Incidence of Digital Adaptive Learning Programs on Academic Results in Mathematics

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Abstract

This research aimed to analyze the incidence of digital adaptive learning programs in the academic results of the students of the seventh year of basic general education in the area of mathematics. Deductive and inductive methods were used which allowed analysis of the state of the art on adaptive learning programs due to its relevant formality for the review of scientific literature, to support this research work, the theoretical contributions of several authors on the themes of adaptive learning programs, the Aleks artificial intelligence program, the use of technology as an educational resource and the academic performance of students in the teaching-learning process and the cross-sectional analytical method was used that allowed the collection of data through Through the survey technique, the population studied was 11 teachers and 105 students who attended the seventh year of basic general education of the 2021-2022 school year from four educational units in the city of Chone. The application of the surveys was through the digital form, in the results, it was determined that the artificial intelligence program to teach mathematics and that is currently used very frequently by teachers and students is Aleks, in addition, it was verified with the affirmation of 73 % of teachers surveyed that adaptive learning programs have a positive impact on the academic performance of students.

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1   Introduction

For the development of this research work, the scientific literature of different authors of theses, scientific articles, and books, among other scientific information documents, was reviewed; information that allowed us to know different realities and behaviors of phenomena to support this study that deals with the incidence of adaptive learning in the academic results of a group of students from different educational units of the city of Chone around mathematics. It is understood that mathematical skills are skills that a person acquires and develops throughout his life, through the application of exact sciences, logical, argued, expressed, and communicated reasoning is developed, integrating various knowledge to respond to problems. daily that occur in different contexts of the life of human beings. These skills allow students to seek the meaning of truth and justice, in addition to understanding what it means to live in a democratic, equitable, and inclusive society, and to act with ethics, integrity, and honesty (Ministry of Education of Ecuador, 2021).

The new trends in learning assessment indicate that it is a means to learn to do and learn to be, this requires innovations from the perspective of the teacher according to the context and interests of the students, these readjustments must be permanent so that they contribute the best way in the student learning process in correspondence with current trends in pedagogy and didactics in education (Azcárate Goded & Cardeñoso Domingo, 2012). For most students, learning mathematics turns out to be complex, sometimes these anomalies are evidenced in the academic results or in the teacher-student interaction within the classroom, this leads the teacher to seek other strategies and new educational resources, among them the use of different digital media, such as digital book readings, tutorial videos, web pages, among others, as well as the adoption of digital programs where lessons can be managed, among which classroom or moodle stand out; and use free or paid license video-call services, such as Google meet or zoom, etc., that allow developing the skills desired by the study curriculum, however, this teaching process is not enough (Rodriguez et al., 2021).

One of the most important challenges faced by educational systems in developing countries is the great disparity in the levels of curricular mastery of their students, even within the same classrooms, adaptive learning programs seek to correct the difficulties that in many situations the students failed to acquire the desired knowledge; However, these programs have disadvantages which are often notorious, one of them is that they do not favor teamwork because they are support programs for individualized learning. Adaptive learning is a method of instruction that creates a personalized learning experience through the use of computational means. Instructions, comments, and content corrections are adjusted according to the performance of each student. An adaptive tutor system is an interactive learning environment in which the student does not remain passive, this is the most relevant characteristic of the adaptive tutor system. In this type of program, the accompaniment of the classroom teacher is not exempt, he must continue to ensure that the student maintains his autonomy and builds his own knowledge. In other words, we work with a cognitive approach to learning (Fernandez, 2010). It is an adaptation of learning in real-time, analyzing the successes and errors of the students to know where it should be improved and strengthened, which allows teachers to obtain accurate and updated data from each one for future decision-making.

The adaptive learning programs are critically and constructively analyzed so that they can be applied in the teaching-learning process, especially since they are adjustable in the area of mathematics, it is convenient that these programs be easily and effectively manipulated, to interfere significantly in the academic performance of the students and from the results and reports to be able to make decisions that serve for academic improvement. This research will contribute scientifically to the educational field because it allows analyzing a new way of teaching and reinforcing mathematical knowledge using technology as the main resource, some adaptive learning programs are exposed as digital resources for the teaching-learning process of mathematics and emphasizes the Aleks digital program, a digital platform that acts as a virtual tutor to accompany the student at any time it is required to develop technical, technological, objective, human, constructivist, analytical and reflective skills and abilities (Lewin & Smith, 1996; Tambychik & Meerah, 2010; Maloney et al., 2010).

2   Materials and Methods

In this investigation, the deductive and inductive method was used, which allowed analysis of the state of the art on adaptive learning programs due to its relevant formality for the review of the scientific literature, to support this research work, the contributions were studied. Theorists of several authors on the themes of adaptive learning

programs, the Aleks artificial intelligence program, the use of technology as an educational resource, and the academic performance of students in the teaching-learning process, and the cross-sectional analytical method were also used. that allowed the collection of data through the survey technique, the population that was studied was 11 teachers and 105 students who attended the seventh year of basic general education of the 2021-2022 school year of four educational units of the city of Chone. The application of the surveys was through the digital form, the results were processed using statistical methods and their interpretation was carried out in the light of the sciences of contemporary education (Hardman, 2019; Mahendra, 2016; Suweken et al., 2017).

3 Results and Discussions

Mathematics is an art, a science, a collection of ideas and techniques that allow the resolution of problems that come from any discipline, including mathematics. It is applicable in much of the life of human beings and constitutes an indispensable language and framework for all sciences. For mathematicians, truth and beauty are held in equal esteem, select methods are sought and unsightly arguments are generally avoided (Lluís-Puebla, 2006). This subject is one of the oldest sciences, as the knowledge of man itself arises from the practical needs of the human being, new theories are born as a result of the search for solutions to practical problems and the construction of new methodologies for their resolution. Currently, there is a close relationship between science, technology, mathematics, and society; aspects that contribute significantly to problem-solving, becoming a fundamental part of the evolution of humanity in the different contexts in which it operates (Camero Reinante et al., 2016).

Application of mathematics in solving problems of daily life

Mathematics has aesthetic characteristics: universality is one of them, most of the branch of knowledge has aspects that can be analyzed and solved mathematically; the development of simple and concise arguments is essential for progress; the selection and formulation of problems is an art that depends on the intuition of the mathematician. In formal mathematics, the individual creates mathematics without wondering too much about the meaning, as long as the correct result is obtained, this is essentially an activity of human beings, and the goal is not only to invent it but to transmit it through methods that facilitate its understanding (Lluís-Puebla, 2006). In the Ecuadorian educational system, there is a national curriculum in which the guidelines for action and orientation are indicated. on how to proceed to make these intentions a reality and verify that they have been achieved, the curriculum is divided into sublevels and by areas (Ministry of Education of Ecuador, 2016). Figure 1 shows the description of the areas of Basic General Education that include from the second to the tenth year of basic general education.
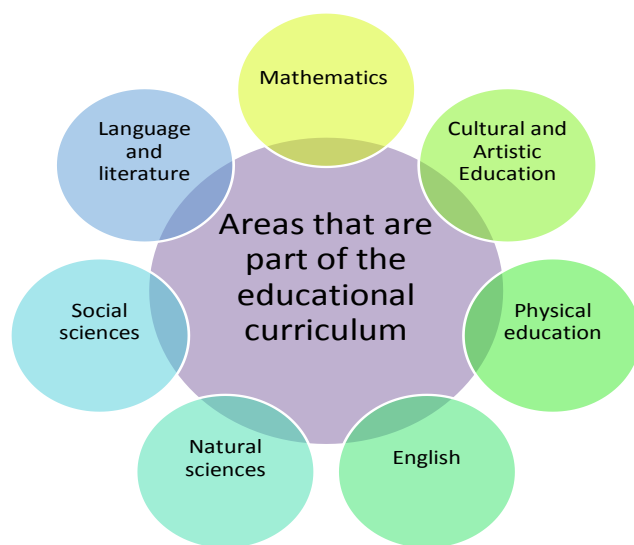

Figure 1. Areas that are part of the basic general education curriculum
Source: (Ministry of Education 2016).

The process of evaluations adopted in the teaching-learning process in the area of mathematics should be critically and constructively analyzed, especially in the selection, planning and execution of evaluation indicators, managing to develop skills that allow the teacher to manipulate Effectively these evaluation guides, significantly interfering with the academic performance of students and from the results obtained to be able to make decisions that serve to improve teaching practice with the adoption of new educational strategies (Chu et al., 2009; Skryabin et al., 2015; Hu et al., 2018).

Formative evaluation as an indicator of the skills acquired by students in the teaching-learning process

At present, the student is the main actor in the learning process, for this reason, this research will contribute to making educated decisions to achieve significant learning in them, managing to improve the design and reception of evaluations according to the results, applying new educational strategies including feedback. Learning and the evaluation process in the educational field have a star relationship, it is understood that one of the ways to verify that the knowledge was acquired and mastered by the students is through evaluation, but it is not only evaluated at the end, but the evaluation should also be throughout the educational process allowing the teacher to record continuous assessments of the student's performance (Zavaleta & Dolores, 2021). The evaluation allows in the educational process to collect, systematize, and analyze useful data that will allow decision making to improve educational processes, especially in the area of mathematics due to its relative complexity to develop skills in students, for that, it is necessary of relevant instruments according to the evaluation indicators (Flores & García, 2017).

Academic performance, a key indicator of the educational process

These are results those students demonstrate at the end of a topic or time on the knowledge acquired through evaluations designed by teachers, in which a group of factors intervene and within these they have substantial participation: those of a motivational type, those related to study habits and techniques, with the quality of prior preparation and those related to pedagogical aspects, among others (Martínez Pérez et al., 2020). Academic performance is information that is sometimes presented in a qualitative or quantitative way that not only demonstrates the skills that the student is learning in the educational process but also determines other conclusive indicators that are possibly causing unfavorable student performance, such as, among those, there is the socioeconomic, technological, social and cultural level of the environment where it operates (Rodríguez Rodríguez & Guzmán Rosquete, 2019). The integration of ICT, before, during, and after the learning process, with various strategies and new pedagogical models implemented within the planning strengthens the teaching-learning process of mathematics, where technology allows managing interactive and significant learning (Valencia-Velasco & Guevara-Vizcaíno, 2020).

The incorporation of ICTs in the teaching-learning process

Worldwide, the use of new technologies in the teaching-learning process has increased since they allow a human beings to develop more logically and comprehensively in the different activities that perform (Saldaña et al., 2017). ICT tools are applications, infrastructure, and hardware that allow the teacher, through their use, to improve the teaching-learning environment by providing motivation, enthusiasm, and attention to the content of the different subjects (Núñez et al., 2017). The use and interest of ICT in students become one of the fundamental strategies when carrying out a certain academic activity, influencing the acquisition of clearly structured knowledge (Aguirre et al., 2020).

The incorporation of ICTs can serve as teaching support tools to create new environments that break down the barriers of the classroom and in which students feel motivated (Ruz-Fuenzalida, 2021). It is emphasized that the evolution of the human being is driven by the creation and use of new technologies, in the teaching-learning process, motivation is one of the essential strategies of teachers since it has been used in the classroom for many years. Over the years, the incorporation of new technologies has become a motivating and effective strategy in the environments where classes are taught, having a positive effect on the development of student skills.

The good use of ICTs in the teaching-learning process establishes a formative function, not only with the student, it is very possible that it has a positive impact on the family environment: virtual spaces have become an education strategy in the case of presenting catastrophic events for humanity, today it is used by the pandemic declared by the UN in March 2020, therefore it is very important to adapt to this new way of transmitting communication, it is currently the main protagonist in communication between teacher, student, and family.

It is important to point out that many of the digital technologies available in the educational environments of schools and universities correspond to products that combine functionalities associated with the different learning theories. In this way, it is difficult to find digital solutions that are ascribed to a single model, since the most appropriate digital technology will depend on the type of learning that is to be achieved and the educational model that is to be implemented with the students (López-Neira, 2017).

The educational units before applying technological strategies in their teaching-learning process must carry out a fusion study between the teaching method that they apply with the new digital technologies that are going to be used, to mitigate the possible problems in the adaptation of the actors of the educational community, allowing students to consolidate their knowledge in an analytical and technological way. Innovative processes require a significant modification of what has been done, by implementing elements of technology to improve instructional design, and to achieve training objectives, thus strengthening the path towards comprehensive transformation (Garcia Gutierrez & Ruiz Corbella, 2020).

Currently, innovative ideas expire in a very short time, so not changing the processes where there are no positive results may continue to obtain adverse results, especially in education, the application of innovative ideas in the teaching-learning process will allow the success of the method used to achieve the proposed educational objectives.

Teachers must lose their fear of incorporating new information and communication technologies in the teaching-learning process with an open, creative, and flexible mind since it is confirmed that minors are fully incorporated into the use of ICTs, understood as a fundamental stage of the life cycle of human beings (Pascual, 2006). The use of new technologies still causes some rejection by a certain group of teachers, many of them fearing to incorporate them into their work planning in the classroom, simply because they do not know how to use them, it is evolving, and it must be understood that this process of change leads to the adoption of new technologies for an effective teaching and learning process.

Adaptive learning programs as innovative strategies in the educational process

All learning strategies are significant and complementary, they allow different techniques to learn the knowledge received and can be easily applied and managed by the person who uses them. According to the type of knowledge, it is necessary to use some learning technique that improves receptivity towards it and contributes to its better use (Camizán et al., 2021). Adaptive education assumes that there is no single effective method for all students, the effectiveness of educational treatment depends on the one hand, on the degree of adjustment of the educational intervention to the needs and demands of the student and, on the other hand, of the instructional situation (García, 1997).

Corno & Snow (1986), cited in García (1997), the adaptive theory associates the differences in educational results to the degree of instructional support that the method offers the student based on the cognitive processes that need to be put into play to perform a task determined; that is to say, it seems that the differences between students related to educational methods are not due so much to the method as a whole, but to its components and to the aptitude demand that it requires of the student. Adaptive developments are the skills and abilities that the child makes use of in a functional way in his daily life when facing all the demands that his context demands of him. Considering that, when the child is growing up, one of the most complex situations occurs now in which he must learn to be autonomous in his activities of daily life (Campo Ternera, 2011).

Adaptation supposes assuming diversity, and differences. In how we conceptualize these differences (cultural group differences, individual differences, high ability...) the different approaches of Differential Pedagogy are configured; In this section, we are going to focus on the individual differences of the students (Torres, 2019). Individual differences are present in the classroom and have been the object of study in differential pedagogical research and it is precisely on them that the Adaptive Education approach is focused (Torres, 2019). In recent decades, adaptive learning and the insertion of learning and knowledge technologies (TAC) in education have become important and interesting topics in the field of teaching techniques in different areas of knowledge, they were a pedagogical trend considerable. At the same time, competency-based education is immersed in educational institutions (Feregrino et al., 2020).

Advantages and disadvantages of adaptive learning

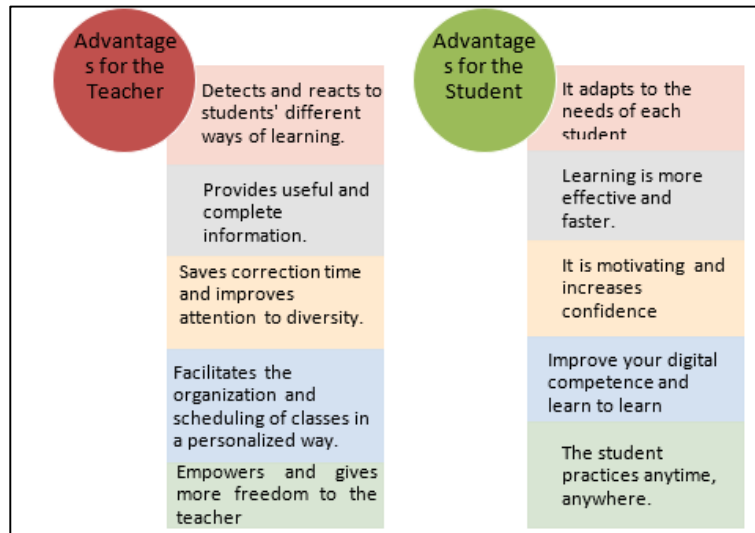Figure 2 describes some advantages of adaptive learning for the teacher and the student.

Figure 2. Advantages of adaptive learning for the teacher and the student
Source: (Morillo, 2016).

Adaptive learning is a revolution for education since it tries to serve all students equally, no matter how advanced or delayed the student is, the important thing is that everyone advances at their own pace without leaving any of us behind, this favors student confidence and motivation. It is now when it is expanding because there are more resources both for technology research and for the acquisition of devices (Morillo, 2016).

Disadvantages

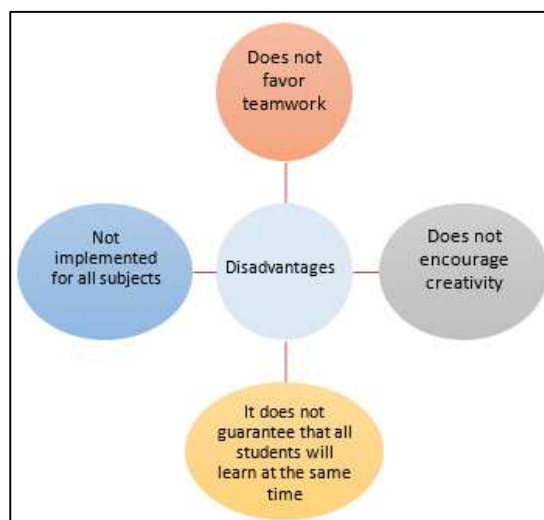Figure 3 shows the disadvantages of adaptive learning for teachers and students.

Figure 3. Disadvantages of using adaptive learning programs
Source: (Morillo, 2016)

Adaptive learning programs

There are many adaptive learning programs. Figure 4 shows the names of 5 programs that in some cases have similarities in the services they offer. Provide your platform.
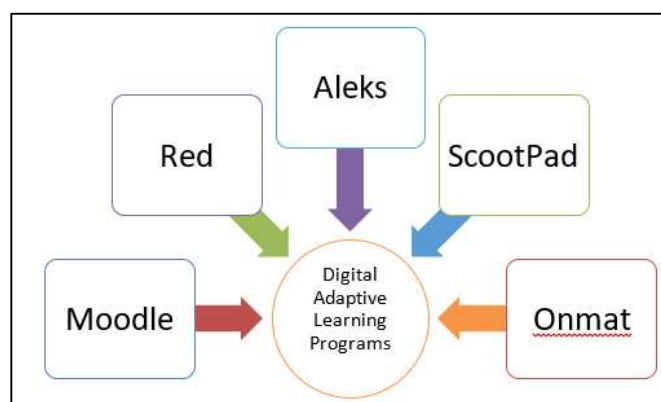
Figure 4. Disadvantages of the use of adaptive learning programs

Moodle

There is a wide range of virtual learning platforms, of which one of the most used is Moodle, which is Freeware-type software. , this tool allows the interaction of teachers and students through the creation of courses based on activities and resources, which allow the development of learning sessions using technological equipment connected to the Internet. (Pérez Pérez et al., 2020). It is a free and open-source system, it has multiple adaptive functionalities for the creation and administration of activities that allow the personalization of the learning process. One of its most substantial characteristics is the use of specific feedback techniques, activated based on the student's response (González et al., 2017).

Red

The rescue program of the kingdom (RED) consists of six procedures: a) the diagnosis of the students: characteristics, interests, background, social, economic, cultural aspects and learning styles, among others; b) the establishment of learning objectives: preparation of the lesson to ensure and guarantee learning, having already recognized the particularities of the students, which makes art of the first procedure that the students do; c) generation of the selection of strategies, media, technologies and materials: the researcher-producer chooses the elements that the resource will have, as well as the introductions, texts, animations and strategies to guarantee that the digital material and its use promote the expected learning in students; d) the use of means and materials: once the elements of the resource and the strategies have been selected, these must be incorporated in such a way that they are optimally structured for the fulfillment of the objectives; e) the participation of the students: they analyze and synthesize the information of the virtual environment. As the tutor knows him (data from the procedure a) of this sequence), everything has been arranged so that he becomes participative and actively involved in all the processes designed to achieve his learning; and f) the evaluation and review of the implementation and learning results: the tutor evaluates the achievement of the learning objectives, the instruction process and the impact of the use of technology in the instructional processes (Becerra & Rivera, 2021).

ScootPad

This platform offers continuous adaptive learning for each student, through personalized placement, just-in-time enrichment, scaffolding (at or below grade level), and automatic mastery assessment, with adaptive practices. When students encounter an obstacle, they are automatically redirected to resources that help them intervene in their misconception or in their case when they successfully master a concept we speed up and offer more content to expand their knowledge (Mosaic, 2022).

Onmat

is a digital platform of mathematics with which you can program, sequence, customize activities, observe pending tasks or evaluate in an easy, agile and intuitive way. It has several contextualized activities that allow the student to establish connections between mathematics and the world around them, promoting their motivation. Competence evaluation and the use of rubrics allow you to continuously assess the progress of the students and share it with them, so they will know how they are progressing and where they can improve. ONMAT proposes microlearning units with clear objectives shared with students, to adapt classic topics into motivating learning paths (Tekman Education, 2022).

Aleks

It is an educational system based on artificial intelligence that provides students with material to achieve the learning objectives that, according to the results of the diagnostic test applied to them at the beginning of the course, they still have to acquire. It provides information to the teacher and students on the progress per topic/week, as well as practical exercises to reinforce learning. ALEKS is an innovative technology developed from research at New York University and the University of California, Irvine, by a team of software engineers, mathematicians, and cognitive scientists with the support of a multimillion-dollar grant from the National Science Foundation. ALEKS is fundamentally different from previous educational programs. At the heart of ALEKS is an artificial intelligence engine that evaluates each student individually and continuously

In order to enter the Aleks adaptive learning program, those interested must have their username and password that the promoters must previously provided, the program does not use multiple choice questions using flexible and easy-to-use options to enter the respective answers, these tools mimic what you would do on paper and pencil. When a student logs into the ALEKS system, a brief virtual guide is presented that demonstrates how to use the resources, then proceeds to assess the student's current knowledge by asking a few questions. Each student, and therefore each set of assessment questions, is unique. When the student completes his evaluation, ALEKS already has an accurate picture of knowledge, it knows which topics are mastered and which ones he needs to learn, the results of the student's knowledge are represented by a multi-colored pie chart (Bloor, 1973; Hssina & Erritali, 2019; Tseng et al., 2008).

ALEKS offers you practice problems that reinforce the proposed topic, which have enough variability that a user can only get the correct result if he understands the central principle that defines the topic. If a student does not understand a particular problem, they can access a full explanation of the problem. Once you consistently answer the problems of a topic correctly, the program considers that the student has learned the topic leading to the next module. As the student learns new topics, ALEKS updates the student's knowledge map. To ensure that the topics the student is learning are retaining them for the long term, ALEKS re-assesses the student periodically, using the results to adjust the student's knowledge of the course. Students must demonstrate mastery through assessments with mixed questions that cannot be predicted (Mendoza Rosado, 2018).

Results of the surveys applied to the students and teachers of four educational units of the city of Chone that use the adaptive programs.

The Ministry of Education of Ecuador to improve the quality of education and to reduce the teaching-learning gaps caused by Covid-19, has agreed to the intervention of the Affirmatio program - Individualized Training Support for Reinforcement in Mathematics using a platform assisted learning (Computer Assisted Learning - CAL) to improve learning mastery of the mathematics subject. Una alternativa para abordar este gran reto es utilizar las tecnologías para la educación que permitan personalizar el proceso de enseñanza-aprendizaje. Se sistematizan los datos obtenidos después de la aplicación de encuestas aplicadas a 11 docentes del área de matemáticas ya 105 estudiantes de cuatro unidades educativas de la ciudad de Chone para conocer sobre el uso de programas de aprendizajes adaptativos.

Figure 5 shows the responses of teachers and students about the adaptive learning programs they use for the teaching-learning process of the mathematics subject.
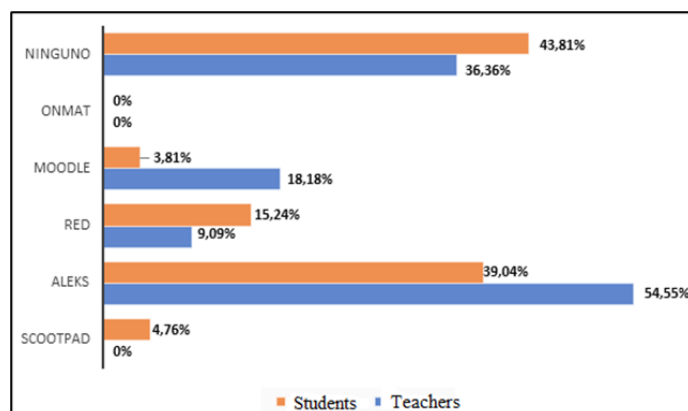
Figure 5. Use of adaptive learning programs

The Ministry of Education of Ecuador has adopted the Aleks adaptive learning program as a pilot plant for a group of educational institutions in the country that benefits students who are studying the seventh year of basic general education of the 2021-2022 school year, in order to eliminate learning barriers in the subject of mathematics that have been created as a result of the Covid-19 pandemic, where it was necessary to strategically use technological resources with the internet to be able to transmit knowledge and for students to develop their skills. All learning strategies are important and complementary, they allow from different techniques that the knowledge received is learned and can be applied and managed easily by the person who uses them. According to the type of knowledge, it is necessary to use some technique for learning that improves the receptibility towards it and, therefore, contributes to its better performance (Camizán et al., 2021).

Figure 5 shows the responses in the percentage of the experimental group in this case, of students and teachers from four educational institutions in the city of Chone, most of the respondents agree that they use adaptive learning programs, 39% of the students and 55% of the teachers indicate that they use the Aleks program, however, it is evident that there are 43% of students and 36% of teachers who do not manipulate any adaptive tutoring program. Figure 6 shows the responses of teachers and students on the results of academic performance in mathematics with the use of the adaptive learning program.
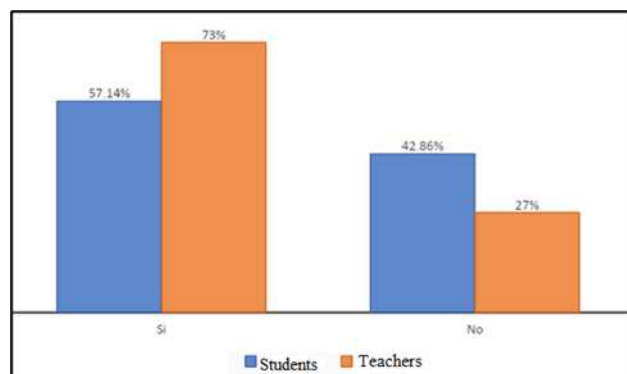

Figure 6. Improved academic performance

Mathematics is one of the subjects that are part of the curricular mesh of the national educational plan of Ecuador, which over time most students tend not to develop the skills proposed in the planning of study, results that are observed in many occasions through evaluations. Academic performance is information that is sometimes presented qualitatively or quantitatively that not only demonstrates the skills that the student is learning in the educational process, it also determines other conclusive indicators that are possibly causing an unfavorable performance of the student, such as, but those is also the socioeconomic, technological, social and cultural level of the environment where it operates (Rodríguez Rodríguez & Guzmán Rosquete, 2019).

In the Graph, in Figure 6 the following results were obtained from the 105 students surveyed and 11 teachers, 57% of the students indicate that if they have improved their academic performance with the help of artificial intelligence,

that is, with the adaptive learning program, 73% of the teachers corroborate the answers of the group of students, admitting that adaptive learning programs did manage to improve school performance, while 42% of students say no, to this is added another group of teachers represented by 27% who say that the program does not improve academic performance.

4 Conclusion

Technological tools are educational resources that are currently part of the teaching-learning process, their use occurs at all levels offering innovative solutions in the classroom, becoming an alternative to energize activities in class, achieving a positive impact on all the educational community, and the implementation of ICTs in the teaching-learning processes is essential, being a challenge in the next school periods. The use of digital adaptive learning programs to reinforce math skills as an individual impact on the academic performance of students, gamification as a formative evaluation or as an activity for the application of knowledge offers us an option to streamline processes of correction and accompaniment, but always taking into account the appropriate strategies for its implementation according to the level and maturity of the group of students.

There are several adaptive learning platforms for mathematics reinforcement, ALEKS is one of the most used digital programs for adaptive learning reinforcement for mathematics, it is an educational system based on artificial intelligence applying evaluations and developing learning. This program quickly and accurately determines the knowledge that each student has on a topic, and facilitates effective learning by offering a solution of topics that are ready to learn, the domains of individual topics are reflected in a circular graph which is motivated by periodically reviewing their progress and also provides a report for their respective analysis and possible decision-making.

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