Design and implementation of an Intelligent Tutoring and Psychopedagogical System for students at a public university in Lima

Diseño e implementación de un Sistema Tutorial y Psicopedagógico Inteligente para estudiantes de una universidad pública de Lima

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Abstract

The main objective of this work is to develop and implement an Intelligent Tutoring and Psychopedagogical System for students at a public university in Lima. To achieve this goal, we collaborated with 9 experts in psychopedagogy, ranging in age from 35 to 51 years (M = 41.2, SD = 4.82), as well as 60 students from the Faculty of Education at the same university, ranging in age from 19 to 28 years (M = 24.3, SD = 2.18). During the development process, components were integrated to assess mental health, family and interpersonal relationships, educational needs, and soft skills, based on a model derived from a literature review. These components are organized into tutoring and psychological functions, following the Computerized Adaptive Testing strategy and a classification system for specific needs for each student, among other attributes within a platform. The implementation results showed the approval of expert teachers on three criteria, with inter-rater concordance coefficients above .80, in addition to the satisfaction of student users with the resource's features. In conclusion, the system's implementation was found to be effective. Therefore, it is recommended to continue developing aspects related to the user experience and audiovisual add-ons for future implementation.

Keywords: psychopedagogy, Intelligent Tutoring Systems, Computerized Adaptive Testing.

Resumen

El objetivo principal de este trabajo es desarrollar e implementar un Sistema Tutorial y Psicopedagógico Inteligente destinado a estudiantes de una universidad pública en Lima. Para lograrlo, se contó con la colaboración de 9 expertos en psicopedagogía, cuyas edades oscilan entre los 35 y 51 años (M = 41.2, DE = 4.82), así como de 60 estudiantes de la Facultad de Educación de dicha universidad, con edades entre los 19 y 28 años (M = 24.3, DE = 2.18). Durante el proceso de desarrollo, se integraron componentes para evaluar la salud mental, la familia y las relaciones interpersonales, las necesidades educativas y las habilidades blandas, basándose en un modelo derivado de la revisión de la literatura. Estos componentes se organizan en funciones tutoriales y psicológicas, siguiendo la estrategia de Test Adaptativos Informatizados y un sistema de clasificación de necesidades específicas para cada estudiante, entre otros atributos dentro de una plataforma. Los resultados de la implementación mostraron la aprobación de docentes expertos en tres criterios, con coeficientes de concordancia interobservadores superiores a .80, además de la satisfacción de los usuarios estudiantiles respecto a las características del recurso. En conclusión, se determina que la implementación del sistema es efectiva. Por lo tanto, se recomienda continuar desarrollando aspectos relacionados con la experiencia del usuario y complementos audiovisuales para su implementación futura.

Palabras clave: psicopedagogía, Sistemas de Tutoría Inteligente, Test Adaptativos Informatizados.

Introduction

Tutoring is defined as a student-oriented accompaniment activity aimed at ensuring the effective development of their training, encompassing both socio-emotional and academic aspects (Gonzáles-Palacios & Avelino-Rubio, 2016). Within the framework of tutoring efforts, evidence has revealed a series of challenges related to mental health, social skills, interpersonal relationships, and educational needs that negatively impact the holistic development of students in both basic and higher education (Clerici & Da Re, 2019; Miranda, 2018; López-Gómez et al., 2017).

The prevalence of these issues has significantly increased among the student population, particularly among university students. Various studies have confirmed that the pandemic exacerbated this situation, profoundly affecting the academic, personal, social, emotional, and familial lives of students (Esteves-Villanueva et al., 2020; Vivanco Vidal et al., 2020). The impact of these multifaceted challenges is evident in indicators of anxiety, depression, and stress, with varying prevalence across the Americas (Vivanco-Vidal et al., 2020; Barrera-Herrera et al., 2019; Caro et al., 2019; Morán et al., 2018; Miranda, 2018). In this context, research conducted in Chile and Colombia has revealed that between 33% and 46% of university students exhibit depressive symptoms, while between 28% and 45% show indicators of anxiety, and over 50% experience high levels of stress; these percentages increased considerably during the pandemic, by approximately 33% (Barrera-Herrera & San Martín, 2021; Caro et al., 2019; Jaramillo-Toro et al., 2018; Monterrosa-Castro et al., 2020). Furthermore, socio-affective dynamics within families and relationships with partners and friends were also affected during the pandemic, due to either prolonged cohabitation or separation and isolation (Tardivo et al., 2021; Araujo-Robles, Diaz & Diaz, 2021; Rodríguez-Salazar & Rodríguez-Morales, 2020; Rojas-Solís et al., 2021). This complex interaction of factors underscores the urgent need to implement effective interventions to address these challenges.

On the other hand, challenges associated with the insufficient development of social skills have been a constant reason for the ongoing development of learning in university settings oriented toward professional practice (Cárdenas et al., 2018; Caldera et al., 2018; Melgar-Begazo et al., 2019). The focus on these skills has been central in university training programs and has been the subject of daily work and experiences for educators and professional counselors (Neyra et al., 2021; Liébana-Cruz, 2017; Vélez et al., 2019; Javier-Napa et al., 2019). In this regard, psychopedagogical support at this educational level has gained relevance for skill development, aligning with the profiles of various careers and the training of competencies through mentorship, according to specific curricular demands (Fish, 2017; Miguel et al., 2017; Camacho-Lizárraga, 2018). All these aspects are related to the formation of potential leaders who contribute to societal development, characterized by self-awareness, problem-solving abilities, and the demonstration of their learning in a highly demanding environment (Franco-Mendoza & López, 2021).

In this context, evaluating the tutoring process according to the individual needs of each student has provided opportunities to enhance methodologies for psychological and psychopedagogical assessment (Hernández & Rengifo, 2015; Muñiz, 2010; Orjuela et al., 2020b). However, the historical use of traditional instruments such as pencil and paper tests, or tests based on divergent approaches, has limited the ability to

extrapolate and generalize information across different contexts (Hernández & Rengifo, 2015; Souza, 2019). Additionally, the tension between prioritizing individual differences and the capacity to evaluate with the potential for generalizing models for tutoring practice has encountered technical barriers that have yet to be fully overcome in the Latin American context (Muñiz, 2005; Orjuela et al., 2020a).

The main challenges in implementing efficient evaluation systems are linked to the classical concept of validity, defined as the ability to infer behaviors from measurements based on specific samples (Muñiz, 2005, 2010). From the perspective of Classical Test Theory (CTT), this has driven the use of standardized instruments such as questionnaires, scales, and tests designed to ensure objectivity (Muñiz, 2005; 2010). Nevertheless, these methods face two critical issues: 1. **Measurement variability**: Errors increase due to the diversity of traits being measured and the contexts in which they are applied. For instance, disparate results arise when assessing complex constructs such as attitudes or socio-emotional skills, which limits the generalization of data (Muñiz, 2005), and 2. **Methodological alternatives and their shortcomings**: In response, specialists have adopted contextualized strategies such as portfolios, rubrics, and checklists that link evaluation to specific academic outputs. However, these tools lack solid external validity, as their contextual flexibility complicates the replicability of results in other environments (Muñiz, 2005).

Nonetheless, working with these tools also presents significant advantages. Among them is their capacity to enhance the classification of needs that guide tutoring actions in the daily lives of students, particularly through the implementation of Computerized Adaptive Tests (CAT) (Souza, 2019; Hernández & Rengifo, 2015; Orjuela et al., 2020a). The development of programs that integrate these resources not only optimizes time in evaluation processes but also allows for the personalization of interventions based on the individual characteristics of each student.

In this regard, the systematization of student data on virtual platforms, which adapt to individual responses as a behavioral sample (Muñiz, 2005), can significantly improve the efficiency of analyzing problematic situations and their development in real contexts. In addition to assessments, monitoring facilitated by these tools allows students to engage in simulated environments where they can practice various skills, such as social, verbal, and computational skills, among others (Lozzia et al., 2015; Orjuela et al., 2020a, 2020b; Moreno et al., 2015). This capacity for adaptation and training is the foundation of the present proposal, which seeks to implement a tutoring system that addresses the more complex needs of university students, integrating a model that responds to their specific requirements.

From this conceptual framework, the Tutoring and Psychopedagogical System is defined as a tool capable of conducting mass diagnostic tasks, monitoring, and tracking students in a virtual and automated manner, facilitating collaborative work and coordination for tutors and evaluators focused on this purpose. Experiences from the implementation of such systems can be observed in analyses of natural dialogue with simulations, detection of feelings and emotions, social and cognitive skills, or the prediction of behavioral and academic performance in various subjects (Vilas-Boas & Pontual, 2017; Maris et al., 2018; Barrón-Estrada et al., 2018; López, 2019).

In a comprehensive review of the state of the art, Reis et al. (2018) conducted a systematic review of 628 reports on the development of Affective Intelligent Tutoring Systems. These systems are designed to detect emotions in students across different educational levels, from primary to professional, using clustering strategies and pattern recognition based on artificial intelligence. The review method involved classifying the evidence according to their introductions and conclusions, leading to the selection of 40 key articles. From these, four main categories for emotion recognition through artificial intelligence were identified: linguistic (17%), behavioral data (17%), physiological signals (20%), and facial expressions (46%). The most commonly used instruments in these studies were cameras (37%), keyboards and mice (23%), followed by questionnaires (8%) and other devices such as microphones and posture-sensing chairs, which represented less than 5%. Notably, 39% of the empirical evidence focused on university students from various regions. Additionally, a growing trend toward collaboration among authors, rather than individual publications, was observed ($r = .63$, $p < .001$). The authors agreed on the effectiveness of these systems for detecting affective traits, enabling a better understanding of the behavioral characteristics of different student groups.

Similarly, Pincay et al. (2019) conducted a systematic review of 10 studies on implementations of Intelligent Tutoring Systems, analyzing the computational strategies used to recognize behaviors and emotions, as well as the algorithms and methods employed to evaluate the efficiency of the models. The review was based on a search in the Scopus database using descriptors such as “intelligent,” “tutoring,” “system,” “emotions,” and “applied,” considering all possible studies without publication year restrictions due to the novelty of the field. Studies were selected using rigorous inclusion and exclusion criteria. The team identified various explanatory models of emotions based on computational strategies that utilize pattern recognition through artificial intelligence,

including emotions such as joy, despair, anxiety, and anticipated relief, which interact with students' academic performance.

In this context, the objective of the present work is to develop an Intelligent Tutoring and Psychopedagogical System to address gaps in assessments related to mental health, educational needs, soft skills, and aspects associated with family influence and interpersonal relationships in training professionals, contributing to the development of adequate psychological well-being (Franco-Mendoza et al., 2021). The expected impact of this contribution arises from the resources and virtual means that facilitate decision-making for tutors and psychologists to evaluate, monitor, and design programs tailored to the specific needs of each educational group in higher education.

Methodology

Participants

The study involved 69 individuals of both genders, selected through a non-probabilistic convenience sampling method, following inclusion and exclusion criteria established by the researchers based on the context and their determinations (Otzen & Manterola, 2017; Arias, 2012; Hernández-Sampieri & Mendoza, 2018; Supo, 2014). Additionally, 9 experts contributed to the analysis of user experience. These experts were tutors with psychopedagogical training and psychologists affiliated with a public university, aged between 35 and 51 years (M = 41.2, SD = 4.82). Furthermore, a total of 60 students from the Faculty of Education at a public university in Lima participated in the user satisfaction evaluation of the platform. These students were aged between 19 and 28 years (M = 24.3, SD = 2.18).

Techniques and instruments

In the study, the survey technique was employed using three key instruments:

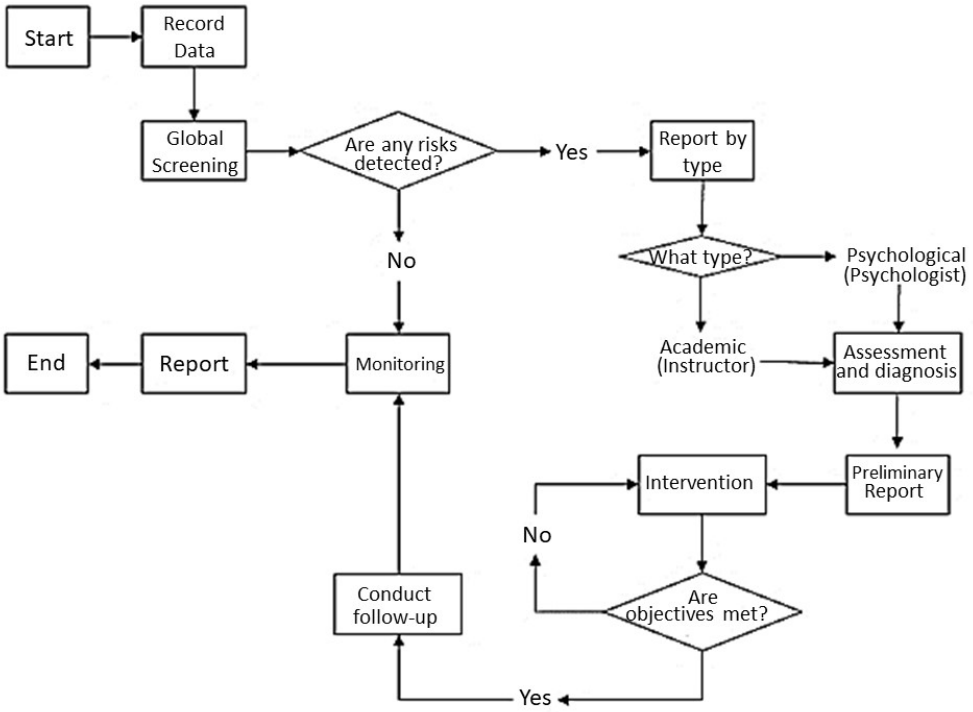
One of the instruments used was the **Intelligent Tutoring and Psychopedagogical System (ITPS)**, developed as part of the study. This system allowed interaction among up to three users: tutor, psychologist, and student, following a structured information flow (Figure 1). The Tutor module focused on assessing educational needs and developing soft skills, while the Psychologist module incorporated mental health and interpersonal and family relationships. Both modules included specific features to systematize care, agendas, reminders, specific feedback, and the use of computerized adaptive tests, with a total of 41 tests distributed across the four topics defined by Franco-Mendoza (2021).

Additionally, the **Quality Assessment Survey of the ITPS** was utilized, designed with three specific quality criteria for evaluation by expert judges. These criteria were functionality, which assesses ease of use and platform features; relevance of use, defined based on the topics and components evaluated by each user; and conceptual ease, which is based on the flow of information and attention channels for timely referrals in response to presumptive diagnoses. The survey consisted of a brief questionnaire of 9 Likert-type questions, rated from 1 to 5, measuring the degree of agreement of the judges regarding the posed questions.

Finally, a **Virtual Satisfaction Survey** was implemented, designed with 4 Likert-type questions ranging from 1 to 5 points, with ordinal values from "not at all satisfied" to "very satisfied." This survey considered aspects related to user experience, result reporting, scheduling, and specific feedback.

It is important to note that the ITPS was developed using classification algorithms for the provided information, employing various Machine Learning (ML) strategies in a Python 3 environment, with web development modules such as Django and HTML extensions for visualizing relevant attributes. More broadly, these strategies respond to the need to optimize processes related to the management and control indicators of the mentioned activities remotely, following the flow described in Figure 1.

Figure 1
Flowchart of the Process



In the first phase of the research, the quality of the measurement instruments was analyzed with the aim of integrating them into the Intelligent Tutoring and Psychopedagogical System, based on criteria of validity and reliability evidence (Franco-Mendoza, 2021). For this process, a pilot group with characteristics similar to the final beneficiary population was utilized, ensuring the use of informed consent for the initial data collection.

Simultaneously, Frontend and Backend algorithms were designed and developed to meet the visual and functional characteristics of the platform for different users. This integration allowed for the measurement instruments of psychological and academic well-being (Franco-Mendoza, 2021) to be included, along with relevant tasks and functionalities for each user level, leading to the creation of the first prototype of the system.

Subsequently, a mass data collection was carried out using the developed prototype in various professional schools of the faculty. This enabled the identification of at-risk cases regarding the psychological and academic well-being of students. Consequently, training sessions were scheduled for evaluators and tutors to familiarize them with the technological resource and provide feedback on the system's strengths and areas for improvement. Finally, user experiences were collected to compile reports on the study, supplemented by additional data analysis and observations during the final stage.

Ethical considerations

This study adhered to the ethical principles established in the Declaration of Helsinki (World Medical Association, 2013) and received approval from the Ethics Committee of the institution to which the principal author belongs.

Data analysis

To assess the consensus among experts, Pearson inter-rater correlation coefficients were used, considering values above .80 as indicators of consensus among peers. The remainder of the analysis was descriptive, focusing on the satisfaction level of student user experiences. This analysis was based on a group of 60 students who provided their evaluations of the platform.

Results and discussion

The study obtained inter-rater correlation measures among the experts using Pearson's correlation coefficient. These measures evaluated the agreement of the raters regarding the platform's characteristics, considering three criteria: functionality, relevance of use, and conceptual ease. The results are presented in Table 1, where values above .80 are observed, with a 95% confidence interval.

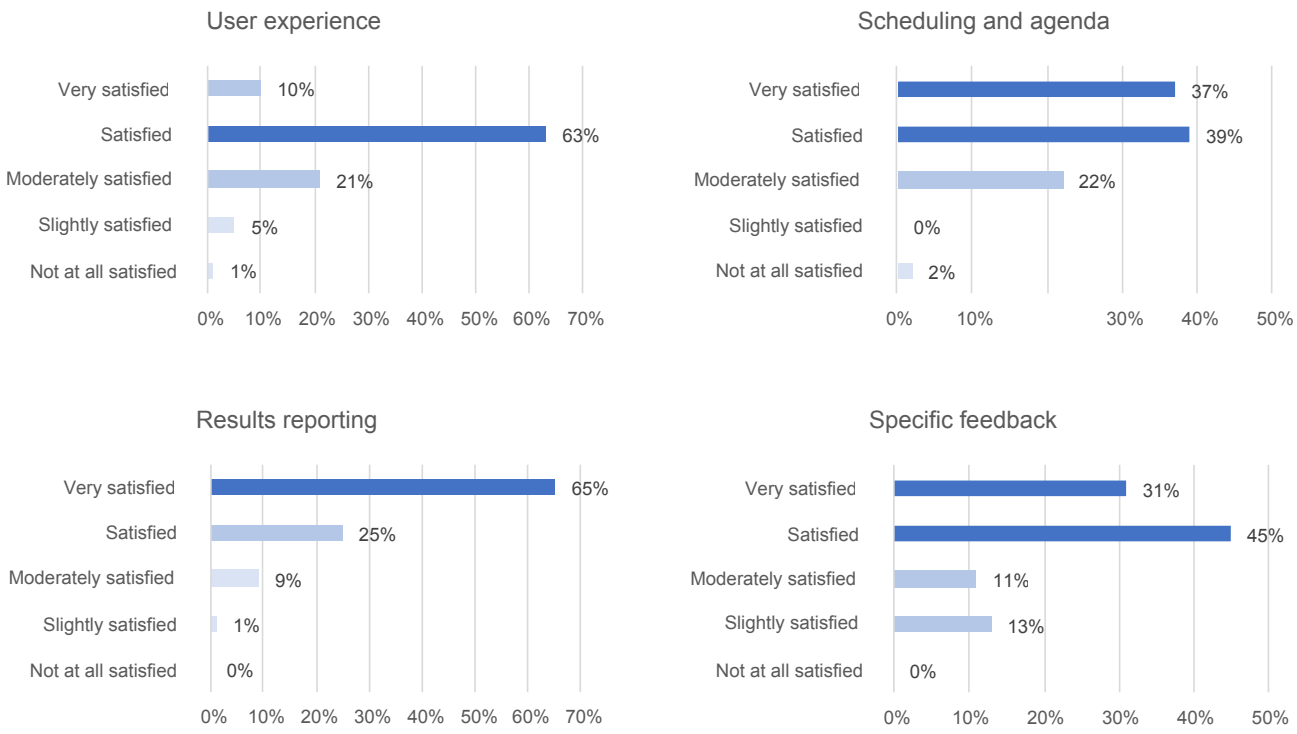
Table 1

Inter-rater concordance coefficients

Functionality									
Judge	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	1	-	-	-	-	-	-	-	-
2	0.86	1	-	-	-	-	-	-	-
3	0.90	0.89	1	-	-	-	-	-	-
4	0.84	0.92	0.93	1	-	-	-	-	-
5	0.86	0.89	0.92	0.94	1	-	-	-	-
6	0.91	0.87	0.96	0.83	0.85	1	-	-	-
7	0.92	0.94	0.88	0.91	0.90	0.89	1	-	-
8	0.88	0.97	0.93	0.88	0.94	0.96	0.83	1	-
9	0.84	0.95	0.86	0.92	0.96	0.90	0.88	0.85	1
Relevance of use									
Judge	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	1	-	-	-	-	-	-	-	-
2	0.94	1	-	-	-	-	-	-	-
3	0.94	0.94	1	-	-	-	-	-	-
4	0.98	0.86	0.92	1	-	-	-	-	-
5	0.98	0.96	0.96	0.94	1	-	-	-	-
6	0.94	0.94	0.88	0.89	0.96	1	-	-	-
7	0.92	0.96	0.88	0.94	0.87	0.83	1	-	-
8	0.86	0.94	0.98	0.88	0.89	0.96	0.89	1	-
9	0.92	0.95	0.90	0.89	0.96	0.91	0.93	0.91	1
Conceptual ease									
Judge	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	1	-	-	-	-	-	-	-	-
2	0.88	1	-	-	-	-	-	-	-
3	0.94	0.94	1	-	-	-	-	-	-
4	0.96	0.89	0.94	1	-	-	-	-	-
5	0.83	0.92	0.89	0.86	1	-	-	-	-
6	0.87	0.96	0.98	0.89	0.88	1	-	-	-
7	0.94	0.94	0.88	0.88	0.85	0.94	1	-	-
8	0.87	0.89	0.86	0.92	0.84	0.86	0.94	1	-
9	0.86	0.92	0.84	0.96	0.91	0.92	0.83	0.96	1

Once the judges approved the quality criteria of the platform, it was transitioned to testing processes with the aforementioned students, using the medium virtually via the web. In both environments, students were instructed to complete the user satisfaction survey upon finishing their use of the platform. Students responded favorably according to the survey criteria. The results of this process are presented in Figure 2, where it is observed that most students expressed satisfaction and high satisfaction with the platform's features.

Figure 2
Evaluation of student user experience

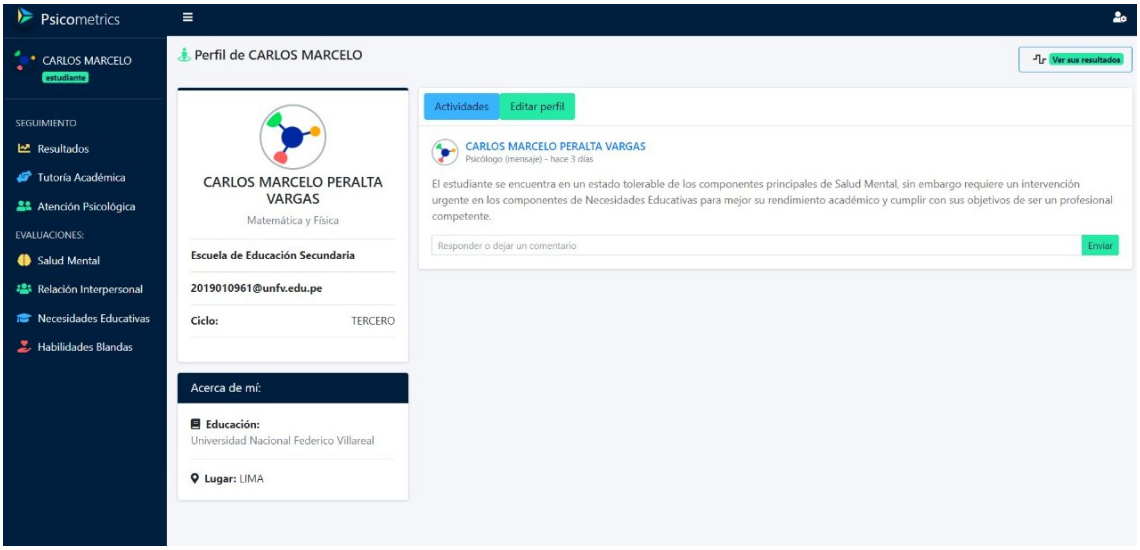


During a brief testing period, students, tutors, and psychology staff involved in evaluating the quality of the resource explored the benefits of the platform. The goal was to identify potential system setbacks or the emergence of technical errors. The platform's features and the design of the environment in its preliminary phases can be observed in Figure 3, which considers student users, tutors, and psychologists.

Within the virtual environment, functions that characterize the platform related to the four topics of tutorial and psychopedagogical evaluation can be seen. These aspects include mental health, family and interpersonal relationships, educational needs, and soft skills, available in both mobile web and desktop versions.

Figure 3

User interface

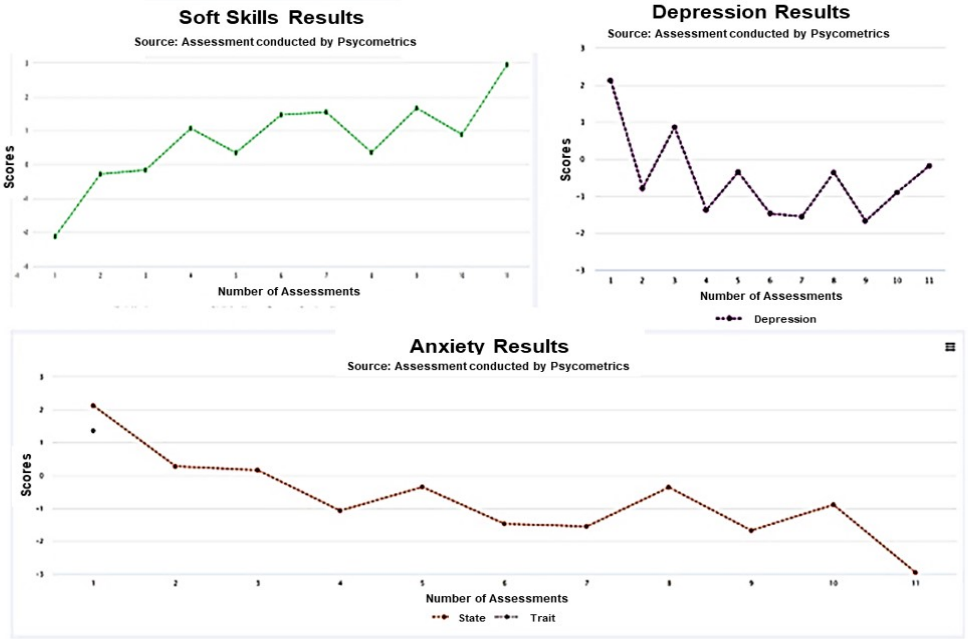


Alongside the calendar scheduling for appointments with tutors and psychologists, a section for interactions within each student module was added. This section allows for automated messaging, rescheduling of consultations, the use of an interactive chat, and access to each student's profile (with restrictions for tutors), as well as tracking specific measurements of each component of the four initially established topics. This last point is illustrated in Figure 4.

The ability to conduct evaluations over time, monitor, and track student activity through tutoring and psychopedagogical efforts resulted in favorable outcomes for the design and implementation of the platform. These results align with the specified requirements, according to user evaluations and the accuracy of psychological and psychopedagogical measures over time, aimed at continuous behavioral improvements.

Figure 4

Measurement of psychological and psychopedagogical components in the ITPS platform



The results obtained from the Intelligent Tutoring and Psychopedagogical System show favorable performance from its design to implementation, being approved by both experts and students. The agreement in its use is based on criteria of relevance, functionality, and conceptual ease, establishing differential indicators for tutorial and psychopedagogical activities in the Faculty of Education. The evaluation of psychological and psychopedagogical components through Computerized Adaptive Tests (CAT) on the platform optimizes tutoring, allowing for a systematic collection of information for decision-making, supported by the development of scientifically based technological products (Melgar-Begazo et al., 2019; Barrón-Estrada et al., 2018; Hernández & Rengifo, 2015; Lozzia et al., 2015; Maris et al., 2018).

Moreover, the use of the ITPS by tutors, teachers, and specialists optimizes material and human resources, improving the quality of care for users and responding to the increasing demand for mental health and social skills development (Reis et al., 2018; Orjuela et al., 2020a, 2020b; López, 2019; Vilas-Boas & Pontual, 2017). It also enables valid measures of student behavior through CAT (Pincay et al., 2019; Orjuela et al., 2020b; López, 2019). From a methodological perspective, the ITPS facilitates the replicability and standardization of results in programs with a greater impact and transnational reach, considering individual differences (Camacho-Lizárraga, 2018; Barrón-Estrada et al., 2018; López, 2019; Orjuela et al., 2020b). Additionally, it contributes to a more precise evaluation of formative behavior, ensuring a common analytical framework and avoiding issues in structural models through invariant measures (Muñiz, 2010; Lozzia et al., 2015; Souza, 2019; Franco-Mendoza, 2021).

It is important to highlight that the Intelligent Tutoring and Psychopedagogical System is not limited to students, as its functions can extend to gathering needs from training tutors and psychological evaluation, as well as other stakeholders in the educational environment that influence student development in higher education (Neyra et al., 2021; Orjuela et al., 2020a, 2020b; Maris et al., 2018; Reyes-Manrique, 2016). Furthermore, channels for psychological evaluation with advanced technologies, such as image processing and emotion recognition through neural networks and artificial intelligence, can be incorporated, provided they are justified in clinical or educational practice (Pincay et al., 2019; Reis et al., 2018). This task remains an ongoing opportunity to expand technological advancements for the benefit of the university community.

In this regard, it is recommended to continue studying behavior in tutoring actions and to improve the design of the ITPS, given its technological potential. The integration of these resources in mentoring, social skills development, mental health, and family environment can significantly benefit the socio-emotional, academic, and personal development of university students, as supported by evidence (Esteves-Villanueva et al., 2020; Clerici & Da Re, 2019; Javier-Napa et al., 2019; López-Gómez, 2017; Miranda, 2018).

Conclusions

The implementation of the Intelligent Tutoring and Psychopedagogical System has proven to be an effective strategy for enhancing university education in Lima. From its design to its implementation, it has received positive evaluations for its functionality and ease of use, optimizing resources and improving information management for decision-making in academic and psychological support.

Additionally, the integration of Computerized Adaptive Tests (CAT) has enabled precise evaluation of student behavior and needs, favoring attention to mental health, skill development, and learning strategies. Moreover, its potential is further enhanced with advanced technologies such as neural networks and artificial intelligence. However, challenges remain, such as expanding its use to teachers and other educational agents, as well as incorporating more sophisticated tools for psychological evaluation.

In this sense, the standardization and replicability of the results obtained are crucial. These can be applied in different educational contexts, overcoming regional and national boundaries. Nonetheless, it is recommended to continue researching and improving the ITPS to strengthen its impact on higher education. Integrating new technological tools can enhance its intervention capacity, ensuring comprehensive support for the academic, socio-emotional, and personal development of students. Ultimately, this advancement responds to the need for adaptation to Information and Communication Technologies (ICT), ensuring innovative strategies for higher education.

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