Model for Enhancing Inclusive Education through Intelligent Personal Learning Environments

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Abstract

Inclusive education is a topic that has acquired relevance in last years with an extraordinarily strong, and it's because education in general is crucial for the development of any country. However, most higher education institutions aren't prepared to attend to the real needs of teaching-learning process to each student in a personal way, this situation is more complex when college students have one or more kinds of learning deficit or belong to one or more vulnerable social groups. In other hand, college teachers play a very important role in teaching-learning process, but unfortunately most of them don't have necessary digital skills to teach their students from an inclusive education perspective. Besides, technological resources in higher education institutions are designed and developed for regular students. This research has as its main goal explain how a federated learning model trained with higher education data students helps to understand students' characteristics to get a student profile and be able to provide each student useful educational resources as support to satisfy every kind of personal learning needs, to mitigate historical learning disadvantages of student with any kind of learning deficit.

Keywords: Inclusive Education, Learning Analytics, Federated Learning, Personal Learning Environments.

1 Introduction

Some international organizations had a meeting in 2015 and talked about a global goal to be reached in 2030, related to inclusive education, where main objectives are to get an equitable and lifelong learning for all, putting special attention for vulnerable social groups [1].

In Mexico, situation about inclusive education isn't too different to the rest of countries, according with data from National Institute of Statistics and Geography (INEGI), there are a high number of Mexicans in scholar age who are illiterate, this causes that this social group live in an inequality way [2]. Following in this national context, in Mexico was proposed and approved a new law in higher education matter that guarantees from a social dimension perspective equity criterion for all college students, mainly protecting those who belongs to vulnerable groups, this action is an example toward an implementation of inclusive education [3].

Currently most higher education institutions (HEIs) don't have the physical infrastructure, material, or

technological resources, not pedagogical and technological trained teachers to attend the learning needs of students who present some type of learning deficit in a completely satisfactory way [4].

Inclusive education is complex at the university level, because it demands many changes, not only special infrastructure, academic, technological, and human resources, besides there are several types of learning deficits and various levels of severity that could present university students, therefore, institutional educational policies are required that consider all these needs.

Information, and communication technologies (ICT) have been closely linked to education and its processes, it had served as support and to implement advances in the educational sector, however, the target population has always been students who belong to the majority group, forgetting those students who have some learning deficit [5].

A personal learning environment (PLE) is a way of individualizing educational technologies for each student and give them a new autonomy level for their self-regulated learning, this characteristics of PLE could be useful to support the paradigm of inclusive education, because this paradigm focuses on to personalize the learning environment of each university student [6].

To implement inclusive education, it is not only necessary to apply educational technologies in HEIs, also it's essential to know the students, is required to have additional information on the academic profile of university students.

Thanks to the use and management of students' academic data, both teachers and HEIs can make more precise, data-based decisions in favor of students' learning needs, from the perspective of inclusive education [7].

The structure of this paper is next: Section 2 presents the definition of fundamental concepts. Section 3 provides information about the problem outline to attend. Section 4 shows a conceptual model for federated learning applied on higher education institutions in relation with inclusive education perspective. Section 5 presents an architectural model of an intelligent personal learning environment. Section 6 talks about three main stakeholders of an intelligent personal learning environment. Section 7 explains through a case study how both models address and solve the problem of this research. Section 8 presents a discussion about data of students with a learning deficit and some statistics in the previous academic levels. Section 9 provides the space for the conclusion of this work.

2 Theoretical foundation

2.1 Inclusive education

If someone tried to investigate academic records of people with disabilities, perhaps only 300 or 350 years ago, one could verify that such information does not exist because simply, at that time, the possibility of that people who presented some type of physical and/or intellectual deficiency, in the vast majority of cases were segregated and even isolated from society, therefore it was practically impossible for those people to access even basic levels of schooling [8].

Higher education students currently face a list of shortcomings in their academic environment: lack of a personalized and inclusive teaching design, rigid study programs, teaching-learning standardized paradigms, useful only for the regular student population, insufficient adapted educational resources and technology, poor teaching specialization, etcetera [9].

Education in general has been evolving in such a way that practically only students belonging to the majority student population benefit, this has generated a social and pedagogical debt for the student population that presents some type of learning deficit [10].

2.2 Learning analytics

The increase in the implementation of technologies in the educational sector has generated that educational institutions have the possibility of accessing valuable information obtained from students, this information is extremely relevant to improve the quality of education and understand in a simple way how the teaching-learning process works through learning analytics [11].

Learning analytics (LA) are divided into three main levels: descriptive analytics, diagnostic analytics and predictive analytics, each of these levels works differently with the data, in the first level is carried out a common statistical analysis, at the second level the analysis focuses on existing prior information and at the third level the data is used to predict new information [12].

LA satisfies the requirements of recording and analyzing which elements impact the learning process and how those elements are useful to determine student performance, learning analytics are being widely used in university studies [13].

It's use goes beyond the prediction of student performance; other objectives are to make suggestions according to the students' profiles about educational resources, improve the reflective level of learners, identify undesirable behaviors in students, as well as detect their emotional states [14].

The appropriate use of educational data sets is possible thanks to employment of learning analytics, this process consists of with the aim of carrying out an effective analysis, the information in the datasets integrates the activities of students and teachers in the teaching-learning process [15].

2.3 Federated learning

Federated learning is a new paradigm of machine learning whose main characteristic is to be decentralized and that runs on n nodes connected to a server, in this configuration, for model training information that flows are useful parameters for the analysis, in such way sensitive data remains in each of the nodes [16].

Is a technique that complements learning analytics. There are two main architectures for federated learning models: cross-silo also called vertical, and cross-device also called horizontal [17].

Considered a useful technology able to track the knowledge generated by students based on their academic information. This feature is essential for the so-called intelligent education [18].

This machine learning's paradigm satisfactorily solves problems associated with the vulnerability of the protection, privacy and security of sensitive information generated by students in an educative institution [19].

It was designed to improve the results obtained with the use of centralized machine learning, because through the sum of training results from n nodes on a main server, results obtained collaboratively are better than those produced with the classic centralized model [20].

2.4 Personal learning environments

The concept of personal learning environments is considered a new field of study within the context of online and distance learning. It is a demand from students who study online to be supported in the creating learning environments that are useful for the courses they access [21].

The most convincing argument of a PLE is to be able to create educational technology that satisfies the learning needs that people require in such a way that it allows them to develop their own learning environments, consume content and share resources, as well as form learning communities [22].

Are generally defined from two main areas of knowledge, technological and pedagogical, in the first case, a PLE is an application developed by software engineers and pedagogues, for the second case, PLE is a way of learning that allows students to choose their own educational resources [23].

PLE are considered a new way to facilitate the generation of learning spaces where students develop various digital skills that support their learning process in an active way [24].

Implementation of a PLE is based on the principles of self-regulated learning, in this sense, for the scientific community in the educational field, having information about the way of thinking, feel and students' actions in a learning space is relevant because these data help students achieve their academic goals [25].

3 Problem outline

Based on literature reviewed, it is considered that efforts at higher level to implement inclusive education at the global and national level are not enough. There are several factors that can be improved to integrate inclusive education at the higher level. This study focuses on the feasibility of supporting implementation of inclusive education at this academic level, based on the use of ICT and artificial intelligence (AI) techniques.

However, integration of ICT in education hasn't been accurate enough, because there aren't many reliable and verifiable results on the impact of the use of ICT and how its use serves to learn from a better way [26].

The gap between educational institutions and the use of digital teaching materials is evident; although there is availability of access to them, their use is not the most effective [27].

Simple fact of the existence of any technology in an educational institution does not imply an improvement in the teaching-learning process, other strategic elements are required such as the implementation of pedagogical methodologies and understanding of the student's social context, so that such technology is applied in an effective way [28].

Necessity to design an educational model that integrates the diversity of learning, teacher training, the necessary technological infrastructure, and sufficient digital educational resources to cover the learning needs of the entire student population [29].

A significant number of educational technologies and resources were designed in a standard way for the majority student population, without considering the learning needs of minorities.

Therefore, this work seeks to provide a solution to the inequity of the teaching-learning process that exists between learners with learning deficits and those who are considered the majority and don't require this type of support, based on the use of personalized ICT educative resources using learning analytics that manage academic data from student profiles.

4 Federated learning model

A technological solution is presented at a conceptual level that reduces the disadvantages of students who have some learning deficit. Based on the literature reviewed, no technological solutions based on ICT and AI were found that resolve the learning needs of students with some learning deficit, based on the use of federated learning model to generation of intelligent personal learning environments (IPLE) at the university level, from the perspective of inclusive education.

Federated learning is a technique that can be considered recent in machine learning and deep learning. This machine learning paradigm is quite useful for training an intelligent model that is capable to personalize

learning needs of each student.

The aim is to implement federated learning because it offers privacy features when obtaining data in this case from university students. Once you have certain data of each student and after carrying out a training model, model will be able to suggest educational resources based on ICT according to the preferences and learning needs of each student that support each of them and improve their experience with the learning environment and suggested applications.

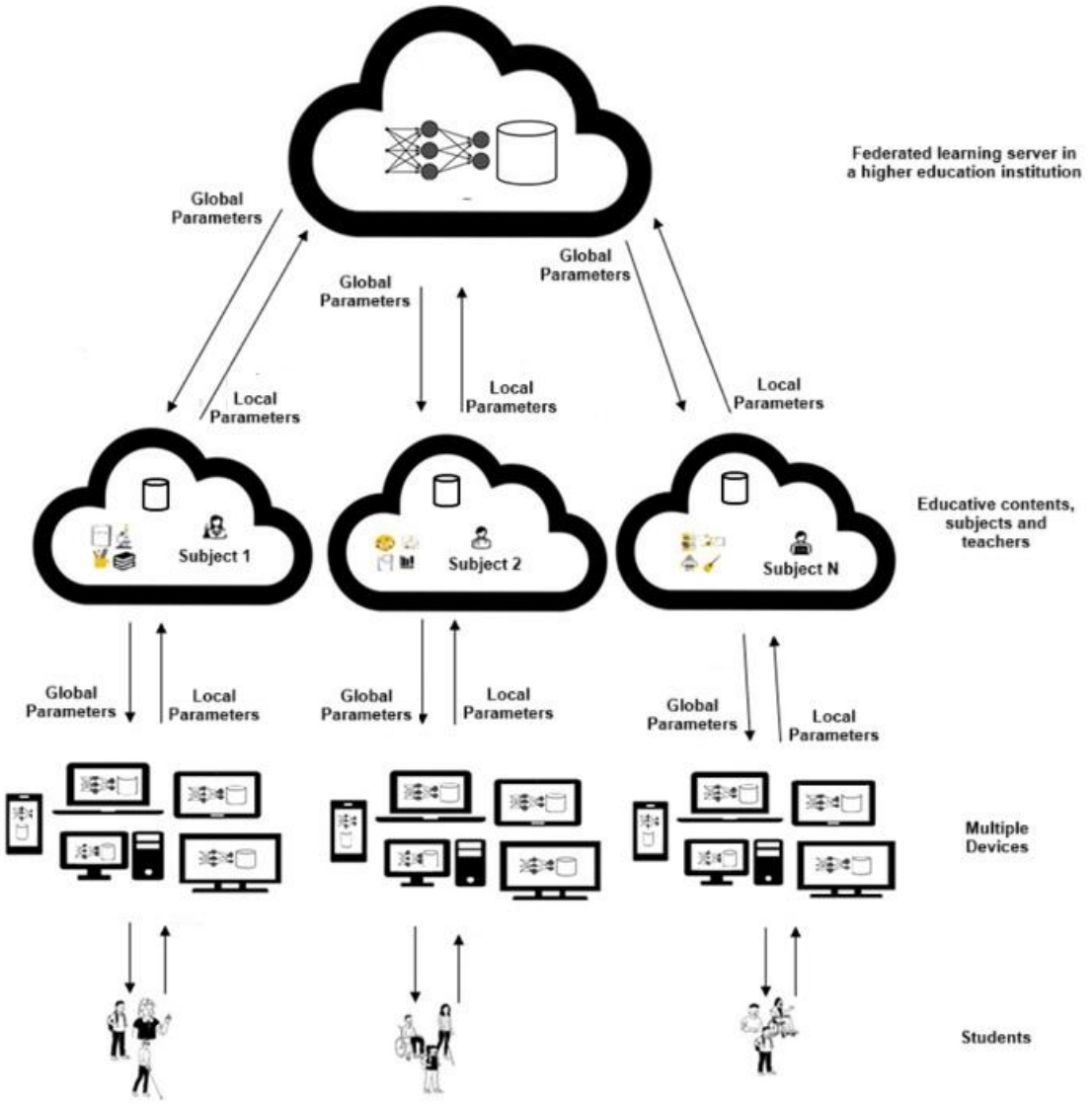

Figure 1: Inclusive Education with IPLE on Federated Learning Model

A federated learning model is presented in Figure 1. This model is based on the cross-device federated learning architecture, from the bottom up, it can be seen how students interact with an IPLE, through different devices, it is relevant to mention that in this federated learning model, each device of each student is a node that provides information to the entire federated learning model.

This information is processed by the main server. On each device IPLE interface is presented, the interface is made up of a set of educational content that satisfy the learning needs of each student for each of their subjects.

It can also be seen that each subject is taught by a teacher, in the context of the federated learning model, the role of the teacher is very relevant, because he is in charge of managing, channeling and developing individual educational resources, finally in the at the top of the model is the main server of the HEIs, where the general learning model is stored, which receives, processes and aggregates the information sent by each student's devices.

In layer three of the architectural model of the IPLE, it will be implemented the federated learning model, thanks to the results of this model it will be possible to generate the different interfaces of the IPLE according to the profiles of each student.

5 An Architectural model of IPLE

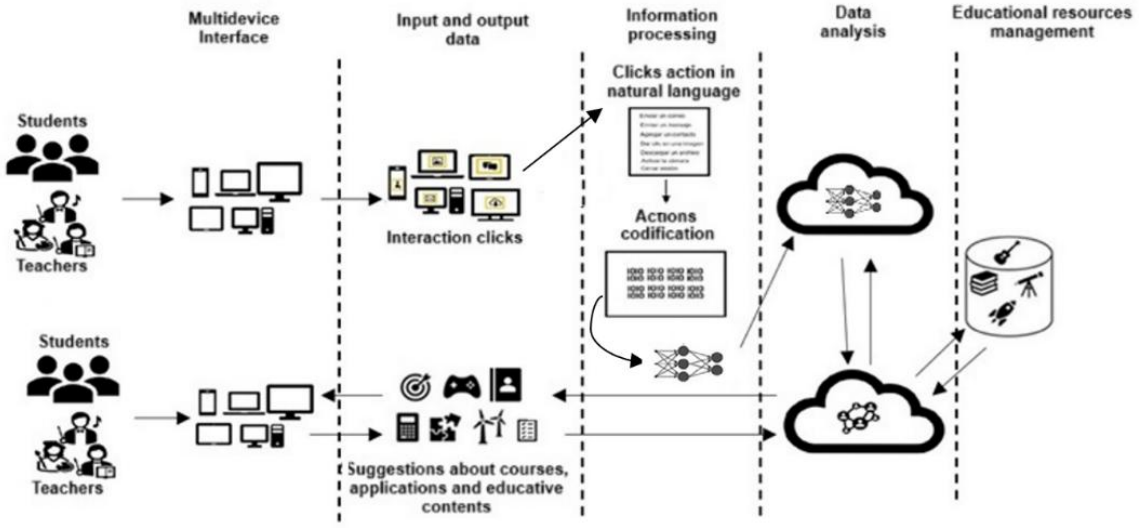

Figure 2: Architectural Model for an Intelligent Personal Learning Environment

The architecture of the model in Figure 2 is made up of four general layers, these layers are: multidevice interface, input and output data, information process and control and management of educational resources, it can be seen that it has a flow from left to right and from right to left, this is due to the obtaining of data derived from the interaction of teachers and students with the IPLE and the processing of it, after those data will serve to associate it with the available educational resources, which are subsequently presented to each user according to their profile.

This architecture improves accessibility to information in general and to existing educational resources for students who present some type of learning deficit and for students from the predominant population at the university level, because integrates Universal Design for Learning (UDL) principles and WCAG 2.2 guidelines, plus according with students' most used applications and personal interests in specific learning topics, each interface will be particular, distinct of any other interface. Below is a more detailed description of each layer of the IPLE system.

Multidevice interface. This first layer of the proposed solution is the most important because it's the one with students and teachers who will interact. For both users, the design of the interface and the ICT resources that are presented to each of them will be through a personal learning environment that meets their needs for access to information and educational resources in an ideal manner based on a recommendation from IPLE.

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 for using certain types of digital resources, etc. It is important to note that obtaining 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 IPLE will provide an interface tailored to each student and access to digital resources based on the recommendation module.

It is considered relevant to describe in a more detailed way the process of the module because through the academic monitoring of the students, we can identify in a more precise way their learning needs and what are the preferred technological resources, this situation justifies the use of learning analytics to benefit the academic achievement of the students, for it be more significant.

In accordance with the above, the paradigm of inclusive education is integrated at the higher level, where it is sought that the benefits of personalization of learning based on learning analytics reach not only the majority student population, but also consider the university students who present some learning deficit.

The architectural model of the proposed IPLE system requires that student tracking module, be fed with data in a non-intrusive way for students. In Fig. 2 it's observed that each student can access the IPLE through different devices; some interface icons are highlighted in yellow, alluding to the interaction of each student in their respective environment; each click on an element is recorded in natural language and then that action is encoded so that it can be interpreted by the federated learning model. At this point in the cycle, each student is associated with its corresponding interaction in the IPLE. The academic profiles of the students are subsequently stored. Once these data are available, the IPLE shows the information of each student and teachers can track that information for each of their students.

Information processing. In this layer has as main goal transform interaction activities of teachers and students, from natural language to a codification actions, this process is necessary to convert information provided by IPLE users in a way that be understood by the federated learning model.

Data analysis. 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 of the higher level and their learning needs in relation to their individual profile and the needs for accessibility to information and ICT-based educational resources that adapt to said personal requirements.

To achieve the above, the federated learning model is integrated into the architectural model of the IPLE system in this layer, this is where the student data that has been obtained through the tracking system and has been stored in the database of the student profiles, which will be used as input parameters to the federated learning model together with the data from the educational applications that serve as support to the teaching-learning process for teachers and students.

Educational resources management. In this layer of the proposed solution there will be the repositories with the information on the student profiles, as well as the repositories of educational resources for the majority student population and educational resources for students who present some type of learning deficit. It is important to mention that free licensing applications and digital materials will be stored in both repositories of educational resources.

Talking of student academic data obtained through the student tracking system, it is relevant to emphasize that both the federated learning model and the architectural model require students' data to function.

Even so, it is imperative to address the issue of the data that will be collected and that will be used to train the federated learning model and in the architectural model of the IPLE system to be visualized and analyzed with the purpose of serving as learning metrics to the entire student population, to make a comparison of the evolution of university students' learning with current technologies and the results obtained after the models presented in this research are implemented in a higher education institution.

Based on the above, it is considered convenient and necessary to say that those variables that are useful to measure must be specified, to assess the improvement of student learning. In this sense, there are several data sets that have been designed and developed to put them available to the public, for example the KDD Cup 2015 dataset or the OULAD dataset just to mention someone.

In this sense, it is considered that part of the contribution of this study is to propose variables that belong to a set of useful data to be able to achieve what is proposed conceptually through our models, as a technological solution to implement inclusive education in the higher level.

Table 1 Dataset proposal.

Variable	Description
Dispositive type to access EPAI	Identify most used or preferred device as educative support to work in IPLE
Session Schedule	Preference to IPLE access time
Session Time	Total inverted time in IPLE
Id selected educative resource	Number to identify different educative resources in IPLE
Use time with each educative resource	Total interaction time with educative resources
Type of most used educative resources	Detect the most used educative resource inside IPLE
Time to deliver assignments	Used time for each student to deliver tasks in IPLE
Time to solve exercises	Employed time for each student to finish exercises in IPLE
Visited URL	Check the most URL visited while IPLE is in use
Search words	Review words more typed in browser

Table 1 presents a proposal for a set of variables that can be used to train the federated learning model presented in this research.

6 IPLE stakeholders

6.1 College students

University studies have a key role for the development of people and society in general; unfortunately, at this educational level, students with disabilities fight a daily battle, first to access to this academic level and once there, to be able to graduate [30].

Unfortunately, only 2% of the population that has some type of disability has a university education, due to this it is indicated that training on inclusive education at the higher level is urgent for be able to provide support to the student population with disabilities and particular learning needs [31].

Inclusive education addresses learning demands of the entire student population from the perspective of the particularity of each student, this way of implementing inclusive education enriches HEIs [32].

Due to the confinement caused by the COVID19 pandemic, students were forced to develop a set of digital

skills to be able to meet their learning needs and carry out the work and tasks indicated by their teachers. This situation sets a positive precedent, from the perspective of student-centered learning, since in this way are students who choose which resources are most appropriate for their learning [33].

Table 2 Some characteristics of college students.

Characteristics
Barriers to learning and participation
Based project learning
Student habits
Social development
Favorite tools
Psychological development
Multiple intelligences
Collaborative learning

Table 2 presents some of the main characteristics of students in higher level should develop in a personal intelligent learning environment.

6.2 College teachers

Teacher's role in educational models based on ICT is very important because their digital skills impact directly on student learning, especially in those with learning deficits, for this reason in these educational paradigms, teachers must be in a permanent training process to remain current in their digital competencies applied in their teaching process [34].

Generally, teachers don't have the knowledge or skills to satisfy the requirements of inclusive education in the classrooms. This situation is considered serious, given that in their professional work they will encounter a diversity of learning needs from their students, due to this, training in inclusive education is needed for educators during their first years of training [35].

Some teachers' perceptions, according to the implementation of the inclusive education paradigm, are related to skills and competencies that they should have. Teachers consider these abilities to be essential elements for inclusive education works, however the teachers are aware that to reach this optimal level, a set of actions must be carried out to achieve it, for example timely and constant training on these topics and the acquisition of educational technologies that support those student demands [36].

Table 3 Some digital skills of college teachers

Skills
Knowledge of individual student learning needs
Problem identification with students
Development of digital skills
Adoption of new strategies and educational fields
Adaptation of educational contents based on ICT
Continuous training in ICT
Adequate selection of educative resources
Monitoring students learning advances

Table 3 shows the main digital skills and competencies that a teacher must have or develop within a personal learning environment, to enrich and improve their teaching process.

6.3 Higher education institutions

Higher education institutions are an academic level that must implement the characteristics of education 4.0, among which the following stand out: permanent communication between teachers and students, implementation and development of technological infrastructure, training and development of digital skills, solution of real problems, among others [37].

Access to higher education by people with disabilities continues to be an academic frontier that few people from this social group reach and even fewer who manage to complete this educational level, mentions there

are several reasons that cause this situation, one of the main ones is that higher education institutions are not qualified to receive this type of students and professors are not trained to meet their learning needs [38].

Following these ideas, access and graduation of people with disabilities at the higher level is a relevant indicator to know how inclusive a country is, because the inclusion of these people at this academic level reflects the acceptance and participation of these individuals in society [39].

HEIs must integrate the paradigm of inclusive education within their organizational mission and vision, as well as in institutional development plans, and they must also invest resources and implement strategies that facilitate the implementation of inclusive education [40].

Table 4 Some responsibilities of HEIs.

Responsibilities
Ensure the security of student information
Ethical management of data
License tools review
Accessibility standards
Infrastructure and IPLE maintenance
Technical specialized team
Use monitoring of IPLE system
Ethical and privacy standards implementation

Table 4 establishes a set of responsibilities and services that higher education institutions must implement to have a well-functioning of an IPLE.

7 Implementation of IPLE model

UAA counts with a Department of Institutional Statistics, which conducts a study of student population traits at the undergraduate and high school levels every school year. According to [41] there are 13,391 students, where 2% present some learning deficit. To explain the operation of our conceptual model, the following hypothetical case study is presented. The Mrs. López is a full-time professor in the Department of Mathematics and Physics at the UAA. This semester he will teach the subject of Advanced Programming to students of the Computer Systems Engineering degree.

It is a group of 37 students and this group has 3 students with learning deficits: María Gómez, Luis González, and Gonzalo Canales. María has a moderate hearing problem in both ears, Luis lost his right hand and arm in an accident when he was a child, his motor level is considered intermediate, Gonzalo has Low Vision, which has increased over the semesters at the university, his level of low visibility is still moderate, but he decided to learn Braille.

Table 5 Learning situation before proposed model implementation

Students	**Learning deficit**	**Learning indicators**	**Values**
María	Low vision	-Accessibility support	Partners and Prof.
		-Interactive dependency level	
		-Meaningful learning	High
		-Probability of failure	Very few
		-Learning interest	High
		-Dropout Possibilities	Few
			Very high
Luis	Low motricity in arm and hand	-Accessibility support	Partners and Prof.
		-Interactive dependency level	Medium
		-Meaningful learning	Medium
		-Probability of failure	Medium high
		-Learning interest	Medium
		-Dropout possibilities	Medium high
Gonzalo	Moderate hearing loss	-Accessibility support	Partners and Prof.
		-Interactive dependency level	Medium High
		-Meaningful learning	Medium Low

	-Probability of failure	High
	-Learning interest	Medium Low
	-Dropout possibilities	High

Table 5 presents information on some of the metrics that serve to evaluate the level of learning, according to the current circumstances at the UAA for the three students in the case study.

Through the federated learning model within the IPLE architectural model proposed in this document, these three undergraduate students can attend the online subject of the Mrs. López, given that for each of them and based on their academic information and physical conditions, they are presented with a different interface according to their learning needs.

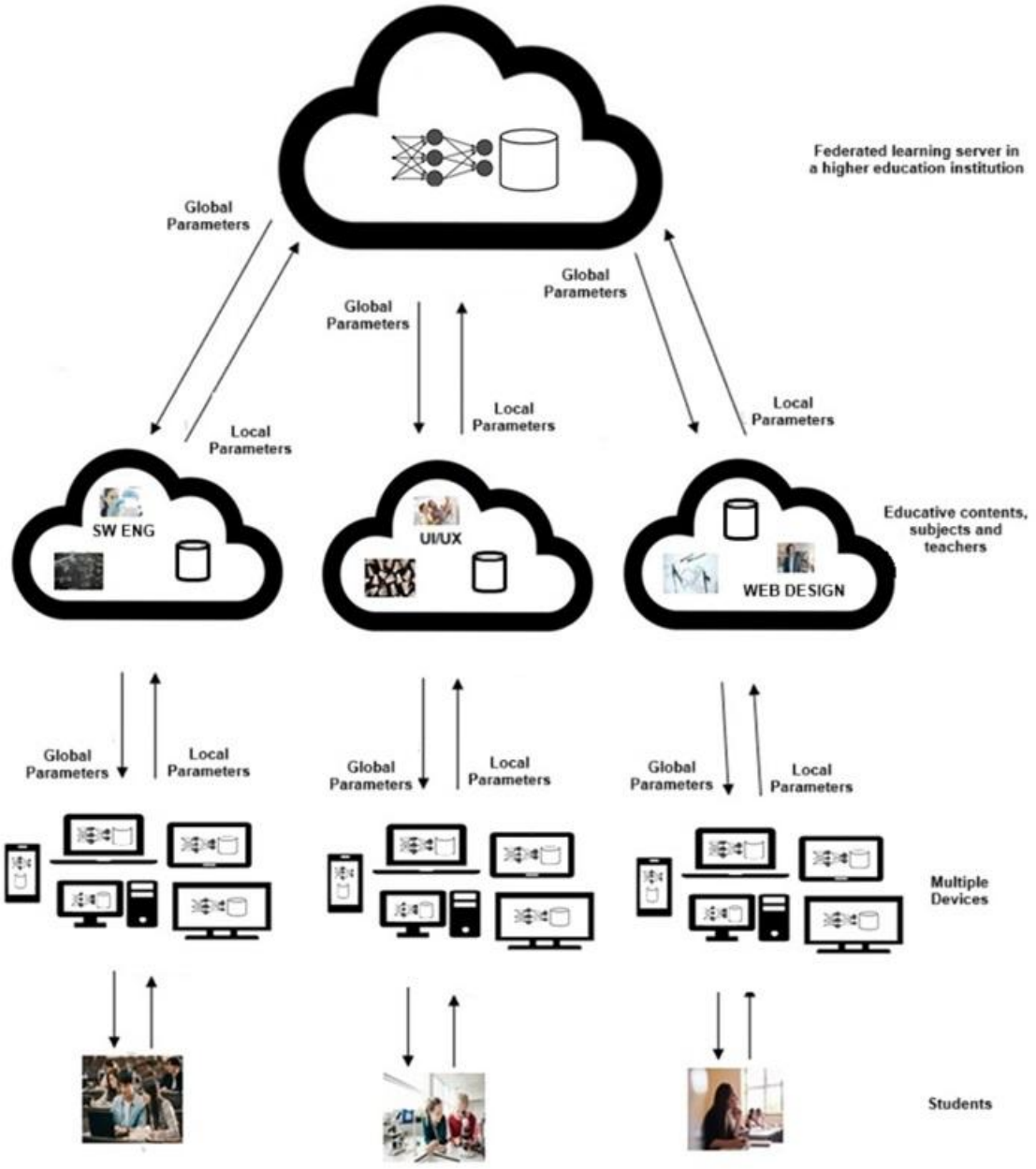

Figure 3: Proposed Federated Learning Model applied to some UAA courses

Figure 3 presents an instance of a federated learning model with students, teachers and UAA tools. Through federated learning model, data can be obtained that associate such needs with the ideal digital educational content so that the entire student population is within a context of equity and equality, regarding the accessibility and use of said resources for their learning to be meaningful.

Some benefits from the model's architectures are:

- Timely monitoring of teachers in relation to the learning needs of students.
- Implementation of a continuous improvement process for teachers in relation to the development of their digital skills.
- Generation of digital educational resources, accessible to all university students.
- Multi-device students' access to their inclusive educational environment.
- Increase students' interest and motivation to learn through innovative and creative educational strategies.
- Use of content in different formats according to the specific needs of each student.
- Increase in accessibility and use of the technological infrastructure that exists at the UAA.
- Use of existing academic information from students and generation of new information.

What is intended with the model proposed in this work is that teachers implement innovative teaching techniques so that, through flexible educational resources, user and learning experiences be generated for students that keep them in a learning process that awakens their interest in learning more on a continuous way.

Both content user experiences and experiences in their role as learners will be carried out within an environment where learning barriers are diminished, giving rise to equality and equity so that the entire student population without exception has the same opportunities for learning and participation.

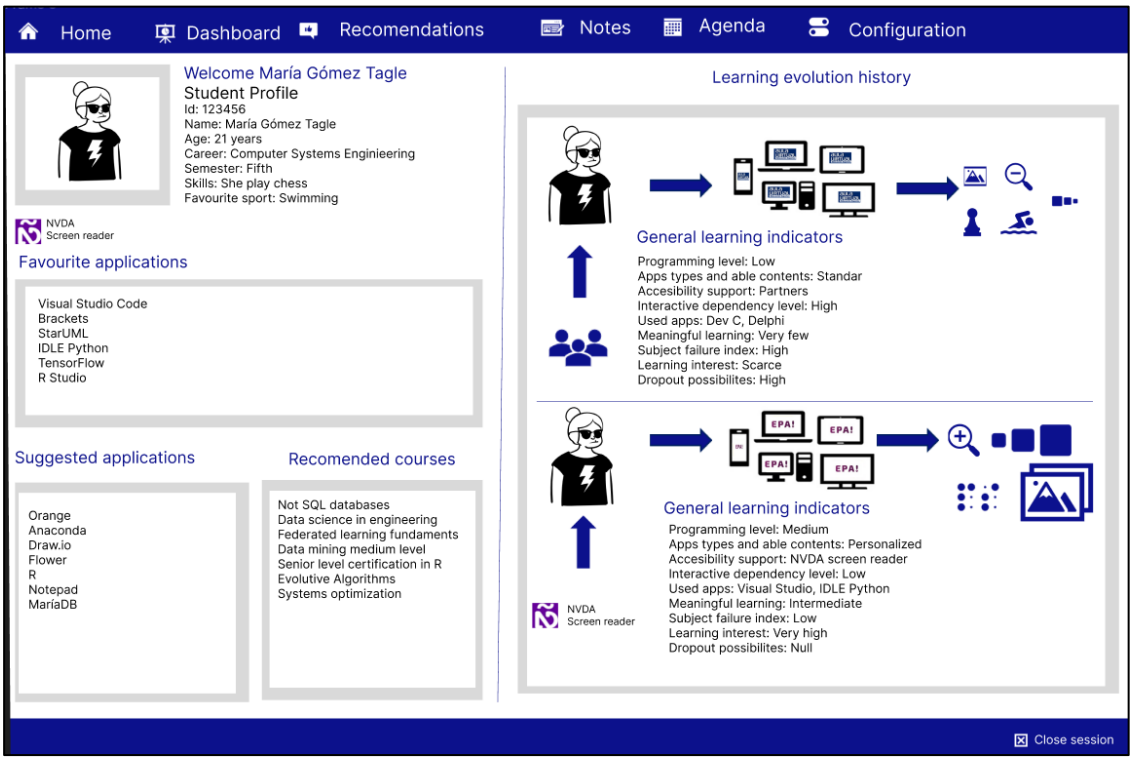

Figure 4: An historical evolution of María's learning journey showed by IPLE user Interface

Figure 4 shows the prototype of an interface of the IPLE system that is proposed in this study. On the left side, an initial view of María with information about her profile is shown. On the right side, you can see two moments in María's learning evolution history, in the first where María only uses the current educational technologies provided by the UAA.

Besides, some general indicators related to María's learning process can be displayed: accessibility support, level of interactive dependency, applications used, significant learning and failure rate, to mention a few.

In the second moment, thanks to the implementation of our models, the indicators of María's learning process have improved significantly. María has achieved a high degree of self-confidence, her dependence on her classmates has decreased, she has achieved a certain learning autonomy thanks to the NVDA application, and she wants to continue and conclude her university career.

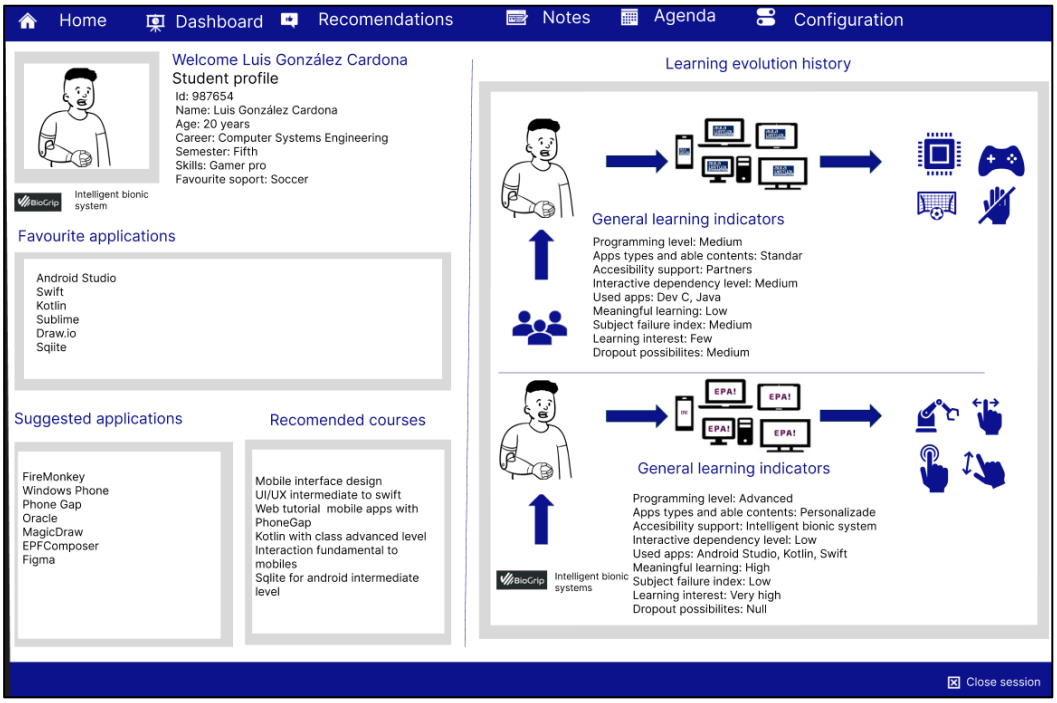

Figure 5: An historical evolution of Luis' learning journey showed by IPLE user Interface

Figure 5 shows the prototype of an interface of the EPAI system, but now in the case of Luis, it can see information about his profile and the evolution of his learning, on the top side, his current learning situation before the implementation of our models, at the bottom, the general learning indicators have improved thanks to the solution models proposed in this study.

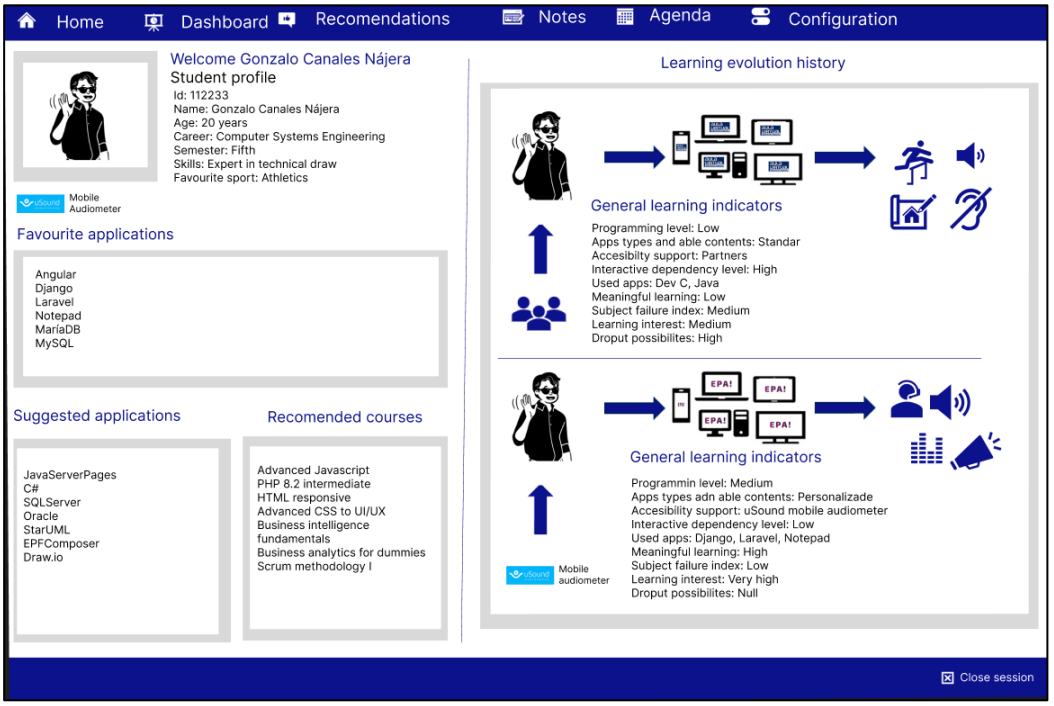

Figure 6: An historical evolution of Gonzalo's learning journey showed by IPLE user Interface

Figure 6 shows the prototype of an interface of the IPLE system that is proposed in this study for the case of Gonzalo; it can see his profile information and the way in which Gonzalo has evolved his learning, in relation to some general learning indicators, according to these metrics, it is evident that after the models of this research are implemented, these variables positively impact in Gonzalo's learning.

Table 6 Learning situation after proposed model's implementation

Students	Learning deficit	Learning indicators	Values
María	Low vision	-Accessibility support	NVDA screen reader
		-Interactive dependency level	
		-Meaningful learning	Low
		-Probability of failure	High
		-Learning interest	Low
		-Dropout possibilities	Very high
			Null
Luis	Low motricity in arm and hand	-Accessibility support	BioGrip system
		-Interactive dependency level	Low
		-Meaningful learning	Very high
		-Probability of failure	Low
		-Learning interest	High
		-Dropout possibilities	Null
Gonzalo	Moderate hearing loss	-Accessibility support	uSound audiometer
		-Interactive dependency level	
		-Meaningful learning	Low
		-Probability of failure	Medium high
		-Learning interest	Low
		-Dropout possibilities	Very high
			Null

In Table 6 some of the metrics are presented to evaluate the learning level of each student, according to the values achieved in each of these indicators in comparison with those shown in Table 5, it's clear that the values of these measurement variables have positively improved, demonstrating the effectiveness of the models.

8 Discussion

From the total number of people between 0 and 14 years of age recorded by the Census, 1.4 million children, adolescents and young people speak an indigenous language 5.4% of the population, 1.7% of children under 15 years of age are afro-Mexicans or afro-descendants, and 6.5% of children in Mexico have a disability, mental condition or limitation to walk, climb or descend, see even with the use of glasses, speak or communicate, hear even when using a hearing aid, dress, bathe or eat, remember or concentrate [2].

According to the 2020 Census, there are 2 million 108 thousand 786 people with disabilities between 5 and 17 years old, that is, of school age. 506,455 students with disabilities are in school, which represents 24 percent of this group, the other 76 percent of children and adolescents with disabilities are not covered by the National Education System [42].

The schooling of the population with disabilities at different educational levels "does not always guarantee their graduation". Although 66.6 percent of young people between 20 and 24 years of age with disabilities report that they have completed high school, the gaps within this sector of the population are also a challenge. 8.8% of people with disabilities between 25 and 24 years old had at least a bachelor's degree, in the words of [42].

In the case of Mexico, there are federal government initiatives at the basic education level (pre-school and high school) to meet the educational needs of people with disabilities: the Multiple Attention Centers (CAM by its acronym in Spanish) and the Support Services Units for Regular Education (USAER by its acronym its Spanish). At the high school level, there are the Attention Centers for Students with Disabilities (CAED by its acronym its Spanish). Thus, from pre-school to pre-university education, Mexico's National Education System offers coverage for students with disabilities at these educational levels. Thanks to these initiatives in Mexico, some students with certain types of disabilities can complete these educational levels and aspire to enter higher education.

The Mexican government's initiatives to serve students with disabilities from kindergarten through high school have specialized teachers to address the characteristics of these students at these educational levels, these institutions have specific educational resources that are used by teachers to teach these students. At least up to the high school level, there are alternative and flexible forms of evaluation that allow teachers to evaluate

the learning of this group of students.

For the high school level, unfortunately the evaluation is carried out according to the current open high school program, where the evaluations are rigid and focused on the regular population, therefore, not all students can pass this academic level. Even so, depending on a few students, they manage to conclude this academic level and decide to enter the higher level.

Considering specifically impact region, in 2020, the main disabilities present in the population of Aguascalientes were physical disability (26.3k people), visual disability (23k people) and disability to remember (9.98k people). A person can have more than one disability and be counted in more than one category. Figure 7 shows this information about Aguascalientes citizens of this group [43].

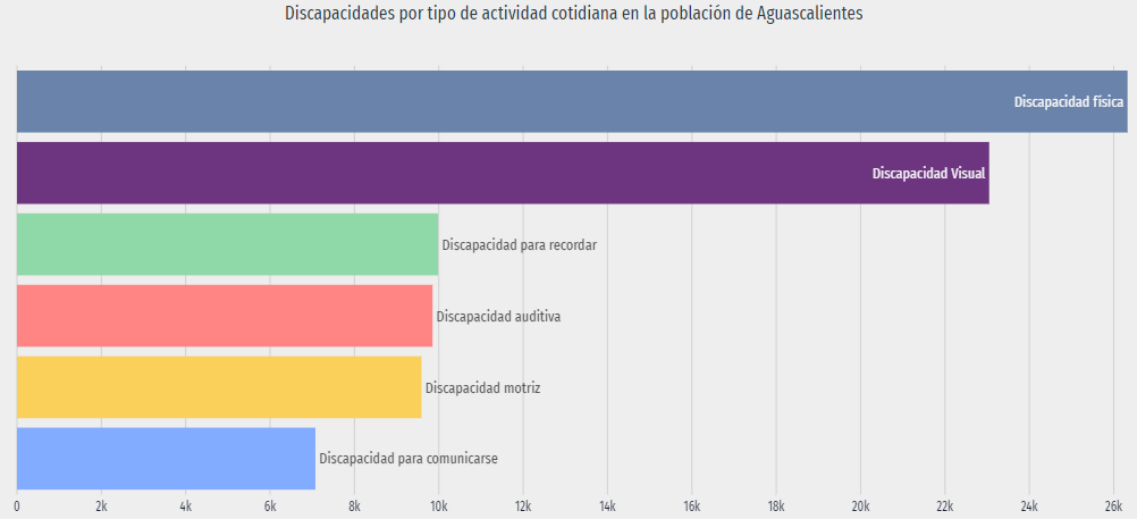

Figure 7: Main types of disability presented by the population of the State of Aguascalientes. Source: [43].

The matrix graph shows the distribution of the population with disabilities according to the type of disability and the causes or origins of the disabilities [43].

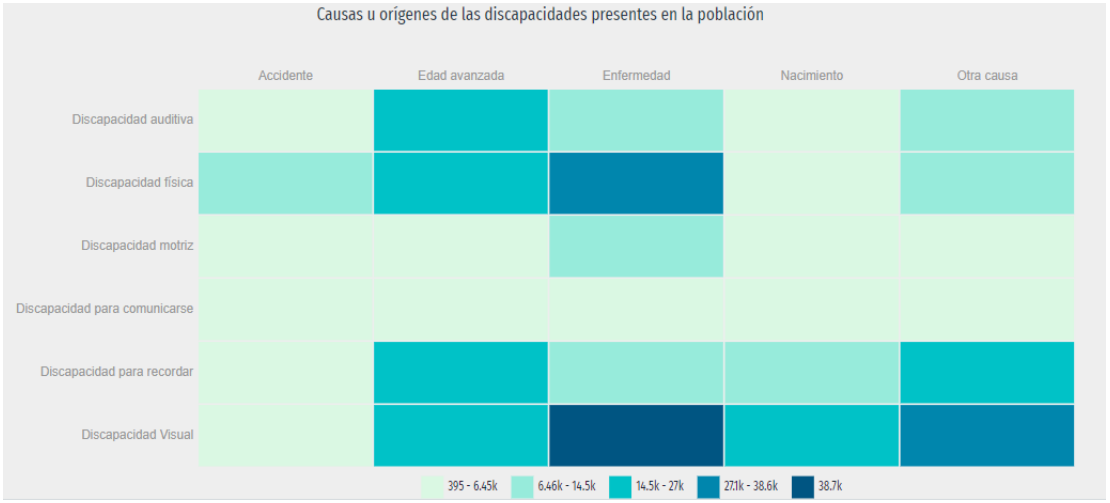

Figure 8: Main causes of disability in the population of the State of Aguascalientes. Source: [43].

In a concrete context, focus only in the higher level at UAA, the document on the characteristics of the student population of this college, 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, deaf 3, intellectual 14, motor 27, multiple 5, psychosocial 13, low vision 13 and blind 22 [41].

Figure 9 shows by one hand a comparison between regular students' population in UAA and students with some learning deficit in the left side, and in the right side is possible to see the way that percentage of UAA students who present some learning deficits are distributed by disability type.

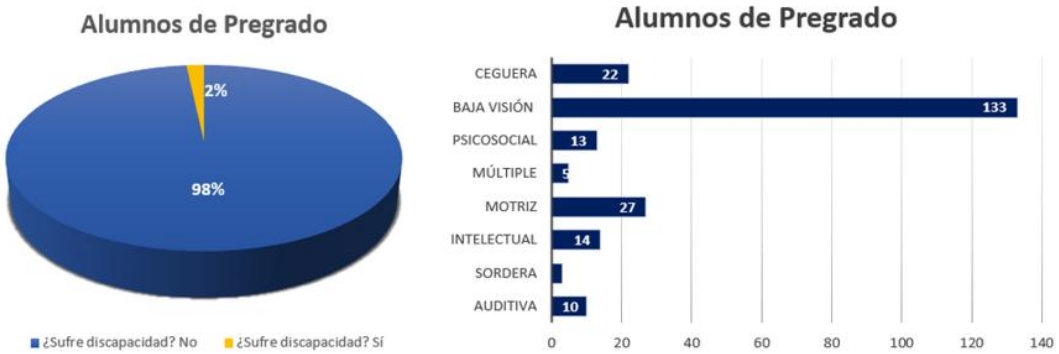

Figure 9: Total number of students with disabilities and types of disabilities in UAA students.

According with information and statistics showed in this section, previous academic levels in Mexico are covered by Mexican government in the context of inclusive education, however there is a key data from students with a learning deficit, most of them reach only the secondary level, from this level high schools level presents more difficult and higher level is even more difficult to access and conclude for this students' group.

That's why this research focuses on the higher level, because this academic level has the smallest population of this student's group. In the previous academic levels still there are too many requirements to attend however at least, in Mexico exists federal government dependencies that work in the adoption of inclusive education.

Besides, IPLE architectural model and federated learning model of this study could be modified and adjusted to basic level and high school level, isn't exclusive for higher level.

9 Conclusions

The lack of educational policies and technological adoption processes in favor of the implementation of inclusive education is a reality that prevails at the higher level of most educational systems around the planet. The good news is that for some years some efforts have been implemented to mitigate the exclusion of learners who present some learning deficit at all educational levels, including the university level.

Furthermore, there are technological proposals based on artificial intelligence techniques, massive data and learning analytics that add to the effort to resolve this situation. Since only through these modern, innovative, and intelligent technologies, the learning needs tailored to each student could be met, in such a way that normal or "non-intelligent" ICT applied to education, although useful, aren't encompass this diversity of learning needs.

In this work, several topics related to technological development were presented, such as learning analytics, federated learning, and personal learning environments. From an inclusive perspective, these technologies have a quite significant positive impact within the teaching-learning process since they improve access and use of information for students who present some learning deficit.

It is considered relevant to say that, despite the advancement of technology, teachers have and will continue to have a strategic role for the teaching-learning process, their role in the new educational models based on ICT does not diminish. One could even say that it is increasing, because now teachers must have the necessary digital skills to be able to present the contents of the subjects, they teach in virtual learning environments, and they must also be able to generate educational content with applications and software tools, so in relation with this ideas, is clear that our solutions aren't useful only for student, teacher will be benefit too.

In this order of ideas, inclusive education demands a high level of learning personalization, where study programs be flexibles, and educative digital resources be presented in many ways, useful to all student population, mainly for vulnerable groups and students with a kind of learning deficit.

However, is evident that implement the proposed models in this work, isn't an easy task, it requires a coordinate work between students, teachers, and higher education institutions' stakeholders. It's a multidisciplinary job where each role has its own responsibility level.

As future work, there are many things that should be designed, developed, imagined, and implemented, to pass from this theoretical and conceptual solution to a real solution. It's necessary investigate about free educative applications and resources, useful for all student population in higher level, mainly useful to those students with any kind of learning deficit, besides it'll be to build a federated learning model, to reach this a search will be carried out to choose some machine learning algorithms to make a test and select the most effective algorithm to proposal federated learning model.

Another pending task is to define those variables who are useful to generate a student profile in relation with their learning needs, in this document, proposal variable list is showed, a test is necessary to know if this proposal satisfies research goals solution or be necessary to redefine this variable list. Also, is relevant to realize tests and the experiments to prove effectiveness of federated learning model, another essential task is to find a way to track students' interaction with IPLE interface, check devices configurations, guarantee students' information privacy and security, from a legal and technical perspective, etc. There are many things to do.

Despite all the pending and according to study case presented in this research, in a theoretical and conceptual way,

both models, federated learning model and IPLE architectural model are a feasible solution to implement inclusive education in higher level, because thanks to these models, is possible to attend specific learning needs for each student, especially for those who presents any kind of learning deficit.

Once that our theoretical models be designed and developed, proposed solution in the research will help to facilitate usability and accessibility to information and educative digital resources, is known what inclusive education covers a wide range of topics, however this study focuses on how ICT resources, in this case personal learning environments and federated learning model, combined, this technologies can a be a support to learning needs for all students.

This research is looking for an increment in the meaningful impact of ICT resources in the teaching-learning process at higher education institutions. Knowledge about student learning needs will reduce to implement useless ICT resources and platforms.

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