Systemic Analysis of the Use of Technological Tools in the University Learning Process

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Abstract—The research described in this article is based on interviews to obtain information about the use of technological tools in the university learning process, from different points of view of actors, such as students, teachers, among others. The experimentation was carried out in the University of Lima, Peru. For this purpose, the process implemented consisted of categorizing the information where the confirmed and validated activities were located. The Maltese cross was used to locate in its four quadrants the selected activities, the input, the output of the information category and the procedure of the information processes. The objective of this work is to analyze in depth the problem of the use of technological tools in higher education in Peru under the systemic approach. The methodology of flexible systems and the Wilson methodology with its Maltese cross were used; this fusion is called hybrid methodology. The research has a qualitative approach and a descriptive scope. The result obtained from the category of information and the Maltese cross is that teachers and students have developed their digital skills in the use of technological tools to improve the teaching-learning process after undergoing training. The contribution benefited the students as the teachers trained in the technological tools enabled them to be more didactic during the virtual classroom sessions.

Keywords—digital skills, learning process, malt cross, systemic approach, technological tools

1 Introduction

The general problem raised in this article is the use of virtual tools in higher education in a context where some students may not have technological resources, where teaching methodologies are poor, and where both students and teachers do not know how to handle virtual tools properly [1].

At the national level and especially in Peru, the use of ICT (information and communication technologies) in education is a process that can become an instrument to improve the quality of students' education, facilitating their learning through the use of

technological tools. The integration of ICT in education will depend on the ability of teachers to use these tools, since most of them still use a traditional methodology and therefore are not used to innovate in the teaching methodology [2].

Many universities, such as the one in Chile, have not reached the desirable levels in the implementation of e-learning due to traditional teachers who prefer the old teaching methods and tools and many of them do not want to change their working methods. Resistance to change is strong and affects the academic and administrative culture of the institutions, because what is needed is not only organizational change, but the future positioning of the university [3].

Internationally and especially in Spain, distance learning has had to face the challenge of transforming face-to-face classes into virtual ones, using virtual tools and creating new resources that are very different from traditional ones. These resources, which have been included in virtual platforms, facilitate student learning [4]. In Panama, there are many professors who give presentations that last more than an hour in static, and to make matters worse, the student is loaded with many activities as if they were in person. In other cases, the internet connection can be significantly reduced and it is difficult for students to receive their lectures, which hinders their learning. For content delivery, videos can be used and made available on a streaming platform. For discussion and feedback, video calls, audio calls, discussion boards, and email can be used. For an expository course, it can be turned into a video or screencast that students can view on any platform available for the course [5].

In our study, the problem is that teachers are mostly not trained in the use of technological tools such as the Moodle platform, zoom video conferencing, digital tools such as mind maps, digital whiteboards, content curators, among others. Classroom sessions are conducted in a traditional manner. In this sense, the university, as part of its strategic plan, provides annual training in the use of technological resources so that teachers can develop their investigative skills. In addition, in a university study, 48% of students not only have problems accessing the Internet, but also in using digital tools on the computer and mobile. The University of Lima in Peru proposes policies through student welfare to support its students who have this type of problems, making loans of laptops and also training students from the academic direction. The study proposed here is limited only to the analysis of the problem of the use of technological tools and their environments in the teaching and learning process, both by students and teachers.

With this study, the beneficiaries are the students, teachers and university authorities, since the analysis will allow an effective decision making in the activities proposed in their annual plan. These activities respond to a planning of responses to possible difficulties that would arise. The difficulties encountered are the transition from face-to-face teaching to virtual teaching. Moreover, in this teaching-learning process, the research questions are as follows:

- How to use digital tools?
- How to realize the evaluation system and the strategies, techniques to teach through the use of online tools?
- How could students be well served in the teaching and learning process with the use of technology tools?

The main contribution of the research is to analyze the problem, giving an optimal proposal for a good service to its students through the use of technological tools. It is conducted within the framework of a systemic reflection based on a holistic vision.

The manuscript text continues below with the following sections: Literature Review, Materials and Methods, Results and Discussion, and Conclusions.

2 Literature review

The work proposed here has detailed the importance of the use of technological tools in the process of e-Learning in university higher education. Currently, digital tools in education are extremely used, due to the pandemic of COVID-19 as many authors have pointed out that they allow the learning process to continue in an effective way.

According to the authors of [4], structural equation modeling (SEM) is used to detect factors affecting the role of teachers in universities for online learning systems (Moodle) and AMOS statistical software was used to analyze the data. The implementation of this method yielded good results on the use of the online learning system, teaching quality, satisfaction and confidence of teachers in the online learning system.

The authors of [6] adapted the Technology Acceptance Model (TAM) to predict the use and expected use of online learning systems by undergraduate students at a public university. The validity and reliability of the partial least squares structural equation model was tested. The main result is that social influence and self-calculation effectiveness have a direct impact on fit to the technology acceptance model. It is also found that satisfaction is strongly influenced by perceived usefulness and affects the use of online learning systems, the former being a specific contribution of this study.

The authors of [7] also analyzed the educational process in higher education institutions during the COVID-19 pandemic. In particular, they focused on the relevance of distance learning by studying the issue of distance learning assessment and the tools used by teachers. It was found that most teachers use zoom communication platforms, Viber and Moodle, which meet all the basic criteria for online learning systems. During the quarantine period, the university administration created all the conditions for the use of these different platforms. In conclusion, it is necessary to update the academic framework of distance education, to align face-to-face courses and seminars with the conditions of online education, to increase digital literacy and prepare teaching teams for the use of distance technologies, to provide scientific information and methodological knowledge.

In reference [8], the authors also faced the problems of using and integrating specific educational content, such as engineering perspective courses, in online teaching platforms due to the large number of participants and the weakness of the Internet within university campuses. By analyzing the results of this study, it might be interesting to classify the educational technology tools in general platforms based on the number of students. Technology tools could be classified into digital tools and technology platforms, which would allow for training plans to be put in place so that students and faculty can develop and deepen their digital skills.

According to the authors of [9], the use of online collaborative tools involves the digital skills of learners and teachers and is often neglected in the academic training process. From this study, the authors propose to combine in order to integrate technological, pedagogical, social and cognitive approaches. The impact of social networks can have advantages and disadvantages in their use; this will depend on the use that is made in the students' learning, since they allow a more fluid communication between students and also with teachers.

The authors of [10] point out that successful online learning requires pedagogical approaches other than copying frontal pedagogical schemes using the Zoom platform and other tools such as Weber, MS Teams, etc. In addition, the authors emphasize the need to change perceptions, both on the part of students who are responsible for their own learning, and on the part of instructors who need to re-examine the teaching and learning process and align their roles and responsibilities.

Similarly, the authors of [11] and [12] have shown that the results of different knowledge tests show that, for the same course, distance learning does not reduce the performance of university students. According to the results of the satisfaction survey, for 91.4% of the students with sufficient hardware and software resources, the synchronous e-learning approach presents few obstacles. For 8.6% of students affected by digital exclusion, phones and social networks play an important role in the learning process. The results of several knowledge tests conducted at a distance show that students perform similarly to those expected in face-to-face instruction.

The authors of [13] and [14] examined students' attitudes toward web-based peer review and identified key factors related to students' use and appreciation of feedback. In addition, they present an analysis of the type of feedback for the purpose of assessing the written communication skills of students using online learning tools. On the other hand, they point out that hybrid learning, i.e. a combination of distance and face-to-face learning, seems to be the norm today in most universities, especially in Europe.

The authors of [15] and [16] indicate that e-learning and the social web are part of a process of change and evolution, mainly caused by the current technological revolution. The latter is even more intense than the others, as it is considered by many to be the catalyst for the others, and its pace of change is greater in all respects. To this end, biometric techniques and tools will be used to quickly analyze the main databases, referring to experts, academics and training on the use of e-learning. The authors also state that e-learning and Web 2.0 will allow a greater projection at the international level and a better understanding of its application. On the other hand, thanks to strong political incentives at the national and academic level, many tools have been massively implemented: digital learning management systems such as Moodle, digital collaboration platforms such as Google Meets, Microsoft Teams and Zoom, as well as social networks such as Facebook, WhatsApp and Twitter. The work presented in these articles confirmed that this unprecedented health crisis has highlighted the important role of digital in higher education.

Finally, the authors of [17] proposed a framework for assessing the usability of online learning platforms. Since students with different learning styles learn differently, we develop the first cognitive style-based usability heuristic that can reliably assess the usability of an online learning environment for all types of learners. Currently, Zoom

and Microsoft Teams have become the most popular teaching tools in higher education institutions. Comprehensive case studies are now available to evaluate the usability of Zoom and Teams in higher education institutions.

In conclusion, this literature review identified different research on the implementation of communication technology tools and platforms in the learning process at the university. This review highlights some shortcomings, including the lack of teacher training in the use of technology tools in a consistent manner. The Ministry of Education does it but in a very generic way, it would be necessary to make it more specific where teachers will need it for their course session. That is why we propose here an in-depth analysis of the problem of the use of technological tools by all the actors of the university environment, whether it is students, teachers and more generally, all the personnel of university campuses [18−20].

3 Materials and methods

The work proposed here is based on a qualitative approach and a descriptive scope. In particular, a hybrid approach of the soft systems methodology and the Malt Cross methodology is implemented. The essence of this hybrid approach is the holistic method. It includes the steps that will be described in the following subsections.

3.1 Unstructured situation

In this step, the causes of the problem studied are analyzed using the problem tree tool. This type of tool allows the identification of major problems, their causes and consequences, thus allowing the identification of the central problem of an organization or a particular situation. Figure 1 shows the problem tree for the impact and consequences of using technology tools in higher education.

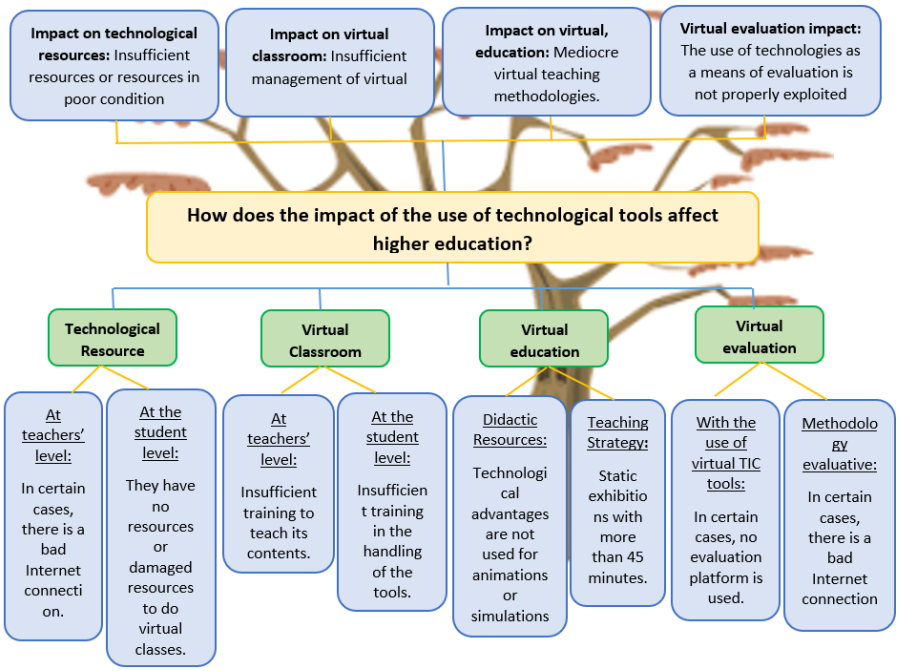

Fig. 1. Problem tree to analyze the impact and consequences of using technology tools in higher education

3.2 Structured situation

In this step, we identify the main actors involved. We selected: the Internet in general, the National Superintendence of University Higher Education (Sunedu), the students, the teachers, the university as a training institution, the virtual classroom and the parents.

3.3 CATDWE mnemonic

At this point, the mnemonic CATDWE [21] has been developed and the meaning of each letter is explained below:

C: Client i.e. the beneficiary or victim of the problem.
A: Actor who performs the transformation.
T: Transformation of the current situation into the desired situation.
D: Owner, that is, the one who has the power.
W: Weltanschauung or worldview. This is the opinion on the problem.
E: Environment. It is the environment that surrounds the studied system.

In what follows, we propose to implement the CATDWE approach for each "Weltanschauung" identified above i.e. the Internet in general, the National Superintendence of University Higher Education (SUNEDU), the students, the teachers, the university as a training institution, the virtual classroom and the parents.

W1. Internet. The Internet is defined here as a global and decentralized computer network, formed by the direct connection between computers through a special communication protocol [22].

C: Students, teachers, University.

A: Elon Musk's Tesla and Mark Zuckerberg's Facebook.

T: See Figure 2.

D: The government of each country.

W: Develop a common plan to present to governments in order to reach a consensus. This plan must be able to be implemented without constraining each government, but rather benefiting them.

E: Governments.

Figure 2 shows the transformation and benefits of the Internet in higher education.

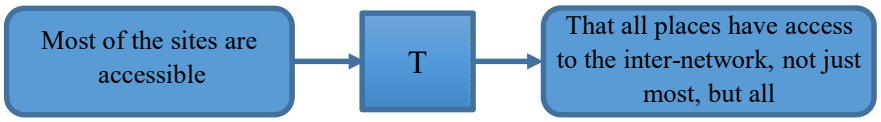

Fig. 2. Transformation and benefits of the Internet in higher education

W2. SUNEDU. The National Superintendency of Higher University Education is responsible for the administration of the National Register of Diplomas and Qualifications, which ensures the legal security of the registered information and guarantees its authenticity [23].

C: University, State.

A: SUNEDU.

T: See Figure 3.

D: Status.

W: The state must pass legislation authorizing SUNEDU to evaluate the institutes.

E: Status.

Figure 3 shows SUNEDU's evaluation of universities and institutes.

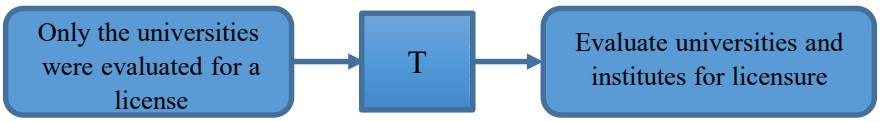

Fig. 3. SUNEDU's evaluation of universities and institutes

W3. Students. A student is defined here as a person who is studying at an institution of higher learning.

C: The university, students and teachers.

A: The Ministry of Education.

T: See Figure 4.

D: The Ministry of Education.

W: We are not yet ready to do virtual classes because there are too many people who do not have the technological resources [24].

E: The Ministry of Education, SUNEDU.

Figure 4 shows the support for students who do not have sufficient resources.

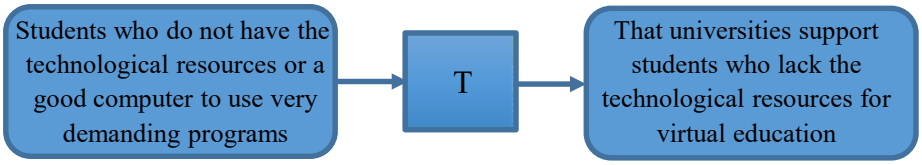

Fig. 4. Support for students who do not have sufficient resources

W4. Teachers. A student is defined here as a person who is studying at an institution of higher learning.

C: The university and students.

A: SUNEDU.

T: See Figure 5.

D: The Ministry of Education, SUNEDU.

W: Teachers who are not adept at teaching in virtual classrooms should be trained to make the classrooms interactive with their students.

E: SUNEDU.

Figure 5 shows that some teachers are not familiar with the technology tools for teaching in virtual classrooms.

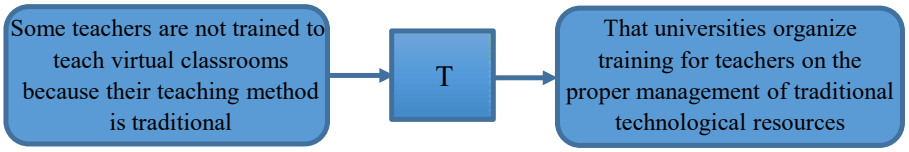

Fig. 5. Supporting teachers with technology tools for virtual classroom teaching

W5. University. Study center that trains students in different faculties.

C: Students.

A: SUNEDU.

T: See Figure 6.

D: The Ministry of Education, SUNEDU.

W: A strategic plan on virtual tools should be established to foster learning with the student so that the classroom is interactive [25].

E: SUNEDU.

Figure 6 shows that some universities are not ready to offer virtual classes.

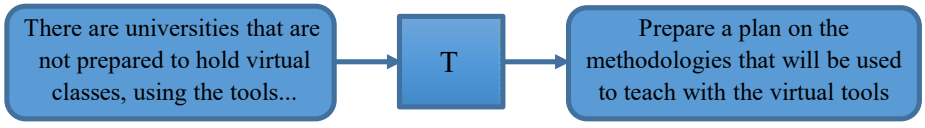

Fig. 6. Supporting University with technology tools for virtual classroom teaching

W6. Virtual classroom. Here we define a virtual classroom as a digital environment that enables the development of a learning process [26].

C: Students.

A: Universities, colleges of engineering.

T: See Figure 7.

D: The Ministry of Education.

W: To solve this problem, prior training should be provided to teach the proper use of this virtual environment.

E: The Ministry of Education, SUNEDU.

Figure 7 shows the problems of digital platforms.

Fig. 7. Transformation and benefits of virtual classrooms

W7. Parents. A student is defined here as a person who is studying at an institution of higher learning.

C: Students and parents.

A: The Ministry of Education.

T: See Figure 8.

D: The Ministry of Education and the Ministry of Labor.

W: Students who do not have these tools should consider a solution that will allow them to continue their education and help them pay the monthly payments.

E: The Ministry of Education, SUNEDU.

Figure 8 shows people who do not have technological resources that affect the learning process.

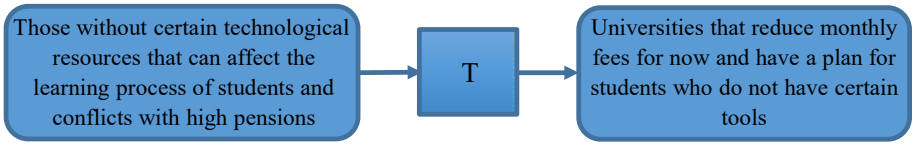

Fig. 8. Supporting parents with technology tools for virtual classroom teaching

3.4 Conceptual models

In this step, the question "How do we perform these activities?" must be answered to achieve the desired transformation.

Figure 9 shows access activities for Internet use. The government must support all academic actors in the massive use of the Internet. In this way, the Internet access deficit is reduced. To do this, it is necessary to start with activities such as planning by the government.

Figure 10 shows the activities of the superintendence of higher education SUNEDU. This body supervises the universities; to do so, it must control the teaching and learning

process according to the new Peruvian law on universities. In this way, the universities must meet minimum quality requirements. Thus, universities must have a good infrastructure, computer labs so that their students can use the different technological resources.

Figure 11 shows the activities for which students initially do not have access to the different technological resources. It is then proposed to the students to have the support of their university, giving privileges to the students who have limitations in the use of the different technological resources. One of the activities to be carried out is to identify those who need it the most, for whom certain conditions must be established to obtain the loan of technological resources.

Figure 12 shows the activities to be carried out, because at the beginning, the teachers dictated the lessons in a traditional way. In addition, they did not make much use of technological tools. The university is carrying out a continuous improvement plan with ongoing training for its teachers to develop their digital skills. The students will benefit, since they will have teachers with the right level of teaching and learning.

Fig. 9. Conceptual model applied to the use of the Internet

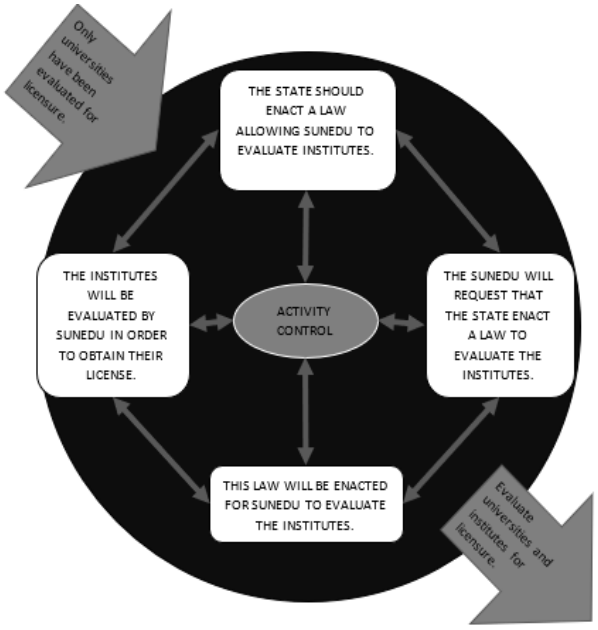

Fig. 10. Conceptual model applied to SUNEDU

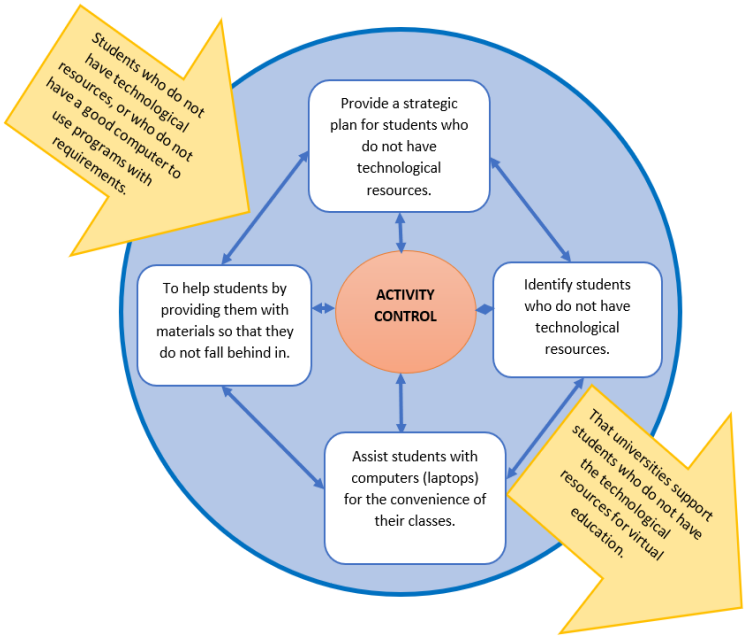

Fig. 11. Conceptual model applied to students

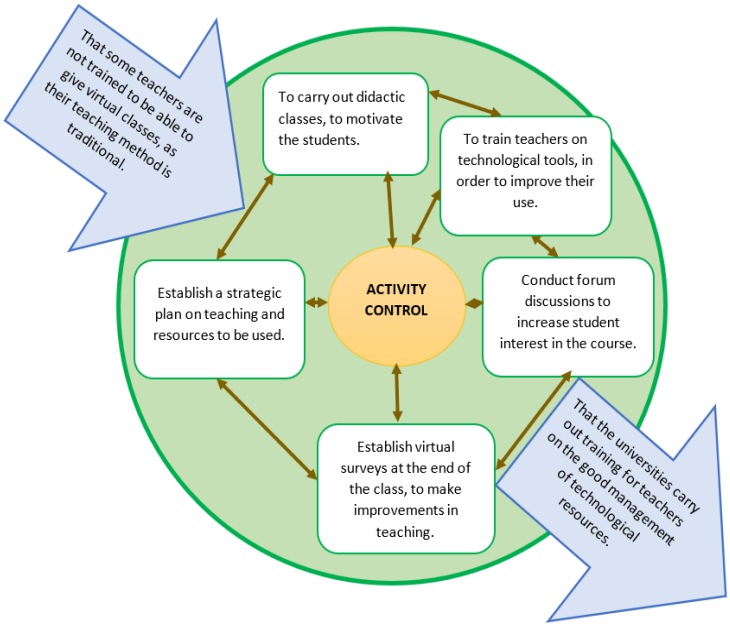

Fig. 12. Conceptual model applied to teachers

Figure 13 shows the activities that the university must conduct for continuous improvement of the teaching and learning process. The improvement must be aimed at providing a better service to the students. For this, it must have a good curricular plan, as well as technological laboratories with free and licensed software facilities. In addition, the university must train its students before they start classes. In this way, the students will have all the facilities offered by the university.

In Figure 14, with regard to virtual classrooms, the activities to be carried out are through a plan, the technological area of the university must give priority to the fact that the classrooms must have all the necessary facilities for their students to use the Internet with good connectivity, the classroom has educational platforms, as well as video conferencing with limited access.

In Figure 15, the activities related to the parents of the students, usually in the first academic semesters, are the parents who assume the expenses of the students. In this sense, the use of technological resources by students at home, in some of them are limited. Since the father cannot have access to several computers with the use of the Internet, since in the family there is usually more than one child. Therefore, students go to the university to get all the facilities for their studies, with loans of laptops at home and the separation of laboratories for their use.

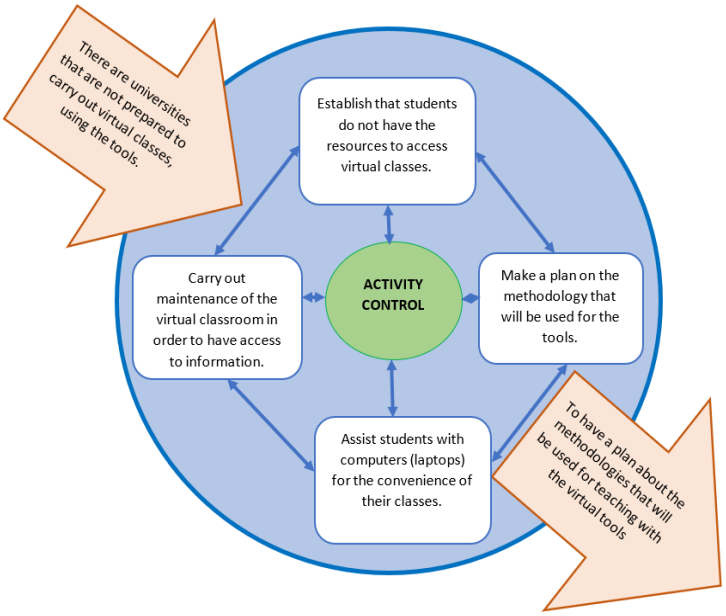

Fig. 13. Conceptual model applied to universities

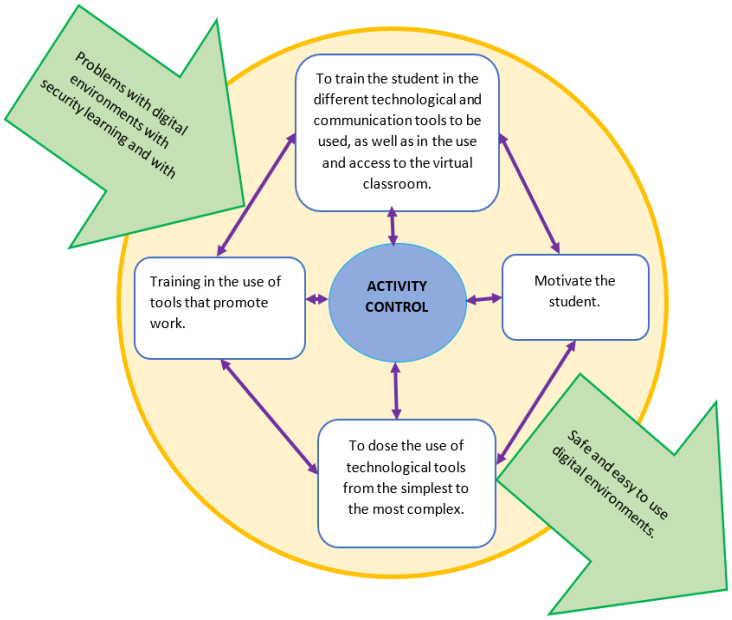

Fig. 14. Conceptual model applied to virtual classrooms

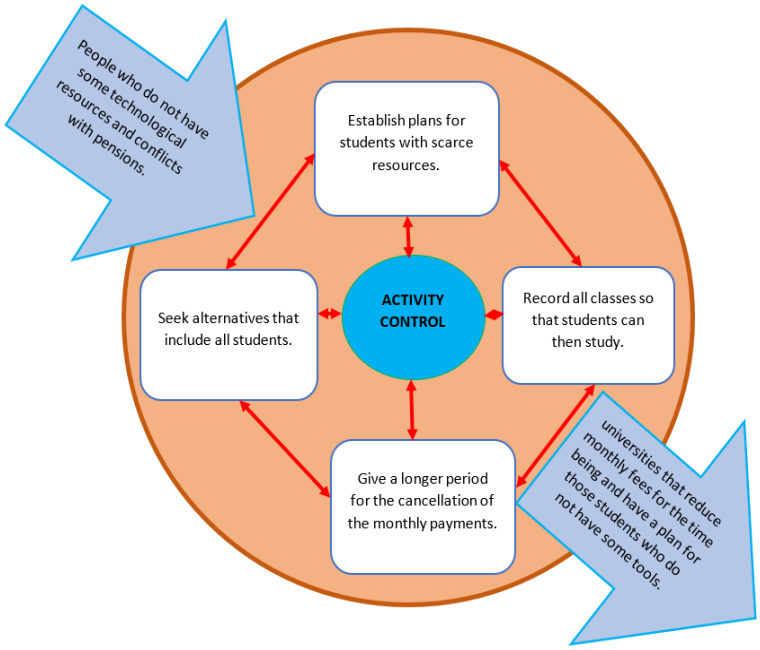

Fig. 15. Conceptual model applied to parents

3.5 List of activities

All activities in the conceptual model are listed below for analysis:

1. Generate a plan for the internet to reach everywhere.
2. Carry out the plan already established.
3. Present it to the state government.
4. Reach a consensus with the state government.
5. The state should enact a law allowing SUNEDU to evaluate the institutes.
6. The institutes will be evaluated by SUNEDU in order to obtain their license.
7. SUNEDU will request that the state enact a law to evaluate the institutes.
8. This law will be promulgated for SUNEDU to evaluate the institutes [23].
9. Identify which students do not have technological resources.
10. To help students by providing them with materials so that they do not fall behind in their classes.
11. Provide a strategic plan for students who do not have technological resources.
12. Assist students with computers (laptops) for the convenience of their classes.
13. To carry out didactic classes, to motivate the students.
14. Train teachers on technological tools, to improve their use.
15. Establish a strategic plan on teaching and resources to be used.
16. Conduct forum discussions to increase student interest in the course.
17. Establish virtual surveys at the end of the class, to make improvements in teaching.
18. Make a strategic plan, to solve and facilitate the virtual tools.

19. Make a plan on the methodology that will be used for the tools.
20. Carry out maintenance of the virtual classroom in order to have access to information about the class.
21. Establish that students do not have the resources to access virtual classes.
22. To train the student in the different technological tools.
23. Training in the use of tools that promote work.
24. Motivating the students.
25. Dosing the use of technological tools from the simplest to the most complex.
26. Establish plans for students with scarce resources.
27. Seek alternatives that include all students.
28. Record all classes so that students can then study.
29. Give a longer period for the cancellation of the monthly payments.

3.6 List of confirmed activities

The following nine activities were specifically selected; activities that were confirmed by three experts in the field. The first expert is specialized in pedagogy, the second in technology and the third in educational management:

1. Develop a plan to make the internet everywhere.
2. Record the virtual classes so that students can study later.
3. SUNEDU will ask the state to enact legislation to evaluate the institutes.
4. To carry out debates, forums and didactic courses, in order to motivate the students.
5. Train teachers on technology tools to improve their use [27].
6. Develop a strategic plan for teaching and resources to be used.
7. Implement virtual surveys at the end of the course to improve instruction.
8. Establish a strategic plan, to solve and facilitate the virtual tools.
9. Perform maintenance on the virtual classroom to access information about the class.

3.7 Confirmed and validated conceptual model

Figure 16 shows the confirmed and validated conceptual model, which is based on monitoring the activities listed above.

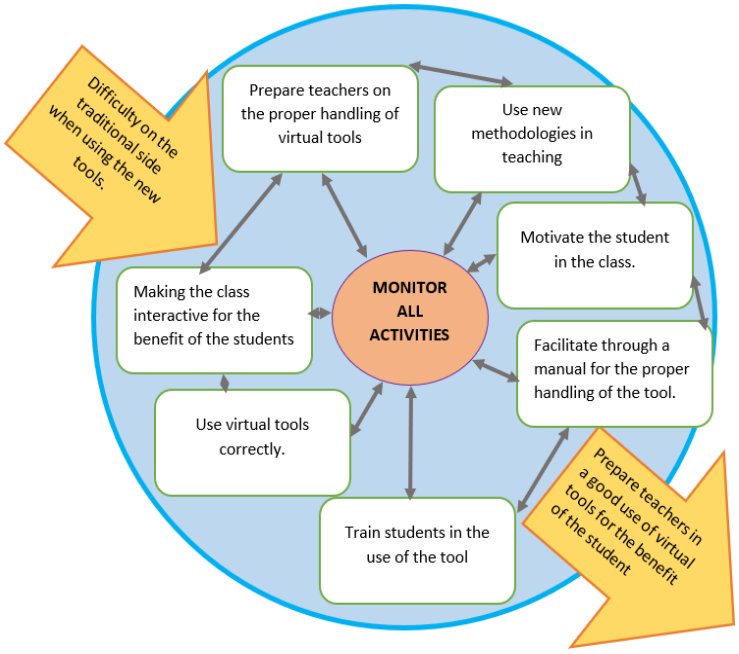

Fig. 16. Confirmed and validated conceptual model

3.8 Information categories

Each category of information is used to place the selected activities in the first row. Then, in the first column, the inputs and outputs of the information are placed. In addition, the table is filled in by crossing the activities with the inputs and their outputs (see Table 1).

Table 1. Information categories

Activity	**Prepare teachers on the proper use of virtual tools**	**Use methodologies in teaching**	**Control activities**	**Motivate the student in the class**	**Makin the class interactive for the benefit of the students**	**Use virtual tools correctly**	**Train students in the use of the tool.**	**Facilitate through a manual for the**
INPUT	Survey report / student on the use of new technologies	Evaluation report on the use of new technologies	Coordination report	Report of results by student	Report on what was done in the class	Tool handling report	Training class request	Report of the tool handling manual
	Evaluations		Activity control report	Report of evaluation results	Reports of class results that the students got		Report on the implementation of the training	
	List of topics to be trained							

OUTPUT	Results report	Evaluation report on the use of new technologies	Progress efficiency report	Progress efficiency report	Surveys	Knowledge of the correct use of tools	Results report	Report on the performance of the use of the manual
	Result monitoring report		Activity control report	Student satisfaction surveys		Good handling		
	Surveys		Schedule of activities			Best virtual class		

4 Results and discussion

The Maltese Cross methodology allows for quadrant analysis and helps analyze the results of the selected activities in the survey by placing the north. It is a technique for analyzing and redesigning information systems. It is composed of cardinal points in which: west is the entrance, east is the exit, north is the activity and south is the PPI [20]. Specifically, the categories of information identified as inputs and outputs are placed to the west and east respectively. And finally, in the south, the information processing process is placed, which serves as a support and can be automated or manual.

Figure 17 shows the Maltese cross. The results of all the reports on the use of technological tools in higher education are oriented according to the 4 levels: North activities, East OUT, South IPP (information processing procedure) and West IN. The letter "X" is placed making the analysis with the 4 cardinal points and the selected activities.

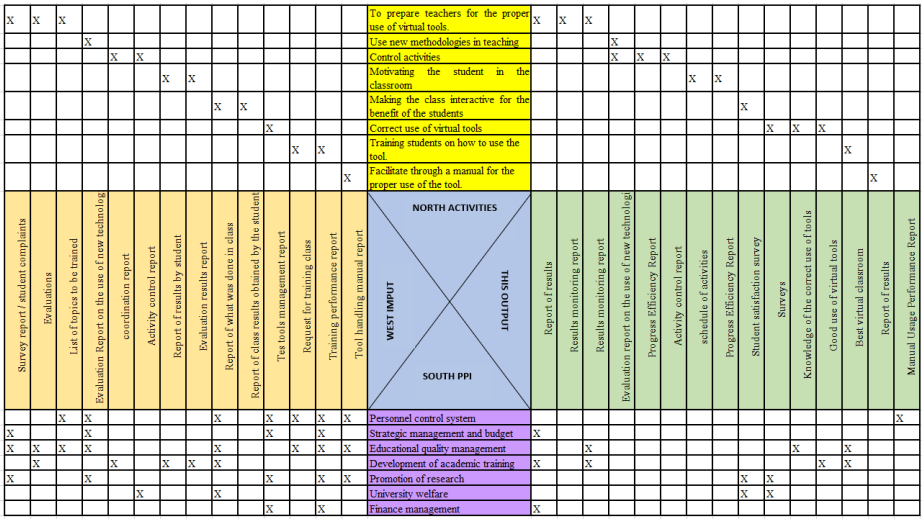

Fig. 17. Maltese Cross and its analysis by quadrants

4.1 Northeast versus Northwest

The teaching training for a correct management of virtual tools is based on the provision of evaluation reports to know their improvement in time, taking into account that there will be a further improvement in the teaching of the teacher with the student, using and taking advantage of the new technologies.

4.2 Southeast versus Southwest

The analysis revealed the need to survey students to determine if the courses were interactive and to their liking. If not, they were asked to suggest improvements to the instruction for the benefit of the student, based on a student satisfaction report after taking the course.

4.3 Northwest versus Southwest

The analysis highlighted the need to account for the assessments that will be done in the teacher's classroom with the use of virtual tools, as well as the methodology used with the student, in order to make it more interactive and understandable, to motivate the student.

4.4 Northeast versus Southwest

Students have access to a manual for the proper handling of the virtual tool, as this would be beneficial in their teaching and would allow for proper handling of the tool. Reporting on the progress of the students' handling of the tool seems to be a priority [28].

4.5 Northwest versus Southeast

The teachers must have a good handling of the virtual tools, for the good teaching of the student being interactive and thus to be able to have good results in the obtained teaching.

4.6 Northeast versus Southeast

The analysis revealed the need to improve the use of technology through animations and simulations in virtual classrooms.

The analysis of available studies in the literature provided similar results, including those in reference [19], where in-service training was also conducted, which allowed teachers to develop their digital skills. Students also benefited as their teachers were prepared to use digital tools in the teaching and learning process. However, the difference lies in the limitations: in this research, there was no budget to organize in-service training with experts in digital tools.

Technology tools for the teaching-learning process are essential to support the course session. Moodle, as an educational platform, and Zoom video conferencing are complements for teaching. The university has supported the use of these technology tools through training. After training teachers and students, the impact has been positive in virtual teaching. This agrees with the authors of [7] who had the support of the university authorities for the use of technological tools such as Zoom and Moodle.

In addition, the technological and digital tools that can be used in the teaching and learning process are summarized below:

- Zoom videoconference;
- Moodle Platform;
- Digital boards;
- Mental maps;
- Digital repositories;
- Online bibliographic manager;
- Online evaluation system.

5 Conclusions

This research work allowed an in-depth analysis of the use of technological tools by applying the steps of the software systems methodology and complementing it with the Maltese cross. The result obtained is that teachers have developed their digital abilities in the use of technological tools through the training provided by the university. These technological, digital tools such as digital whiteboards, Zoom, Moodle, digital repositories, among others, have enabled teachers to use them complementing didactic and technical strategies in the classroom session. Thus, the students accepted the didactics in the classroom. Therefore, the students were the direct beneficiaries of the learning. In addition, the analysis of different points of view allowed the university to have a broader view to make good decisions. One of the limitations was the economic part of the university, since it did not have a budget to constantly carry out continuous training with the teachers. As a future work, it is suggested that the teachers complement themselves with other teaching methodologies, since they will use new technological tools and programs to perform their daily work, for a good education. In addition, it is suggested to carry out a study on the use of digital tools in different modalities such as blended learning, hybrid, etc.

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