investiga os efeitos da sala de aula invertida na percepção de alunos da educação básica durante a atual pandemia. A amostra foi composta por 16 alunos com idades entre 9 e 10 anos que estudavam no período acadêmico 2020-2021 (Tolcayuca, Hidalgo, México). Pesquisas idênticas foram administradas e examinadas por meio de estatísticas descritivas e testes não paramétricos. Diferenças estatisticamente significativas foram encontradas entre o pré e o pós-teste: os alunos melhoraram neste último. A maioria dos alunos teve uma percepção positiva da sala de aula invertida; destaca-se a vantagem das atividades práticas em sala de aula, bem como maior autonomia no aprendizado.

Palavras-chave: aprendizagem, sala de aula invertida, ensino, pandemia.

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Introduction

Currently, technological development is a great ally in the teaching-learning process. Precisely, to encourage the interest of the so-called digital natives, innovative alternatives are constantly sought through information and communication technologies (ICT) with the intention that the student builds, appropriates and transforms digital experiences into knowledge.

Various active learning strategies have emerged in recent years. Among them is the proposal by Bergmann and Sams (2014), which, through the use of ICT, is mainly based on sharing didactic resources in digital formats, videos, readings, and virtual laboratories, which serve as reinforcement before and after during sessions. In academic terms, this pedagogical approach is known as an inverted classroom (flipped classroom in English) and, as we said, it emphasizes the review of materials previously developed by the teacher in order to transmit knowledge of the topics covered (Martínez, Esquivel and Martinez, 2015). In short, it is about making the most of the sessions, enriching them with discussions, with the implementation of previously reviewed knowledge, which is reaffirmed in the work sessions; through the resolution of problems, clarification of doubts and generation of debates, among other activities, that strengthen the teaching-learning process.

One of the objectives of the flipped classroom is for the subject to be an active and responsible entity for their own learning, in addition to being able to acquire skills such as social and attention skills, all with the aim of improving their academic performance, as show the results of the research by Hamre and Pianta (2005). It also seeks to encourage student motivation through the dynamics of virtual materials. Finally, one of the practices used to achieve the above is constant monitoring and evaluation of students.

On the other hand, the teacher develops various roles that distance him from the traditional instructor: guide, counselor, and companion at the various levels of learning (Cedeño and Vigueras, 2020; López, Nó, Martínez, and Conde, 2018). This in order for students to stop being passive recipients of content and become the builders of their own knowledge. (Tourón et al., 2014).

In the flipped classroom model, the development of the student's autonomy in their learning outside the classroom is achieved through the contents: video classes, slides and other didactic resources on online educational platforms. Of course, it is about multimedia resources and the readings provided by the teacher guide the student in solving doubts and that the development of practical activities is interactive using tools such as virtual laboratories. In this regard, these have been defined in various ways, among them we can cite the definition of (Infante Jiménez, Cherlys., 2014.Unesco 2010): "An electronic work space designed for remote collaboration and experimentation in order to research or other creative activities, and processing and disseminating results through widespread information and communication technologies”. Virtual laboratories stand out for their visual impact and their animation characteristics, which simulate the environment of a real laboratory.

For all these reasons, to complement the theoretical aspects and reinforce the development of other skills such as digital ones, in this work a virtual laboratory is used in parallel to the flipped classroom (Paredes and Parras, 2022). Virtual laboratories, that is, spaces that iteratively incorporate technological and pedagogical aspects, have provided support to students in this recent era of the 2019 coronavirus disease (covid-19) pandemic and are gaining importance as simulators. environments where they can experiment without having to spend on materials. Thus, in this work the methodology of the flipped classroom and the use of a virtual laboratory are combined in a basic electronics course aimed at basic level students with the purpose of providing knowledge that at their age is innovative and useful in other levels of his academic background.

The virtual laboratory that is used in this work is TinkerCAD, a free application that simulates models or objects in three dimensions, creates electrical circuits on a breadboard, and develops computer code. Specifically, the use of virtual laboratories plays an important role for students pursuing careers based on science and technology, and in times of pandemic it allows to continue with technical work at home. This type of virtual tools have partly solved the development of practices that at other times could have been carried out in face-to-face environments. Indeed, as observed in the following investigations, the use of the flipped classroom and this type of laboratory have been relevant to face the challenges in terms of distance practices. (Mendoza, 2020).

Among the various works in this field, the one proposed by Pinto, Porto, Battestin and de Oliveira (2020) stands out, who made use of both concepts in question to enhance the teaching-learning process in a fully online robotics subject. The methodology and the implementation of the technological tool, conclude these authors, are useful strategies for subjects where the use of laboratories is necessary.

However, teachers must have training processes for the adoption of virtual laboratories. Novak (2019) urges to re-educate the teacher in activities that involve the use of new teaching methodologies. That is to say, include training so that they know the characteristics of new technologies such as virtual reality and even mastery of work platforms such as Classroom and Moodle, among others, with the purpose of designing better strategies for the implementation of the educational resources.

In the case of the study proposed by Lesku, Ozirny and Zhang (2021) they use the use of the flipped classroom to explain concepts of augmented reality in times of pandemic. In the end, these researchers found an acceptance in the implementation of the model by the children to whom the material was directed, which they could download, use and experiment with over and over again.

The concept of a techno-pedagogical tool becomes an ally of the flipped classroom; thanks to these, it is possible to have greater interaction, greater motivation towards the didactic contents and also maintain a personalized follow-up in its development (Dunn 2011). In short, this type of tool provides various benefits to the actors in the teaching-learning process. In the case of the teacher, they give him the role of constructor of the materials and guide of the students; In the same way, parents, who can be incorporated in a substantive way in the teaching of their children.

The flipped classroom teaching-learning method has been used even before the pandemic, as can be seen in the work of Melo and Sánchez (2017), who identified that, thanks to it, students acquire kinesthetic learning; Through the structure of the contents, the participants found greater relevance in them; the video materials contributed significantly in the practical classes, and, in summary, the time invested was productive. However, other studies have identified a parity of results in applications of this nature in subjects such as Spanish, English and mathematics. For example, Schmeisser and Medina (2018) observed that with the use of this method there was no statistically significant difference between the pre and post tests of the experimental groups and control groups.

Finally, the participants in the study by García and Cremades (2019) defined the flipped classroom as innovative, as well as observing its usefulness in the development of skills such as cooperative work, the development of socialization, which allowed autonomy in the participant. . In addition, the authors detected that the use of the materials and the synchronous activities allowed a better conceptualization of the contents by the students, the facilitation of the development of procedures and the existence of a positive attitude to the work method, therefore, it was implemented a weekly habit among the participants that directly affected both what they did in class and what they reflected on afterwards (Cedeño and Vigueras, 2020).

Providing educational content to students prior to the session that has the characteristic of being attractive both in its core and in the form of presentation aims to focus attention on their individualized progress in the classroom. In addition, with this delivery, analysis, feedback and reinforcement of concepts are encouraged through didactic strategies based on collaborative learning, in order to carry out group activities, which the teacher must design in advance. It should be noted that the flipped classroom adapts to different areas, a versatility that in turn allows it to be susceptible to constant improvements and reinforces the constructivist approach, of which the main protagonist is the student (Garza, 2019).

The flipped classroom is oriented towards reducing student failure rates (Pérez, Rodriguez, Rodriguez and Villacreses, 2020); in motivating to address the issues to be discussed and obtain both theoretical and practical knowledge that is demanded in the different areas of knowledge. This is how the use of asynchronous technology in this model is both positive and important in the achievement of knowledge, as established in the research by Reyes, Villafuerte and Zambrano (2020).

However, Kang and Temkin (2022) propose the use of TinkerCAD as an option to carry out the practical part remotely and thus achieve the reinforcement of the class in times of pandemic. In the case cited, the implementation of the web-based Arduino and circuit simulator led not only to a successful transition into course instruction, but also showed great potential for integration into student-built projects in the future.

Primary education is essential for children to learn to develop abilities and skills, since thanks to the teaching of the teacher, children can learn through different teaching strategies and in a playful way. Currently, ICTs should be considered in the primary education curriculum, since boys and girls are developing along with technology and, therefore, it is easier for them to understand and learn how to use it. In this sense, and with the purpose of recording the experience and at the same time promoting learning in the field of basic electronics in primary education students under the flipped classroom methodology, a course was designed and developed under this methodology through a laboratory. virtual, from which the facts were documented to later evaluate the learning and its acceptance.

Methods

A quasi-experimental design was adopted through the flipped classroom methodology (figure 1). Also, to measure the degree of compliance with the following objectives, a questionnaire was designed and applied.

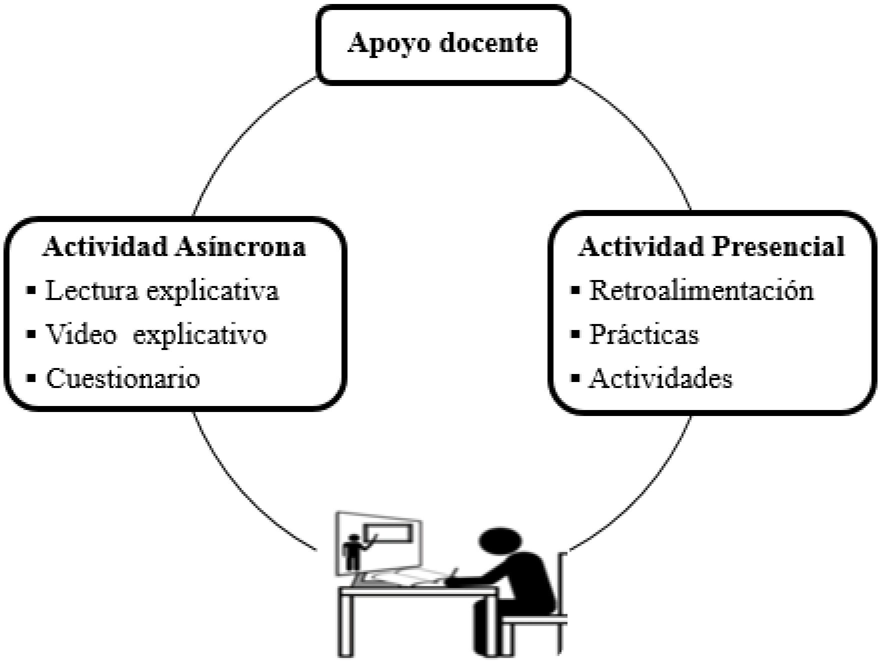
General objective

Assess the implementation of the flipped classroom model for teaching basic electronics to fifth and sixth year students of basic education.

Specific objectives

- Inquire about the perception of students in relation to the applied methodology.
- Assess the usefulness of the resources and activities based on the proposed learning objectives.
- Know advantages and disadvantages during the course delivery.

Figure 1. Flipped classroom methodology for basic electronics course



Source: self made

A quantitative methodology was applied to examine the perception of basic education students about their learning process with the flipped classroom methodology. As we have been saying, this methodology consists of two large components:

- The activities requested to be carried out outside of class (asynchronous activity).
- The activities to be carried out during the class (face-to-face activity).

Evaluation measures were also provided to the participants, before and after having taught classes with this learning approach, to analyze and compare the data from one moment to the other, with a greater emphasis on the significant differences in the learning perceptions at the end. of the course.

The flipped classroom experience was implemented for a group of 16 students between the ages of 9 and 10 who were enrolled in their basic education at the Vicente Guerrero Elementary School in the municipality of Tolcayuca, Hidalgo, Mexico. The selection of the students was non-probabilistic, in this case, mainly, it was sought that the students had a computer and internet connection. Informed consent was obtained from all participants, teachers, and parents to conduct this study.

The teaching-learning process was developed through the construction of readings, videos that synthesize the selected topics to be taught weekly, in addition to synchronous presentations through Zoom. In each of the sessions, new topics were presented to the participating students. The sessions lasted 40 minutes and each of them followed the following format: welcome, questions about the observed material, presentation of the topic, practice in the virtual laboratory, doubts about the implementation, and closing of the session.

The process to address basic electronics topics focused on the selection of topics, construction of videos, readings, brief infographics, and the development of questionnaires that would allow evaluating the relevant points of the weekly sessions.

The material was previously released so that the participants, during a week prior to the activity session, were in charge of reviewing the material, arranged on the Classroom platform. Another means of communication was the WhatsApp social network, in order for the instructors to answer the doubts raised by the contents by the course participants.

The weekly session lasted 40 minutes, which were distributed as follows: in the first 10 minutes, a brief exploration test was carried out, with very elementary questions on the topics that the students had reviewed at home, which allowed them to see up to to what degree the content had been assimilated; then, for the next 20 minutes, attention was paid to the issues in a more particular way; During the rest of the session, they work in the TinkerCAD virtual laboratory with the aim of incorporating the practical part with the demonstration of theoretical points.

The data collected during the investigation were analyzed in SPSS Statistics 26.0. The degree of reliability and validity of the instrument was estimated prior to data analysis.

Results

The basic electronics course was planned to be carried out using the flipped classroom methodology, that is, taking advantage of virtual environments from a model focused on the active construction of knowledge by students. At the beginning of the course, there were 19 students registered to participate. Of this group, 84.2% remained active throughout the course, while 15.8% never entered the virtual classroom. The students who accessed the course demonstrated responsibility and proactivity: they delivered the work actively and within the established terms, as well as participated in the weekly meetings with the teachers. In addition, these students interacted by asking questions about the different topics covered.

The work sessions with the students were six. Throughout these, the basic electronics topics presented in table 1 were developed. There, the results of the questionnaires that were applied prior to the session are also observed. As a result of the application to the workshop participants, a general average of 78.84 is shown on a scale from 0 to 100. Said percentage obtained would seem low, but it is what the participants really advanced, prior to the start of the session in the week , which means that only a minority of the content, less than 30%, was what had to be developed in the session, with the presentation and practice that the person in charge of the module directed.

Table 1. Previous evaluation results

Sesión	Temas	Promedio cuestionario previo general
1	¿Qué es la electricidad?	72.67
	Conociendo TinkerCAD.	
2	Conociendo la corriente eléctrica	78.66
	Conociendo qué es el voltaje	
	¿Qué es la resistencia?	
3	Circuito eléctrico	78.66
	Configuración circuito eléctrico	
4	Uso de *protoboard*	78.66
5	Uso de capacitor	78.84
6	Electrónica digital	85.55
	Promedio general	78.84

Source: self made

If the times indicated for reviewing the videos are added, a total of 1:09:26 is obtained in the sessions shown in Table 2. Likewise, the asynchronous class time is found, a total of four session hours.

Table 2. Activity concentrate

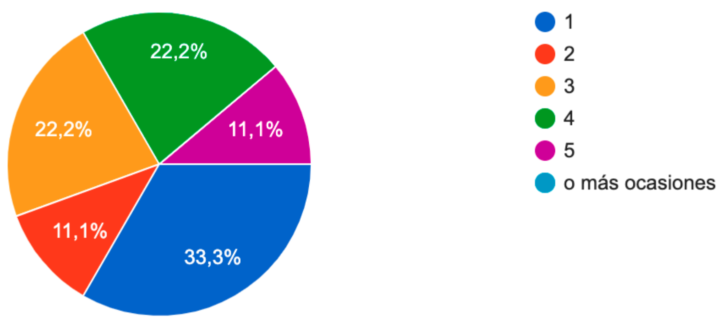
Sesión	Video	Lectura	Tiempo de clase síncrona	Número de preguntas	Número de participantes
1	4:31 5:16	1	0:40	6	15
2	12:00 8:42 7:14	1	0:40	5	15
3	2:10 9:58	1	0:40	5	9
4	12:52	1	0:40	5	15
5	9:37	1	0:40	5	15
6	7:12	1	0:40	6	15

Source: self made

However, a seventh session was held that is not recorded in tables 1 and 2, which was a demonstration by a member of the teaching team, a practice synchronously via Zoom. The objective was to show the construction of an electrical circuit to control the irrigation of a plant. During the session, course participants would chime in with questions or make statements about the items used in the sample session. In short, the students intervened with their participation to identify the components used, as well as to answer basic questions about the implementation of the practice, with this the student gained confidence in the knowledge acquired, this is shown in the results obtained in the course completion survey.

First of all, Figure 2 shows the number of times the students consulted the materials that were shared with them in order to build knowledge themselves. As can be seen, the option of more than five occasions was the one that concentrated the greatest number of responses.

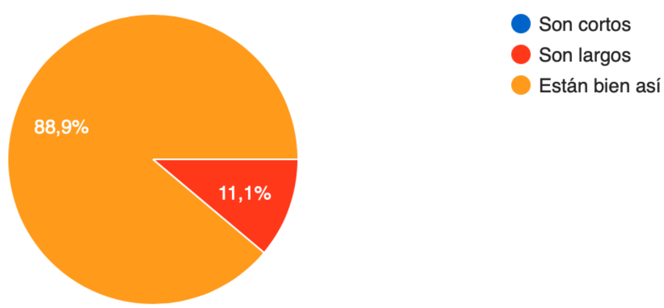
Figure 2. Percentage of access to material



Source: self made

Another of the questions asked was the opinion of the participating students regarding the duration of the video material. The participants mentioned that the time invested in them did not cause them a problem (see figure 3).

Figure 3. Video Time Acceptance



Source: self made

The students invested a total of 1:09:26 time throughout the workshop in order to previously review the material to present themselves to the session with empowered knowledge. In this way, the students arrived previously prepared for the Zoom sessions, where practical aspects were addressed in the virtual environment of TinkerCAD, the assembly of basic circuits and the identification of physical phenomena.

In addition to all of the above, the students were asked if they would recommend to their classmates the prior use of videos and readings to better understand the classes of any subject, to which 88% answered positively, which shows how relevant it is. the investment of time prior to class so that students can adopt positive positions regarding the teaching-learning methodology.

Similarly, 88% of the students in the workshop considered the videos and readings as tools that allowed them to approach the topics in advance and helped them better understand the concepts and steps to follow. The effectiveness of the resources used in the basic electronics workshop to implement the flipped classroom was 55%. In other words, the presentation of the readings, times and quality of the videos contributed in a certain sense to significant learning prior to the presentation in the synchronous class.

Regarding the quality of the synchronous meetings via Zoom, the students considered that the videoconferences were didactic, useful, and that they were developed appropriately. Regarding the didactic material (texts, audiovisual material and proposed activities), the opinion of the students was very favourable; A very high assessment of the audiovisual material and practical activities stands out. Among the greatest difficulties encountered, access to the virtual classroom stands out, since 48.8% of the students indicated that they had had some problem with the Internet connection, power outages or not having adequate devices to maintain video calls. This point is of vital importance when analyzing the percentage of students who did not participate in the course, but who had enrolled at first (15.8%).

The lack of Internet access at home in a context of confinement implies a great difficulty, particularly for those students who live in rural areas and who do not have the possibility of moving to a place with access to this service. Regarding the evaluation of the general design of the course, the students pondered the possibility of organizing themselves to optimize their time. Finally, another point to highlight is that, during the last meeting via Zoom, the students expressed knowing that they were accompanied and guided during the basic electronics course taught.

Discussion

New knowledge in infants is an important part of arousing interest in various topics, even more so if it is accompanied by a methodological structure such as the one implemented in this work. The use of a flipped classroom, together with the use of a virtual laboratory, allows reinforcing theoretical knowledge with practical activities. These two concepts were important in the time of the pandemic to share new knowledge, in addition to promoting the development of digital skills and instilling an interest in learning on the part of the participants, as parents let them know via WhatsApp.

When examining the self-perceived motivation and learning of basic education students under the flipped classroom model during the pandemic in the basic electronics course, along with their 2020/2021 academic period, the data obtained in this study showed a positive evaluation of the applied methodology, both in the reported motivation and in the perception of learning. Cedeño and Vigueras (2020) report that this strategy, in addition to motivating students through collaborative and autonomous learning in a pleasant environment, to improve academic performance, grades, abilities and skills, also includes motivating elements for the teacher, due to the new role played by guiding, guiding and accompanying in the achievement of the maximum levels of learning. Undoubtedly, both learn and use innovative tools, as mentioned in Pérez et al. (2020).

Regarding the use of the didactic platform, the interest shown by the participants in this work can be compared in part with that of the participants in the work by Lesku et al. (2021), who, although their study was aimed at other ages, emphasize that the motivation factor in the use of virtual laboratories is beneficial for obtaining knowledge. Also, TinkerCAD due to its features, ease of use, easy accessibility and free of charge, was quite well received. However, not all students had the possibility of accessing the necessary technology to enter the course taught, just like what happened in the Mendoza research, 2020 at the primary education level there are not the necessary economic resources to guarantee that 100% of students have access to new technologies, since part of the student population lacks sufficient resources; therefore, the economic situation must be taken into account as a limiting factor.

Conclusions

In the implementation of the flipped classroom methodology in the teaching of basic electronics to fifth and sixth grade students, more time and dedication to study by the students has been detected, in addition to a greater commitment and greater interaction between the student and the teacher.

From our local experience, the student requires more preparation time prior to class. However, after it, personal study is simplified, given the emphasis of the flipped classroom. In addition, the stress level of the students can decrease, since each one studies at her own pace, having the necessary time to raise doubts and resolve them in class.

A favorable acceptance is reflected in the use of the virtual laboratory, in this case TinkerCAD. The agreement of students, parents and teachers to get involved responsibly despite being in times of pandemic is visible. The students were receptive; It is worth highlighting the commitment to comply in a timely manner with the virtual activities and classes despite the technological deficiency that some of them faced.

It is observed that, despite being an extracurricular subject and at times outside the academic load, the participants were very active and with the desire to obtain learning, it is also shown that FC is adaptable to teaching in this case of a short workshop at the basic education level.

Finally, it is concluded that the methodology diversifies the moments of learning, strengthens previous knowledge and supports a teaching-learning process fully focused on the student. More than 90% of the students agree that this methodology allowed them to improve their learning and communication skills, in addition to the motivation it aroused to participate in class.

future works

The findings of this research may not be representative of the teaching-learning processes and the methodology that drives the motivation of the students, since they are extracted from a single experience, so that in the following works the analysis will be carried out with different relevant topics of technology, principles of artificial intelligence and automatic learning in basic level institutions in a mixed way, that is, basic education students belonging to urban and rural areas.

Identify the necessary characteristics of the students to integrate collaborative and remote work guided by the teacher, for example, for the development of technology that allows solving problems through computer programming under the flipped classroom methodology.

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Validación	No aplica
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