Personal Learning Environments for Inclusive University Studies with STEAM: An Architectural Approach

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Abstract

This research paper aims to present personal learning environments as a solution based on information and communication technologies, ideal to support the implementation of the STEAM field in higher education within the context of inclusive education. First, some benefits and characteristics of the STEAM field in universities are presented. Next, the theoretical foundations that serve as inspiration for the development of this technological proposal are briefly described: STEAM field, learning analytics and personal learning environments. After, the problem to be solved is developed by talking about the limitations of conventional virtual learning environments. Subsequently, the proposed solution of the architectural model is explained in general terms with its main modules and functionalities in each one of them. Then, the application of the STEAM architectural model at the Universidad Autónoma de Aguascalientes study case, where is presented information about the use of technology as support to students' learning process and some statistics related to the results of the evaluations in STEAM subjects are presented, in this same part of document are shown three tables as report examples of information's type used in this technological proposal. Subsequently, characteristics from others PLE founded in literature are show in a comparative table. Finally, conclusions about this research are exposed.

Keywords

STEAM field, Higher Education, Personal Learning Environments

1. Introduction

According to [1], society demands students and professionals who have a direct and evident impact on the knowledge they are acquiring and/or obtained during their training. This requirement is a real challenge not only for society, but also for the UN, since it is the basis of goal four of the 2030 Agenda.

For [2] it is evident the global trend to implement the STEAM (Science, Technology, Engineering, Arts, Mathematics) field by the different countries of the world in their respective national education systems, and the implementation of this field in developed countries has achieved significant positive results in relation to the learning of students in those nations.

The STEAM field in education is a teaching-learning approach that aims to encourage students' interest in five areas of knowledge: science, technology, engineering, arts, and mathematics, which are considered fundamental for the skills and competencies that citizens of the 21st century must have for effective professional performance in today's society and in the years to come.

In this order of ideas [1] mention that the STEAM field motivates to carry out active learning, where students need to take the scientific method as a basis, obtain data from various sources of information, help each other to accomplish tasks and/or projects and all this associated to their

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ordinary lives, this search process is similar to the way in which science is generated and technology is developed.

The STEAM field offers the educational systems of each country a set of useful features that meet the learning needs and demands of university students in relation to the development of their abilities to: analyze, reflect, create, invent, innovate, propose, improve, change, be critical and self-critical, etc.

Now, the use of ICT (Information and Communication Technologies) and AI (Artificial Intelligence) at the university level, are two elements that directly support the STEAM field, through these technologies can generate a set of intelligent digital educational resources that improve the teaching-learning process and the development of these educational and professional skills in the university population.

The structure of this paper is as follows: Section 2 presents the definition of fundamental concepts. Section 3 provides a series of problems recognized in much of the literature on the subject of study. Section 4 presents the conceptual model of the main proposal. Section 5 tests the proposed model through a case study. Section 6 shows a comparative table about PLE characteristics from related works. Section 7 provides the space for the conclusion of this paper.

2. Theoretical Foundations

2.1. STEAM field

According to [3] active learning methodologies are typical of fields such as STEAM, they are based on a process of interaction between teachers-students, students-students, students-educational resources and student-environment, which generates an active role for students during the teaching-learning process and places them at the center of the process.

In this sense, for [3] the STEAM field integrates from the same set of subjects the relationship that exists between them in order to be taught through theoretical concepts and the development of practical work in solving problems, it is a multidisciplinary and transdisciplinary approach to acquiring knowledge.

In this order of ideas, [3] consider that through the STEAM field complex problems are addressed based on the disciplines that comprise it, reaching extraordinary and functional solutions, which really solve such problems, also this educational field promotes and awakens in students an approach to science and technology, all of the above has a positive impact on higher education institutions.

Also [1] mention that the STEAM field obviously increases academic results, since one of the fundamental premises of this field is learning by doing, the acquisition of knowledge in this way translates into the real capacity of the next professionals and citizens to meet the needs of society.

2.2. Learning Analytics

In the work of [4] they point out that learning analytics is an area of AI that has advanced rapidly in recent years and has become a game changer for education as we know it. They mention some applications of this AI technique: timely identification of students likely to drop out, the acquisition of personalized information "tailored" to each student, the visualization of student data in an innovative, professional, and educational way, among other benefits. In this work, data is a non-tangible resource of high added value, which allows decision makers, teachers and system developers to have more knowledge about the operation of any system (in this case technological-educational) in such a way that the data (or new data) is significant because it will be used to improve a system.

In their research, the authors [4] comment that the goal of learning analytics is for both teachers and educational institutions to adjust learning opportunities according to the particular needs of each learner.

In this order of ideas, it is also commented that learning analytics optimizes the educational experience of each individual, in more technical and/or software engineering terms we could say that such experiences are based, designed, developed and implemented in terms of user-centered UI/UX.

2.3. Personal Learning Environments

In the words of [5] and [8] the main purpose of adaptive learning is to satisfy the need for learning diversity, since no human being acquires knowledge in the same way, they do not have the same type of personality and neither do they have the same intelligence or learning style, due to which adaptive learning contributes to personalize learning.

Currently, according to [9], educational technology has expanded its field of action in such a way that it is also used to address the learning diversity of each student in schools, in this sense, educational technology is responsible for supporting the personalization of student learning through the approach of different learning experiences according to the preferences and needs of each learner.

For their part [5] mention that adaptive learning, ICT and AI are elements that allow to know more precisely the students, in relation to the learning process of each one, this information can be managed and visualized through virtual learning environments, this leads to "traditional" virtual learning environments become intelligent personal learning environments.

In the work of [13] they talk about seven factors considered essential in the teaching-learning process where PLE (Personal Learning Environments) have a direct impact. The following is a brief description of how PLE influence these learning factors.

The role of the learner. In PLE, the role of the learner is more active because the simple need to interact with the PLE interface motivates and inspires the learner to search for and access information that he/she considers relevant, becomes a generator of ideas, and improves his/her capacity for self-management and flexibility in relation to the way he/she learns.

The possibility of personalization of the process. A PLE is a digital environment that offers a high level of configurability to the learners, since in this virtual space students have the opportunity to tailor this learning environment to their technological needs, as a support to their learning process.

The contents. They are a key element in a PLE, through them new knowledge is acquired, and, in this case, it is the students themselves who choose the contents that meet their learning needs, these resources can also be provided by third parties or based on a recommendation, however, it is the students who choose what to use as support for their learning process.

Social involvement. The scope of the PLE in accordance with the professional development at the student level in society is another benefit offered by a PLE, in these learning environments, the interaction between graduated professionals and students to be graduated is promoted and facilitated.

Data ownership and protection. The information of the contents through licensing initiatives such as Creative Commons, favor the distribution and access to them, this is important because, at the university level when you are studying, you generally do not have the economic resources to access commercial content for paid licensing.

Educational and organizational culture. The use of PLE contributes to the evolution of a self-learning culture, always encouraging students in their learning process to increase their level of participation, the student gradually becomes more autonomous and begins to manage the way in which they acquire new knowledge.

Technological aspects. The digital learning space offered in an PLE is the ideal place for both students and teachers to jointly select those tools that are most useful for teaching students.

On the other hand, in the research of [14] the authors propose a rubric that allows evaluating PLE, according to their literature review they decided to present a table with 15 criteria, considered adequate to evaluate PLE, these criteria were evaluated by four PLE experts in relation to the following scale: Essential, Useful but not essential and Not necessary.

Table 1 shows the results of the work of [14]. It is important to mention that, unlike the table presented in the work of [14], the order in which the criteria are listed for the EPA quality rubric was modified for the purposes of this study. In this case, those that had a CVR (Content Validity Ratio) equal to 1 are listed first. The CVR is a validity ratio that [14] used to determine how essential each of the criteria they propose are. It is calculated as follows:

$$\mathrm{CVR} = \left(\mathrm{ne} - \frac{\mathrm{N}}{2}\right) / (N/2), \tag{1}$$

Where ne is the number of experts who indicated that a criterion is "essential" and N is the total number of experts. If the result of the ratio is 1, the criterion is essential, if half of the experts consider a criterion essential and the other half do not, then the CVR is 0, when more than half of the experts consider a criterion essential and the rest do not, then the CVR value ranges between 0.00 and 0.99, finally if more than half of the experts agree that a criterion is not essential and the rest do, then the CVR takes a negative value, and the criterion is considered not useful for the quality rubric.

Table 1
Criteria for evaluating the quality of a PLE. Source: [14]

Criteria	Essential	Useful but not essential	Not necessary	CVR
1. Objective of the project to create and develop their PLE	4			1
3. Ubiquity of PLE (using different devices)	4			1
6. Perception of efficiency in the use of PLE	4			1
7. Systematic use of PLE	4			1
8. Transformation tools PLE (add, connect, create, share, and organize)	4			1
11. Criteria for the choice of tools	4			1
12.Connectivity between tools	4			1
2. Functionality of the PLE (add, connect, create, share, and organize)	3	1		0.5
4. Learning related to the project mediated by the PLE	3		1	0.5

9. Finding information	2	2	0
13. Collaboration with other users	3	1	0.5
14. Share information	2	2	0
15. Transfer to another context	3	1	0.5

Some of the criteria for evaluating the PLE in the table elaborated by [14] can be considered characteristics specific to the STEAM field, examples of these criteria are: the role of the students and their level of participation based on the interaction with the PLE through their functionality, the access to the PLE from different devices, this is very important, especially for students of new generations, the perception of efficiency with the use of a PLE, this criterion is of vital importance because if the students consider that their learning was more meaningful and simple, then the PLE will have achieved its main objective, information management (access and search) in this case the student must develop the ability to have initiative to access useful content for learning, the PLE also offers students to choose their technological tools, share information and work collaboratively with their peers, these elements are also typical of the STEAM field.

In summary and according to [14], if a PLE meets these 13 criteria or most of them, then the PLE is considered to be of good quality and useful for student learning, as most of the expert evaluators of these criteria in the work of [14] consider so.

Now, international trends in higher education require efforts to design, develop and implement personal learning environments, as well as personal and intelligent educational resources, in other words, the idea is to create a synergy between pedagogy, ICT and AI

3. Problem Outline

Currently, the relationship between pedagogy and ICT is very close in the educational sector, at all levels, from the educational area every now and then new teaching methodologies are presented, new paradigms or educational approaches are proposed, which seek to improve the teaching-learning processes, ICT have been used as support to facilitate these processes.

In this order of ideas, technology-mediated learning is becoming increasingly relevant and simultaneously the student is increasing his level of participation in the teaching-learning process, becoming the undisputed protagonist of this process and it is thanks to ICT that the student achieves this role, as noted [6].

However, most higher education institutions have some LMS (Learning Management Systems) that allows to make available to their respective students a set of software tools and digital educational content to improve their learning process, to support the content that teachers transmit directly to them, however, this educational process is increasingly obsolete for the current needs demanded by the student population.

Some of the causes of the learning needs of the new generations of students in relation to the way they assimilate new knowledge are multiple intelligences of the students, learning styles, moods, cultural and social conditions, different cognitive levels to assimilate complex concepts of mathematics and physics, economic level and the presence of barriers to learning and participation in some universities, etc.

On the other hand, the authors [6] state that the fundamental objective of the use of ICT in teaching-learning processes is to know how human beings learn through the use preferences of certain applications and virtual educational platforms.

The current virtual learning environments and digital educational resources are educational technologies that do not cover all the particular learning needs of each student, usually these types of educational tools are designed in a standard way, in relation to its operation and interaction, as well as the form of evaluation, they are also considered rigid according to the way in which the content is presented in them.

Apart from the technologies, a key factor to achieve the implementation of the STEAM field at the higher level in an adequate way, are the teachers, since they must be trained to transmit their knowledge in an original, creative, intelligent and interesting way for the students, it is about making the contents simple, especially the complex ones, so that the students achieve a significant learning, even when the teachers teach subjects different from those that conform the STEAM acronyms.

4. Architecture Model for Personal Learning Environments

The main objective of this research work is to propose the use of PLE as a solution to the growing demand for the personalization of learning environments, since PLE are considered a flexible technology with the ideal technological potential to meet the learning needs required by students at the higher education level. On the other hand, this PLE model is viable to support and implement in an effective way the pedagogical characteristics of the STEAM field in order to awaken the interest and participation of university students in the ways proposed by this field to acquire and generate new knowledge.

This proposal consists of creating an application that integrates learning analytics techniques and machine learning algorithms that allow the generation of intelligent personal learning environments, where each environment will be different from the others since each one will correspond to the specific and particular needs of each student.

Figure 1 shows a scenario of use of PLE-UAA by teachers and students, as an example of the general operation that would be carried out in this technological proposal.

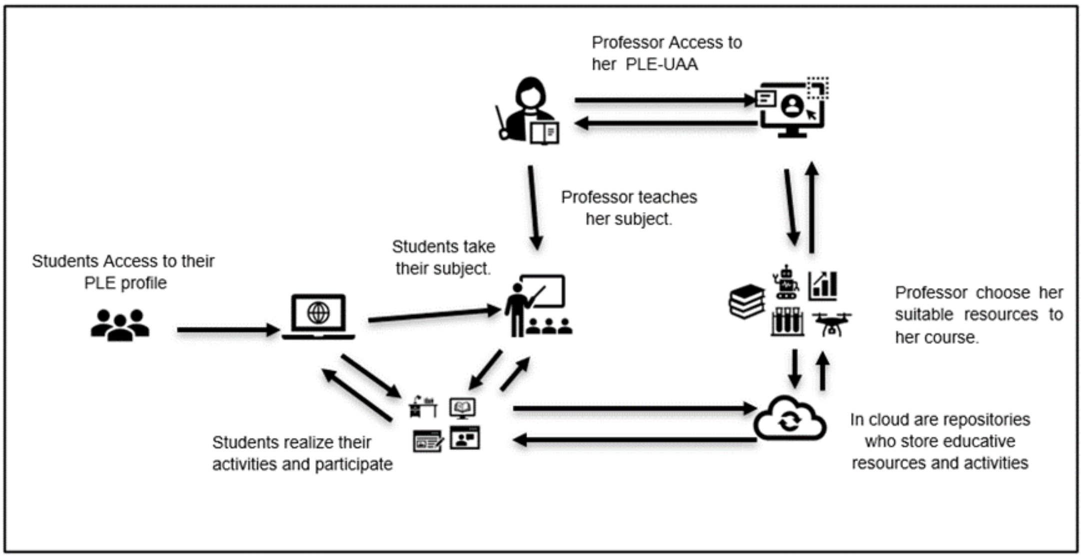

Figure 1: Access to PLE-UAA by teachers and students. A general teaching-learning process is presented through the technological proposal.

The architectural model with a STEAM approach is shown in Figure 2 with the main modules of the application proposed in this study to provide a solution to the generation of intelligent personal learning environments that support the improvement of accessibility to information in general and to existing educational resources for people with some type of disability and/or barrier to learning and participation at the university level.

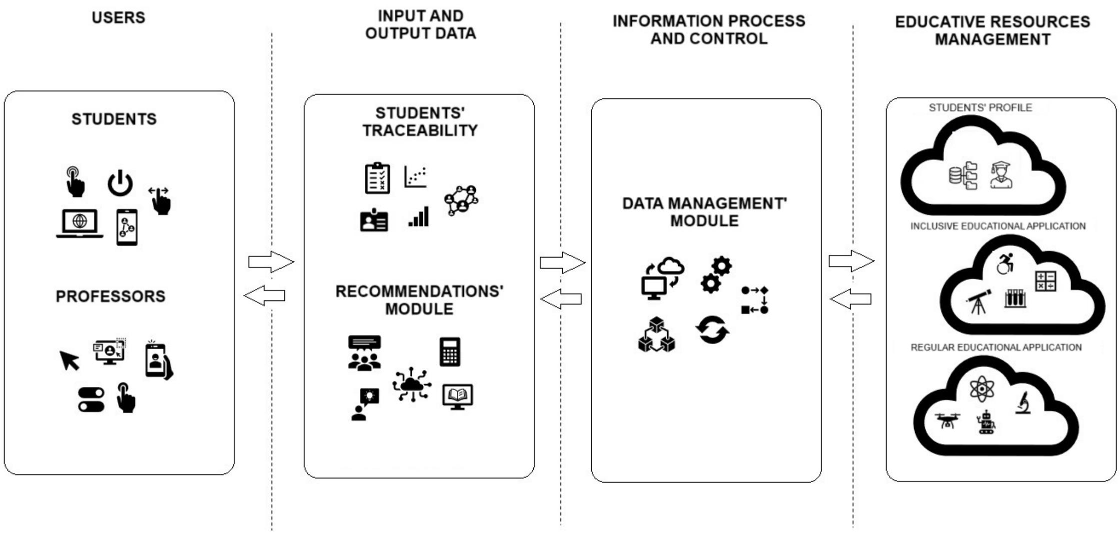

Figure 2: Architectural Model for Inclusive Personal Learning Environments with STEAM at University Level.

Users. This first layer of the proposed solution is the most important because it is the one with which students and teachers will interact. In the case of students, the design of the interface and the ICT resources presented to each of them will be through a personal learning environment that meets their needs for access to information and educational resources in a suitable way based on a recommendation from the PLE.

Input and output data. At this level of the proposed solution there is an input module whose main purpose is to track the academic data of university students in relation to their predominant type of intelligence, their learning styles, their preferences in the use of certain types of digital resources. It is important to note that the collection of this type of information will be carried out under confidentiality standards, authorized use and under the best security practices possible and available for this purpose, as an output module the PLE will provide an interface tailored to each student and access to digital resources based on the recommendation module.

Information processing and control. This phase of the proposed solution is the most important, from a technical perspective, this level of the architecture contains the data management module and thanks to this element of the solution, it will be possible to associate the information of each student at the higher level and their learning needs in relation to their individual profile and the needs of accessibility to information and ICT-based educational resources that are adapted to these personal requirements.

Educational resources management. In this layer of the proposed solution will be the repositories with the information of the students' profiles, as well as the repositories of educational resources for the majority student population and educational resources for students who present some BLP (Barriers to Learning and Participation). It is important to mention that both repositories of educational resources will store applications and digital materials for free licensing.

5. Application of the Architectural Model

The UAA (Autonomous University of Aguascalientes) is a public higher education institution in the State of Aguascalientes, it has administrative management systems for the management of this type of information and in relation to educational tools it has an LMS called Virtual Classroom, which is available to all students.

For this case study, the objective is to present some statistical data of the students of this higher education institution on the access and use of ICT as a support in their learning process and the failure rates of the main groups of subjects related to the STEAM field.

At the Universidad Autónoma de Aguascalientes, the Department of Institutional Statistics conducts a study of student population traits at the undergraduate and high school levels every school year.

Some data of UAA students according to [10] in relation to the use of ICT, according to the study of traits of the student population at the undergraduate level are as follows: of a total of 13,391, 12,611 students have a computer or digital device and 780 do not. Breaking this information down by type of device, at the higher level we have the following amounts: CPU 1,800, laptop 9,908, smartphone 7,354, Tablet 1245. In relation to internet service access these are the figures: 12,234 yes, 337 no and 780 do not apply.

On the use of these devices as support for education also from [10], these are the numbers: 11,359 undergraduate students say that they do employ these technological resources for this purpose, a total of 1,072 say that they do not employ them for this purpose and this situation does not apply to 780.

The document [10] also presents information on students with disabilities and types of disabilities, the figures are as follows: of a total of 13,391 students, 13,164 do not have disabilities and 227 do have disabilities, 98% and 2% respectively, of the 227 who have disabilities by type of disability are distributed as follows: hearing 10, deafness 3, intellectual 14, motor 27, multiple 5, psychosocial 13, low vision 13 and blindness 22.

The UAA also generates another report called Failure Rate by Center and Department, which presents the total number of grades passed and not passed, by Center and by Department. The following data is presented for the Center for Basic Sciences and the Center for Engineering Sciences, because they have the largest number of scientific, technological and engineering careers in relation to the STEAM field.

Some figures on this subject in [11] are as follows: in the Center for Basic Sciences, out of a total of 20,869 grades, 19,297 are passing grades, while the percentage of failing grades is 7.53%. In the Engineering Sciences Center, the total number of grades is 3,037, of which 2,814 are passing grades and the percentage of failing grades is 7.34% of the total.

Breaking down this information by some departments of the Center for Basic Sciences we find the following information and according to [12]: the department of Mathematics and Physics of a total of 4,552 grades, 3,991 are passing and 12.32% are not, in second place is the department of Electronic Systems with a total of 3,585 and 3,280 passing and 8.51% of not approved, followed by the Statistics department with a total of 2,548 grades of which 2,334 are approved and 8.40% are not approved, the Chemistry department has a total of 2,945 grades, 2,827 of which are approved and 4.01% are not approved.

Carrying out the same process, but now for the departments of the Center for Engineering Sciences we have the following and based on [12]: the department of Automotive Engineering out of a total of 1,056 grades, 973 are passing grades representing 7.86% of the total, for the Biomedical Engineering department the total number of grades is 881, of these 848 are passing and failing grades are 3.75% and for the Robotics Engineering department the total number of grades is 1,100 with 993 passing and 9.73% failing.

Based on the data presented from the students in relation to the use of ICT and the failure rate of subjects related to the disciplines of the STEAM field, it is considered that currently the impact of the use of ICT is not sufficient to improve the performance of undergraduate students in these subjects. There is no satisfactory relationship between the use of ICT and good performance in science, technology, and engineering subjects.

The conceptual technological solution proposed in this study uses learning analytics to obtain information about the learning profiles of university students, in relation to their learning styles, type and/or types of predominant intelligences, social and psychological profile, information access needs and/or the use of digital educational resources, as well as the preference of using one tool or another.

The value of the knowledge of students' learning profiles obtained through learning analytics is considered strategic, because in this way it is possible to personalize education through PLE, on the other hand, in the STEAM field they talk about physical and/or virtual spaces to be able to carry out their projects and/or experiments, in the digital context PLE are a good option for this purpose.

The potential of ICT and AI to create and develop new learning content is unlimited and exponentially facilitates the level of interaction between students and educational materials, to truly surprising, functional, didactic, and immersive levels. Some of these technologies are augmented reality, virtual reality, 3D design software, holography, among others.

Now, the proposed PLE technological solution shown in Figure 3 is implemented in the case study of the UAA data, an example of general interaction by teachers and students with the PLE is observed, providing a personal and unique user experience which translates into complete satisfaction and meaningful learning for users.

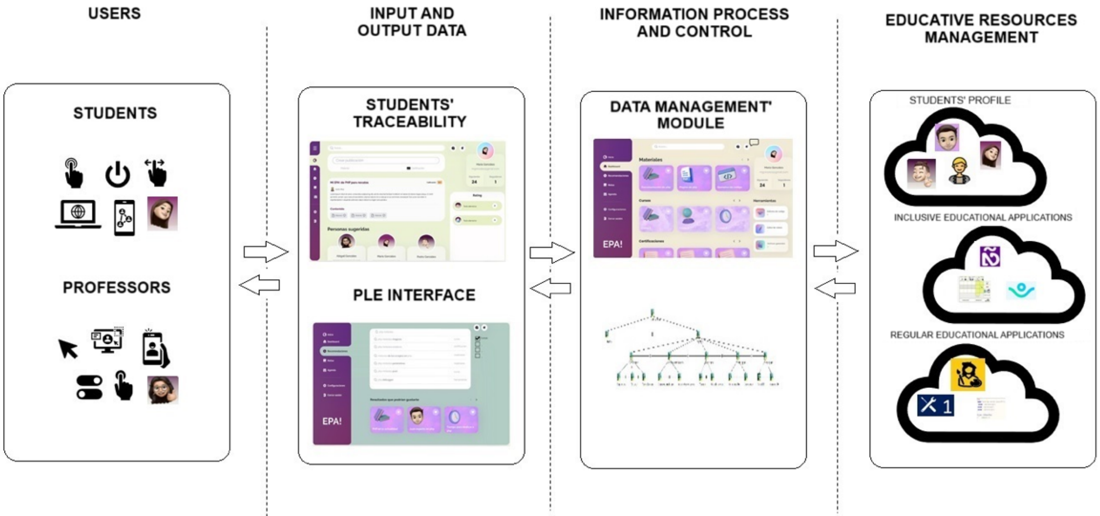

Figure 3: Architectural Model for Inclusive Personal Learning Environments with STEAM at UAA.

Users. In this layer both UAA students and professors will enter the PLE. Each student will have a personal interface to the PLE that corresponds to his or her academic profile and learning needs. UAA professors will be able to recommend certain educational resources to students and will be able to generate their own resources.

Figure 4 shows that both students and teachers access the PLE from different devices and can interact with it through different modalities, such as mouse, keyboard, touch screen, etc.

Figure 4: Multi-device access to the PLE by students and teachers.

Input and output data. This layer of the technological solution will have access to the academic information of the students of the Center for Basic Sciences and the Center for Engineering Sciences, based on this data, with greater precision according to learning analytics the PLE will generate personal learning interfaces for such students of the UAA and will show each one of them the ideal digital materials for their learning process.

Figure 5 shows how in this module, traceability or follow-up is carried out through messaging services within the PLE, where teachers can keep track of the trainees' performance.

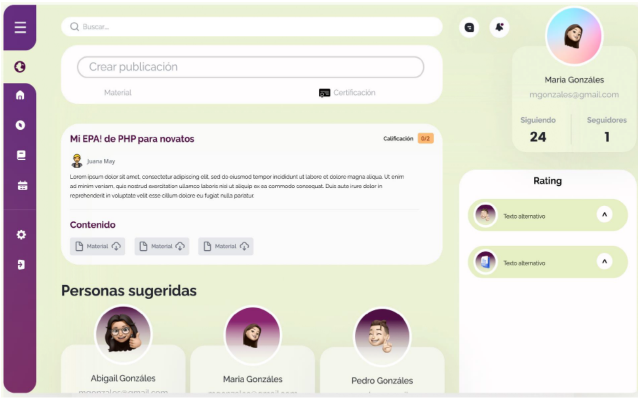

Figure 5: Teacher follow-up of trainees through the PLE.

On the other hand, in Figure 6, in this same layer as output, in the PLE interface the solution presents a set of courses that are recommended to students based on their learning profile data and information from previously taken courses.

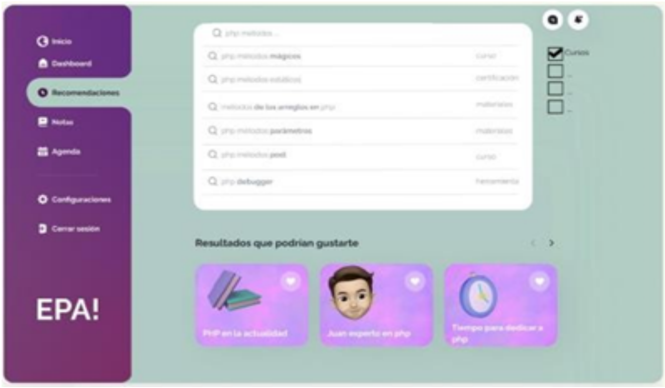

Figure 6: Recommendations of courses that may be of interest to students.

Information and control process. In this layer of the proposed solution, the PLE will present to both teachers and students of the UAA, the set of interaction options that they can perform. As well as all the subsections that the interface of this solution has.

In Figure 7 it can be seen that, in the interface, there are several subsections of the dashboard view: materials, courses, certifications, etc. Each option of the main menu has its respective subsections of information and content.

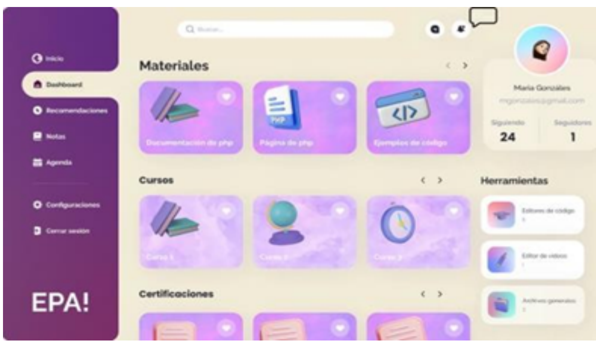

Figure 7: PLE shows different content and information subsections.

Within this same layer, Figure 8 presents a task model under the CTT notation of [17], thus visually and conceptually describing the tasks or activities that can be performed by both teachers and students in the PLE according to the design of their interaction functions.

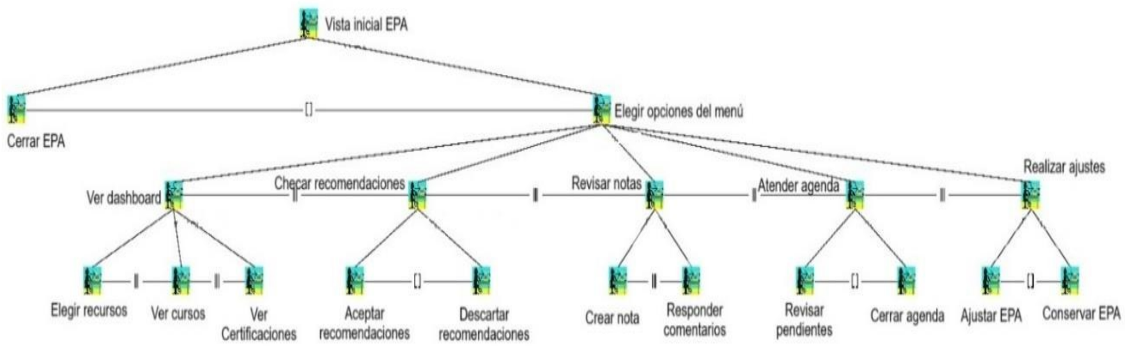

Figure 8: User task model for the PLE with STEAM at UAA.

According to the task tree in Figure 8, it is specified that from the main menu of the PLE, general services are available for accessing content to support an inclusive STEAM approach, such as viewing the dashboard, checking recommendations, reviewing notes, attending to the agenda and making adjustments, among others.

Educational Resources Management. This layer of the proposed solution stores in repositories the information of the UAA students' profiles and the educational resources are stored for their access by teachers and students through the PLE.

Figure 9 shows, as a visual example, representations of the repositories used in the proposed solution: repositories of student learning profiles, as well as repositories of applications for people with BLP like uSound [18], NVDA [15], Headmouse [16] and useful applications for STEAM subjects for mainstream students.

Figure 9: Repositories of academic profiles and student applications.

The expectation after implementing the proposed solution model is that the relationship between the access and use of ICT by UAA students as support tools for their learning will have a greater positive impact in relation to their academic performance, particularly in STEAM subjects, decreasing the failure rates and increasing the significant learning of these subjects.

It is important to mention that ICT alone are not enough for a better academic performance by university students, the role of teachers is fundamental in this process, since they are the actors who must be trained in the use of ICT for educational purposes, so that they can recommend through the PLE the applications required by students, as well as applications where teachers can generate their own content based on ICT.

A few data sets are presented that exemplify information reports on STEAM subjects, level of STEAM skills of students, and presence of barriers to learning and participation in students and some of their respective technological solutions. Table 2 presents descriptive information on some STEAM subjects taught to university students.

Table 2
STEAM subjects at UAA

Name	Semester	Hours/Theory	Hours/Practice
Mechanics I	3º	3	6
Programming	2 º	3	6
Software Engineering	7 º	4	5
Humanistic Training	4 º	2	3
Vector Calculus	5 º	3	6

Table 3 shows data related to the development of general skills related to the STEAM approach by university trainees.

Table 3
STEAM skill level

Student	Science	Technology	Engineering	Arts	Mathematics
Hugo	Intermediate	Under	Advanced	Intermediate	Under
Paco	Under	Intermediate	Intermediate	Advanced	Under
Luisa	Advanced	Intermediate	Under	Intermediate	High

However, Table 4 shows a report on some students who present some barrier to learning and participation, as well as alternative technological solutions that were used to support their learning process.

Table 4
Students with BAP and assistive technology solutions

Student	Auditive	Low Vision	Motor	Assistive Technology
María	X			uSound
Juan		X		NVDA
José			X	Headmouse

6. Related Work

In this section is presented a table where three PLE founded in literature are compared with PLE in this work to analyze some of their main characteristics and explain why our proposal improves some attributes that aren't considered in other PLE options.

Table 5 shows PLE' characteristics and is considered that thanks to this information, is clear to understand main differences and contributions from the proposal in this work.

Table 5
Comparison of some PLE characteristics with the proposal in this work

Characteristics	Symbaloo [19]	Netvibes [20]	Pearltrees [21]	Current Work
Traceability				✓
Recommendation				✓
Learning personalization	✓	✓	✓	✓
Credential management				✓
Blockchain				✓
Multidevice	✓	✓	✓	✓
Portfolio management				✓
Inclusive Learning				✓
Community networks	✓	✓	✓	✓
Teaching management			✓	✓
Connectivity management				✓

According with [19] Symbaloo is about bringing together, in one place, several digital resources that each user considers significant and having the ability to share them with their contacts. In other hand, Netvibes consists of a web platform where users can create a kind of personal online desktop as pointed out [20]. Finally, Pearltrees is an ICT-based service that can be used to generate an EPA, adding several digital resources to the same site [21].

Based in characteristics in PLE according to Table 5, proposal in this document attends three main attributes traceability, recommendation, and inclusive learning, thanks to these elements our proposal satisfies learning process demands from students with BLP.

7. Conclusions

Based on the literature reviewed, the STEAM field is at a point of acceptance and adoption in several national education systems, in different countries around the world, it is considered to be a pedagogical trend at a global level based on the good school results that have been achieved in students in developed countries. On the other hand, the use of PLE at a higher level is an emerging topic, however, the way in which these technologies are implemented to obtain better results in relation to the implementation of fields such as STEAM has not been sufficient.

This paper proposes an architectural model that provides a structured framework and standardize the design and development of a future PLE, which provides a solid foundation that contributes to efficiency, accessibility, and continuous improvement. This is essential in inclusive environments under a STEAM approach for the diversity of students to have equal opportunities.

As future work for the technological proposal proposed in this document, the following activities are proposed:

Integrate a federated learning model that allows analyzing students' academic information with the objective of generating new information that relates the characteristics of each student profile with the technological tools available in the PLE repositories, so that the selection of digital educational resources is the most appropriate for each student.

The expectation is that, through learning analytics, the accuracy of students' academic information will further satisfy the use of this type of content to improve the learning process for all students at the higher education level, including those with BLP.

Once a first version is implemented and running, the objective will be to have the proposed PLE running continuously, so that subsequently, evaluations can be carried out on the impact of the proposed solution on the students' learning process and on its use on an ongoing basis.

As mentioned at the beginning of this document, this technological proposal is focused on the higher education level; however, from an architectural perspective, it is considered that the proposed model can be used at any educational level, probably with minimal adjustments.

In relation to the accessibility of the PLE, the interface of the technological solution proposed in this document will be adjusted to international accessibility standards such as the WAI WCAG, not only for the PLE interface, but the idea is that most of the educational resources managed in the PLE will be designed under this type of standards.

Regarding data privacy, the technological proposal presented in this document will be aligned to the privacy standards of data management, the tool will be in a UAA server that has a good level of security infrastructure and only necessary academic information about the learning process of students will be collected, to which only teachers and technical staff responsible will have access.

In this order of ideas, it is known that a PLE is an interdisciplinary technological solution, therefore, for the proposal to work properly, a work team must be formed in which professionals from different areas collaborate for its development, implementation, and maintenance. Professionals in programming, graphic design, human-computer interaction, lawyers, educators, computer security experts, technology infrastructure managers, etc. are required.

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