The Role of Individual Performance in the Effect of ICT Appropriation on Educational Performance of Students in Public Universities in the Casablanca-Settat Region, Morocco

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Abstract

        Over the past two decades, Moroccan higher education institutions have significantly invested in information and communication technologies (ICT). The integration of ICT in education (ICTE) and learning has led to major changes, including the implementation of digital strategies and

programs that have enriched the educational system. Notable progress has been made, such as providing most institutions with computer equipment and expanded internet access, especially in universities. Despite these advancements, questions remain about the true impact of these technologies on student performance and the overall effectiveness of the educational system. While researchers have explored this issue both theoretically and empirically, they face challenges, including the complex observation of students' individual performance and the rapid evolution of ICT, which makes isolating their effects difficult. This study aims to examine the impact of students' appropriation of ICT on educational performance in public universities in the Casablanca-Settat region and to explore the role of individual performance in this relationship. Using structural equation modeling (SEM) with SMART PLS 4.0 software, data from 185 students revealed a significant positive relationship between ICT appropriation and educational performance, with individual performance serving as a mediator. By employing mediation analysis, as outlined by Baron and Kenny (1986) and MacKinnon et al. (2007, 2012), the study investigated how individual performance mediates the relationship between ICT appropriation and educational performance. This method enabled the identification of both direct and indirect effects, providing a more nuanced understanding of the mechanisms through which ICT impacts educational outcomes via individual performance. The findings suggest that ICT is a crucial factor in improving higher education performance and highlight the importance of platform quality and students' sense of self-determination in the effective integration of ICT in the educational process. Future research should continue to explore individual performance among Moroccan university students and its impact on educational outcomes.

Keywords: The Use of ICT in Education, Appropriation of ICT in Education, Educational Performance, University Students, Moroccan Context

Introduction

Over the past two decades, Moroccan higher education institutions have increasingly prioritized information and communication technologies (ICT). The integration of ICT into teaching and learning has had a major impact, leading to the implementation of digital strategies and programs aimed at enriching the educational system. As a result of these efforts, significant improvements in skills within higher education have been observed. An ambitious national policy has promoted the widespread adoption and integration of ICT into the educational system, resulting in progress such as providing most institutions with computer equipment and expanded internet access, particularly in universities.

However, despite these advancements, questions persist about the actual impact of these technologies on student success and the overall effectiveness of the educational system. Researchers in the field of ICT, including Pierson (2001), Sharpe (2004), Scheerens (2015), Paivandi (2018), and AlAli & Wardat (2024), have attempted to explore this issue both theoretically and empirically, focusing on the academic environment. Yet, two main challenges remain: on one hand, observing individual student performance is complex due to the diversity of possible definitions; on the other hand, the rapid evolution of ICT makes it difficult to isolate their effects in an educational setting.

Despite the potential benefits of ICT, their impact on overall educational performance remains ambiguous. Recent studies by Youssef & Dahmani (2010), Burnett & Lisk (2021), suggest that the outcomes of ICT in higher education can vary depending on the level of appropriation and the opportunities provided by these technologies. Furthermore, the lack of significant organizational changes in universities limits the potential impact of ICT, despite substantial investments in equipment and increasing adoption by students.

There is a lack of empirical studies, both in Morocco and internationally, on the impact of students' appropriation of ICT on educational performance within universities, as noted by Kabore (2021). This absence of consensus on how ICT is appropriated by students and its effect on the educational system underscores the need for further exploration of this issue.

This article makes a significant contribution to the literature by exploring the relationship between students' ICT appropriation and educational performance within the specific context of public universities in the Casablanca-Settat region. Unlike most previous studies, this research also examines the role of individual performance in this relationship, thus providing a more comprehensive perspective on the effects of ICT in higher education. Through a quantitative study based on structural equation modeling (SEM), this research offers an in-depth analysis of the mechanisms by which ICT appropriation influences student performance. By applying mediation analysis as described by Baron and Kenny (1986) and MacKinnon et al. (2007, 2012), the study investigated how individual performance mediates the relationship between ICT appropriation and educational performance. This approach allowed for the identification of both direct and indirect effects, offering a more nuanced understanding of the mechanisms through which ICT influences educational outcomes through individual performance.

The study focused on the impact of ICT appropriation by students on educational performance within public universities in the Casablanca-Settat region. The main findings highlight a significant positive relationship between

ICT appropriation and educational performance. They also reveal the mediating role of students' individual performance in this relationship. Specifically, the data show that ICT appropriation contributes to a notable improvement in individual performance, which in turn positively influences educational performance. The results suggest that ICT appropriation by students is a key factor in enhancing higher education performance. Moreover, the analysis confirms that elements such as platform quality and students' sense of self-determination play a crucial role in the effectiveness of ICT integration into the educational process.

Thus, the article is structured as follows: First, we will define the measures of ICT appropriation, educational performance, and individual performance. Next, we will examine the relationship between ICT appropriation and educational performance, with a focus on the role of individual performance in this relationship. The study will conclude with a discussion of the results, their implications for higher education, and recommendations for future research.

Literature Review
Best use of ICTs

Since the early 1990s, higher education worldwide has undergone a remarkable transformation due to the integration of information and communication technologies (ICT), as noted by Dusen & Gerald (1997). Initially seen as mere innovations, these digital tools have quickly become indispensable in universities and higher education institutions. Their use now extends well beyond administrative tasks, such as decision-making systems, Lévy (2000), to more complex aspects, such as course evaluation, Mangenot (2000). Thus, ICTs have become a central pillar in the daily operations of these institutions, promoting better management and more effective learning.

The highest expectations for ICT outcomes often focus on teaching and learning, Wilson & Wilson (2009). Globally, organization on emphasizing training and development, whether in businesses or educational institutions, Schroeder (2010). These trainings are increasingly technology-based, including online learning, simulation training, and games. Particularly, computer games have taken a significant place in recent research and training, especially in developed countries like the United States, Hilton & Honey (2011), Zeng et al. (2020). It is crucial to differentiate between the use of ICT in traditional educational settings, such as lectures that utilize tools like PowerPoint, which, despite their pedagogical limitations, continue to dominate university teaching, Puranik (2020); Hontarenko & Kovalenko (2024), and their innovative applications for non-traditional student groups, particularly in fields like mathematics, Csernoch et al. (2015) or engineering,

Lukman & Krajnc (2012). In these disciplines, non-traditional teaching methods often emphasize constructivist and collaborative approaches, actively engaging students in constructing their knowledge and solving problems through techniques such as e-learning, group work, and interactive exchanges, Tularam & Machisella (2018).

The increasing internationalization and commercialization of higher education, as well as the development of interactive, part-time, and distance learning models, are transformations enabled by the adoption of new ICTs. These developments lead to intensified competition among higher education institutions, Schneckenberg (2009). This article will examine the use of ICT in traditional higher education environments.

Indeed, the integration of ICT into university teaching is becoming more common. However, the effectiveness of these tools largely hinges on student motivation, as noted by King et al. (2017). This motivation can be intrinsic, aligning with personal values and desires, or extrinsic, driven by external goals (Brault, 2018; Valentin, 2013). It is therefore crucial to understand the extent to which students are willing to engage in courses that place a strong emphasis on ICT.

Despite the importance placed on motivation and engagement in learning through ICT, Agarwal & Karahanna (2000), Tharenou (2001), Heutte (2012), few studies have examined the effect of these factors on students identified as role models, Shé et al. (2023) or broadly referred to as "exemplary technology users" in their learning process, Pierson (2001), Kabore, (2021). Furthermore, there is a scarcity of studies comparing ICT use in post-secondary learning environments from both student and professor perspectives, King et al. (2017).

The meaning of the term "exemplary use" (or best use) generally refers to users who can serve as role models for other users. English-speaking authors use a variety of phrases and expressions to refer specifically to those users who integrate ICT in an ideal way into their work processes. These include "experienced and accomplished teachers at integrating computers into their teaching" Sheingold & Hadle (1990); "exemplary computer-using teachers" Becker (1994); "exemplary technology-users" Parks & Pisapia (1994); Pierson (2001); "exemplary technology teachers" and "exemplary technology-using teachers" Berg et al. (1997). Within the same vein, we emphasize "proficient technology-oriented teachers" Roblyer et al. (1997); "expert users of computer resources" Becker (1999); "exemplary technology integrators"; "exemplary technology-integrating teachers" by Pierson (2001) and Raby C. (2004, p. 41).

For Becker (2000, p. 275), a series of studies have identified significant factors that appeared to be different in the environments of exemplary computer-using teachers, including developmental activities, staff support,

smaller class sizes and access to software. The studies have highlighted the potential influences of the increase in extrinsic enablers, and further attention needs to be paid to intrinsic factors Becker (1991). On the other hand, according to Berg et al. (1997), an exemplary use of ICT is due to the technology's ability to provide learners with the tools they may need to actively process, transform, and appropriate new information Ertmer et al. (2006, p. 55). For Pierson (2001, p. 414) users, especially exemplary technology teachers, spend a great deal of time working with digital tools, but they also have had training and experience, as well as very high levels of innovation and confidence. Colleagues who use computers for meaningful activities surround them; they have support at the school level, and they are offered many opportunities for personal growth. The pedagogical integration of ICT into the teaching field cannot, however, be regarded as a mechanical process; in concrete terms, it raises the whole fundamental issue of preparing and training - both administrators and teachers - for the optimal use of ICT in line with the improvement of teaching and student learning in a purposeful learning context.

However, Raby C. (2004, p. 44) identified a new logic of exemplary ICT use by distinguishing four different stages and cycles: 'awareness', 'personal' use, 'professional' use, and 'educational' use. "Awareness" pertains to vicarious interactions with ICTs, experienced within an individual's personal or professional contexts. The "personal" use stage also appears to be significant. It refers to using ICTs in personal activities, such as communicating with family or colleagues, managing personal and family affairs, or even looking for information directly related to subjects of personal interest, such as finding a specific address. Concerning "professional" use, this refers to the use of ICTs by individuals as part of their professional activities, but not in direct interaction with learners. For example, it reflects the use of a platform within the University for Communication with managers or administrative staff.

The "educational" use level is divided into five parts:
1. During the motivation process, teachers develop a curiosity, a need or a pedagogical obligation to integrate ICTs into the classroom.
2. During the familiarization phase, users prompt learners to use technical tools as a reward or occupation. Beyond emotional interest, the educational value of such activities seems limited to the initial and basic development of the students' ICT skills.
3. In the "exploration" phase, teachers use ICTs to enrich pedagogical content. Students then engage in activities to reinforce or enrich concepts taught in class, or to retrieve information to improve their

learning level. In addition to acquiring knowledge, the activities also facilitate the development of transversal skills related to the ICTs.

4. During the "infusion" stage, teachers engage their students in the use of ICTs. This will enable them to develop disciplinary competencies and further develop competencies in the use of ICTs.
5. The final "appropriation" stage is characterized by the regular and frequent use of knowledge transmission and construction, carried out in an active and meaningful, goal-oriented learning environment.

In this respect, appropriation enables the development of disciplinary and cross-disciplinary skills for the various users.

Technology Appropriation

Adaptive structuring theory, or technology structuring and appropriation theory, defines the concept of appropriation as a set of processes in which users make use of technologies in different ways that are compatible with work requirements, DeSanctis and Poole (1991). In the workplace context of the digital age, technology appropriation refers to the use of technologies in different ways to achieve organizational goals, using different IT tools and communication technologies. More concretely, it is about how a group uses, adapts and reproduces a structure Roux (2007, p. 4).

Ko et al. (2021, p. 2) define appropriation as the use of ICTs in various ways to achieve organizational goals, Poole & DeSanctis (1991). It also argues that, when specific ICTs are accepted and used appropriately to meet task or organizational specifications, this leads to individual employee performance as well as organizational performance DeLone and McLean (1992, 2003).

In the educational field, the integration of ICT goes far beyond mere adoption. According to Meza et al. (2018, p. 2), this integration requires a genuine appropriation by the user, meaning a thoughtful and intentional use of ICT, Chordia & Hiniker (2019), Watson (2024). This appropriation extends beyond merely using tools; it involves a level of autonomy in which users exert control over the technology and the content they manage. In this context, Burnett and Lisk (2021) underscore that ICT usage can boost user engagement in their work or learning, particularly by facilitating enriching interactions and providing meaningful feedback. Additionally, Murray et al. (2021) stress the significance of allowing users to freely select and control the information sources they deem relevant, thereby enhancing their involvement and sense of mastery. However, as O'Brien et al. (2022) remind us, for this technological experience to be truly beneficial, it must be both meaningful and positive. Indeed, negative experiences with technology can lead to user disorientation and disengagement from educational or professional activities, Ferrero & Sainz (2024).

The positive impact of ICT use on educational performance has also been highlighted in several studies, Gutiérrez et al. (2020), Berrocoso et al. (2022), Kilag et al. (2023), Adeniyi et al. (2024). These studies have asserted that students with a favorable attitude toward ICT use them proactively to enhance their study habits and, consequently, their academic outcomes. Furthermore, recent research (Zhang et al., 2021; Cheng & Yang, 2023) has shown that integrating ICT into pedagogical practices (e.g., collaborative or student-centered learning) not only offers opportunities for innovation but also improves learning outcomes. Positive experiences with ICT not only strengthen student engagement and skill mastery but also play a direct role in improving their overall educational performance (Hanaysha et al., 2023; Farrukh et al., 2024).

Educational performance: definition and context

The evolution of the education sector in recent years has been marked by the increasing integration of ICT, leading to a radical transformation in teaching and learning methods, Alnoaimi et al. (2011), Qolamani & Mohammed (2023). Universities' investments in these technologies aim not only to modernize educational infrastructures but also to enhance students' educational performance, often measured by their academic success, graduation rates, and other skill acquisition indicators, Deniger (2004), York & al. (2015).

The impact of ICT on educational performance manifests in several ways. On one hand, facilitated access to digital educational resources, whether generic or university-specific, allows for greater use of educational content by students. This promotes increased flexibility in the learning process, facilitating self-directed learning, such as online education, which proves particularly beneficial for students needing additional support, Ragan et al. (2023). The increase in interactions between teachers and students, thanks to the use of digital platforms, also enhances the educational experience by facilitating collaboration and knowledge sharing, Perrenoud (2002), Hoi (2021).

However, despite these apparent benefits, the impact of ICT on overall student performance remains mixed. Although the integration of technology has led to improvements in certain dimensions such as the quality of training, student participation, and access to data and educational resources, it has not necessarily resulted in a significant increase in success rates or a reduction in university failures, Sharpe (2004), Scheerens (2016), AlAli & Wardat (2024). This raises questions about how productivity in the educational sector is measured and the limitations of ICT in addressing some of the structural challenges faced by universities, Cosculluela et al. (2024).

Thus, educational performance is not limited to immediate academic results (grades, year validation) but also encompasses broader dimensions such as engagement in formative activities, participation in seminars, and involvement in research projects, Brault (2010), Nasirun & Shahidan (2024). It is also essential to consider students' assessments, as they play an active role in their own educational journey, Paivandi (2018). The conventional perspective of performance as solely academic, typically reliant on strict institutional criteria, warrants re-evaluation to include the subjective and personal dimensions of learning. This shift would promote a more holistic approach that addresses the diverse needs of students.

On the other hand, some studies, Bodin & Millet (2012), AlAli & Wardat (2024) challenge the notion of "academic failure." The university should not only be seen as a place for knowledge transmission but also as a space for socialization and personal development, Ou et al. (2022), where study paths may vary without being considered failures. This diversity of paths should be recognized and valued, rather than stigmatized, in the evaluation of educational performance.

Individual Performance

Research on educational performance can be categorized into three main areas when examining individual performance within organizations. "Learning productivity", which explores the learning capacity of students and focuses on the individual's ability to learn. Researchers such as Johnstrone (1993), Hooker (1997), and Kuh and Hu (2001) have contributed to this thematic concern by investigating various aspects of learning productivity.

"Academic experience", on the other hand, concentrates on the learning environment and the overall experience of the students. Scholars like Astin (1985) and Kuh and Hu (2001) have examined how the student's environment and educational experience influence their individual performance. In other words, this aspect explores how the learning environment influences individual performance. Conversely, "teaching effectiveness" focuses on improving student learning by suggesting effective teaching methods. Researchers such as Chickering and Gamson (1991), Hativa et al. (2001), and Sigmen (2006) have contributed to this issue by suggesting strategies and approaches that can improve the student learning outcomes.

Over time, the concept of individual performance has undergone multiple transformations and has extensively been studied. Researchers, including Borman, W. C., Motowidlo, S. J. (1997), Motowidlo & Keil (2003), and Agonhossou & Godonou (2011), among others, have fervently attempted to define individual performance. However, a universally accepted and unequivocal definition of this concept remains elusive. This challenge stems

largely from the nature of academic research, which predominantly focuses on the criteria and methodologies employed in assessing individual performance.

However, Performance was defined as "Action or behavior that is relevant to the achievement of organizational objectives and that is measurable in terms of level of profitability" Motowidlo, S. J. et al. (1997, p. 99). This definition implies that they consider individual performance to be a key factor in organizational success. For Agonhossou D.K. and Godonou C.K. (2011), individual performance is "the total value expected by the organization from the discrete behavioral episodes that an individual performs over a given period of time" p. 109).

Indeed, university education plays an important role in the development of students' skills, preparing them to independently overcome the various challenges they encounter, Almufarreh & Arshad (2023). The university prioritizes individual performance as a crucial measure of its overall effectiveness, according to Youssef et al. (2022). This focus represents a privileged setting for evaluating the efficacy of teaching methods and their impact on students' skills acquisition, even amidst a variety of available of technological tools, as noted by Pandey et al. (2023). Consequently, teachers have the opportunity to tailor and experiment various pedagogical approaches to enhance both students' individual performance and, by extension, the educational performance of the institution as a whole, as highlighted by Kapo et al. (2024).

Hypotheses and Research Model
The Direct Effect of ICT Appropriation on Students' Individual Performance

ICT appropriation in education goes beyond the mere use of technology; it is embedded in a broader context of interactions and cultural practices, Cárdenas & Manuel (2004), Holmfeld et al. (2023). It involves epistemological, pedagogical, and axiological dimensions (Heath et al., 2023), forming a set of actions that shape a digital culture and connectivity (Lundholm, 2023). The actors in this process—students, teachers, and administrators—are thus encouraged to develop digital skills and innovative teaching practices (Espinosa et al., 2023). This is particularly important as labor market demands and the challenges of the digital society require continuous adaptation, Canal et al. (2022), Yüceol (2021).

In this context, the study by Giraldo & Báquiro (2020) on the appropriation of Colombian public policies regarding ICT in education, conducted over the period from 2000 to 2019, highlights the importance of training focused on the use and appropriation of ICT. They show that this training is essential for promoting pedagogical innovation and the development of digital skills. The authors emphasize the creation of spaces for

reflection and collective decision-making, enriched by the experiences of academic actors, to strengthen innovation and effectiveness in the use of ICT.

Furthermore, the conclusions of the qualitative study by Boufarouj & Mdarbi (2022) reinforce the idea that ICT appropriation has a direct and positive impact on pedagogy. They demonstrate that it not only improves users' knowledge but also stimulates their engagement by offering more attractive and dynamic content. This active appropriation of ICT thus contributes to enhancing skills, increasing student engagement, and ultimately improving their individual performance.

These findings align with recent research by Ley et al. (2021), Zhao et al. (2023), and Ekwufolu (2024), which indicate that ICT appropriation is a crucial factor in skill development and the enhancement of student performance. They emphasize the importance of an integrated approach that goes beyond the acquisition of technical knowledge to include reflection, decision-making, and pedagogical innovation, Montoya et al. (2024).

Based on these findings, we propose the following hypothesis:
H1.1: ICT appropriation has a significant and positive impact on students' individual performance.

The Direct Effect of Students' Individual Performance on Educational Performance

In the African continent, the examination of educational reforms reveals several relevant results, Adeniyi et al. (2024). First, these reforms aimed to enhance the quality and relevance of education, leading to modifications in curricula, teacher training program initiatives, and increased integration of educational technology, Ganiyu et al. (2024). The impact of these reforms has been measured using various performance indicators, such as standardized test scores and graduation rates, Oguguo et al. (2021), Adeniyi et al. (2024).

In the same vein, the results of recent studies, Calderón et al. (2020), Zhou et al. (2023), David & Weinstein (2024) emphasize that improving educational performance is intrinsically linked to innovative teaching practices and student engagement, Shin & Bolkan (2020). Educational reforms have also considered socio-economic, cultural, and infrastructural contexts, which play a determining role in their implementation and effectiveness. The conclusions of these studies show that when reforms are well-designed and adapted to the specific needs of local contexts, they have a positive and significant effect on students' individual skills in ICT use, Tolani et al. (2011), Sun et al. (2022), on their academic success, and on the performance of educational institutions, Kimuya et al. (2021).

Therefore, the data suggests that ICT appropriation, when embedded within a framework of thoughtfully designed educational reforms, can significantly and positively influence both individual and overall student performance. This supports the hypothesis that the effective integration and utilization of technologies in education enhance learning outcomes and strengthen student performance.

These observations allow us to conclude that ICT appropriation, as a key element of educational reforms, Wang et al. (2024), plays a crucial role in improving educational performance. This reinforces the idea that students' individual performance is positively influenced by their ability to engage with and integrate these technologies into their learning process, which in turn positively impacts overall educational performance.

In conclusion, empirical studies indicate a positive correlation between individual performance and overall educational performance, which leads to the formulation of the second sub-hypothesis:

H1.2: Students' individual performance significantly and positively impacts educational performance.

The Mediating Effect of Students' Individual Performance on the Link between ICT Appropriation and Educational Performance

Researchers in the field of ICT, such as Ben Youssef and Dahmani (2010), Abdel-Ouahed (2014), and Ko et al. (2021), have studied the use and appropriation of ICT and their impact on students' educational performance. According to Ben Youssef and Dahmani (2010), ICT has a profound impact on the learning process by offering new possibilities that can improve students' performance and outcomes. However, they emphasize that ICT appropriation by higher education institutions requires a long process before significant changes can be observed. The adoption of complementary organizational innovations is essential for students to acquire skills aligned with labor market needs. Abdel-Ouahed (2014, p. 103) adds that student autonomy is essential for effective ICT appropriation. This autonomy is acquired through involvement, mutualization, self-observation, and self-evaluation. Student motivation plays an important role in ICT integration, as it directly influences learners' attitudes toward the use of technological tools. Indeed, a technological tool can only promote a knowledge mediation process only if the receiver maintains a favorable cognitive stance toward the medium.

In parallel, although cognitive absorption is recognized as an important element of high engagement and involvement of an individual during training, Webster & Ho (1997), several studies, Andersén & Kask (2012), Yildiz et al. (2019), Shirish et al. (2023) have shown that it is insufficient to focus solely on this dimension to understand under which conditions it promotes individual learning. Cognitive absorption largely relies on intrinsic motivation, Agarwal

& Karahanna (2000), but this motivation can sometimes indicate a total or partial lack of self-determination, Deci & Ryan (2000, 2002). Learners might attribute their actions to intrinsic factors that are beyond their control or be driven by external goals, such as passing exams, which may not align with their personal values, Blanchard et al. (2004), Kindelberger et al. (2023). The self-determination theory, Deci & Ryan (2000) allows us to distinguish between different types of motivations in various learning contexts, including academia, Reeve (2012), Litalien et al. (2017). According to Ko et al. (2021, p. 6), platform quality, task performance, and a sense of self-determination positively influence ICT appropriation, which in turn significantly impacts educational performance. Thus, an environment conducive to self-determination and the quality of technological tools promotes more effective ICT appropriation, leading to improved student performance.

These empirical works suggest that for ICT appropriation to positively impact educational performance, it is necessary to consider individual factors such as autonomy, intrinsic motivation, and student engagement. We can thus conclude a mediating effect of students' individual performance on the link between ICT appropriation and educational performance. These conclusions lead us to formulate two hypotheses, namely:

The main hypothesis regarding the mediating effect of students' individual performance on the link between ICT appropriation and educational performance:

H1: Students' individual performance mediates the relationship between ICT appropriation and educational performance.

Additionally, the hypothesis positing a significant relationship between students' ICT appropriation and educational performance is as follows:

H2: Students' ICT appropriation has a significant and positive impact on educational performance.

Figure 1: Research Model
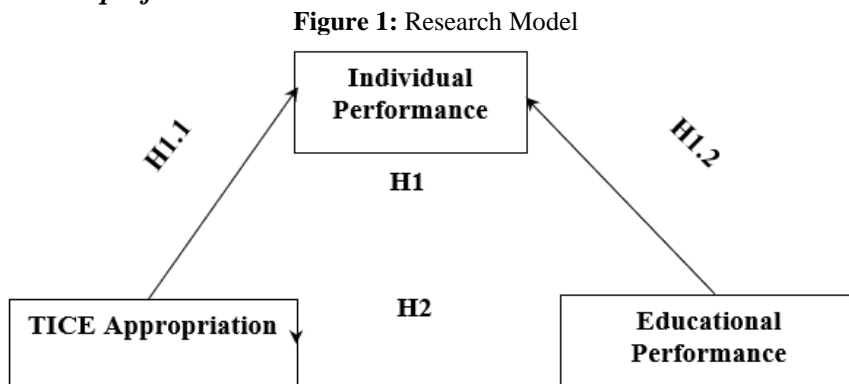
Source: (Authors)

Methods
Research methodology

In this section, we will move into the research methodology adopted in our study. We will explore various aspects, including the selection of the target population, our epistemological stance, the methodology chosen, and the sampling and data collection procedures implemented to effectively address our research question.

Population

Nowadays, educational systems have significantly ramped up their technological resources to resume normal activities. The integration of technology in education has taken various forms such as distance learning, e-learning, hybrid learning, virtual education, and the traditional approach supported by technology. These advancements have had a substantial impact on educational performance.

The incorporation of Information and Communication Technology in Education (ICTE) plays a crucial role in creating a highly effective teaching and learning environment. It enhances the overall educational experience for students by improving the teaching and learning processes. Higher education administrators are actively involved in facilitating the integration of these new educational technologies across institutions through a continuous cycle of design, development, and advancement of functionalities.

In this context, appropriation refers to the conscious adoption and control of ideas, tools, technologies, and more, within the context of users' actual and perceived culture. The appropriation of ICTE encompasses the use of laptops, digital content, software, projectors, platforms, and the internet for educational purposes in the classroom, aiming to enhance teaching quality and educational performance across different educational settings.

Learning to effectively utilize ICT has different interpretations. Since the impact of ICT on student outcomes heavily relies on the consistency of its implementation, it becomes challenging to separate this type of learning from the inherent infrastructure of ICT as it pertains to academic achievements. The use and implementation of ICT in learning have demonstrated significant success in improving academic performance, especially in an increasingly globalized environment.

Considering the significance of the topic, our research focuses on university students. They play a central role in our research context and are actively engaged in pedagogical projects that prioritize student-centered learning approaches over traditional teacher-controlled methods.

Epistemological positioning

In order to ensure coherence between the research problem and the research context, it is widely acknowledged that the epistemological position, research approach, and choice of methods should align.

As far as our epistemological stance is concerned, we have adopted a positivist perspective for our study, as we seek to examine the growing significance of ICT appropriation in the educational performance of students in Moroccan public institutions. Positivism justifies the construction of a hypothetico-deductive system, which is subsequently tested against representative empirical situations. This approach involves formulating one or more hypotheses and comparing them with real-world observations. The objective is to assess the validity of the initially proposed hypothesis. In other words, our analytical tools are derived from theoretical foundations.

We have employed a quantitative research approach for our study, utilizing structural equation modeling and software such as SPSS and SMART PLS. This approach allows us to examine causal relationships between variables and test our proposed hypotheses.

Measurement scales

To measure ICT appropriation, we used the 3 dimensions adopted by Pelletier C. et al. (2008). The instrument consists of 4 items, covering 3 dimensions of ICT appropriation, namely cognitive absorption, inspired by the "Flow Theory" presented by Csikszentmihalyi (1990), user skills, inspired by the model unveiled by Munro M.C. et al., (1997), and feelings of self-efficacy towards technology, inspired by the "Social Cognitive Theory" put forward by Bandura A. (1977).

To measure educational performance, we used the approach adopted by Charlot et al. (1992). The instrument is made up of 3 items, covering a single dimension of educational performance, and consists in drawing up a balance sheet of knowledge and appreciation regarding the use of ICTE in connection with a job.

To measure individual performance, we used the 2 dimensions adopted by Koopmans L. et al. (2011). The instrument consists of 18 items.

Sampling and data collection

We conducted a questionnaire survey of students at public universities in the Casablanca-Settat region of Morocco. The survey covered all streams and cycles of the three universities in the region, namely: Hassan II University of Casablanca (UH2C), Chouaib Doukkali University of El Jadida (UCD), and Hassan I University of Settat (UH1). These universities comprise 32 establishments, with 193,509 students.

The region was chosen because of its involvement and progress in implementing information and communication technologies in education (ICTE). In this context, we collected 185 questionnaires, a sample comprising 46% men and 54% women, with an average age between 18 and 30.

The data collection method differed from one school to another, as each school had its contextual constraints. Indeed, the questionnaire was distributed via social networks, emails, etc. Students participated voluntarily in the contribution of this article. The "snowball" method was also used to distribute the questionnaire to reach a large number of students.

Results

The model is tested by the PLS-SEM (Part Least Squared Structural Equation Modeling) method, this choice is motivated in particular by the fact that this method does not require a standardized distribution of the data Chin (1998); Fornel & Larcker (1981); Gefen et al. (2011); Ringle et al. (2012), and is considered the most suitable for moderate sample sizes Fernandes (2012).

A three-stage analytical procedure is followed using Smart PLS 4.0 software: evaluation of the psychometric specificities of the research model (measurement model), followed by hypothesis testing (structural model). Finally, the mediation analysis procedure was conducted to assess the mediating effect of individual performance in the relationship between ICTE appropriation and educational performance.

Method of Data Analysis: Mediation

In this study, the mediating effect is observed when the relationship between an independent variable (ICT appropriation) and a dependent variable (educational performance) occurs through an intermediary variable (individual performance). This mediating variable acts as a bridge between ICT appropriation and educational performance, revealing a multi-step process. In other words, ICT appropriation has a direct impact on students' individual performance, which in turn influences educational performance. The illustrative (figure 2) below helps to clarify these relationships:

Figure 2: Details from Baron and Kenny's (1986) mediation model
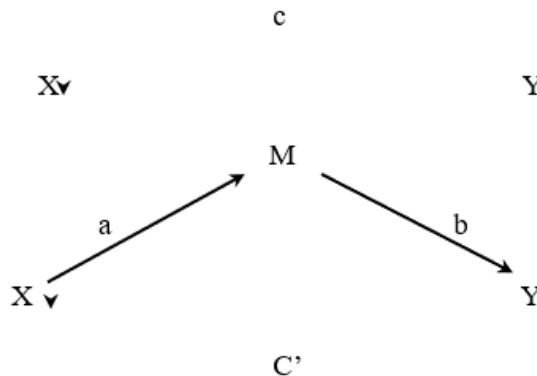
Source: Pardo & Román (2013)

Indeed, the direct effect (C') occurs when ICT appropriation (the independent variable) directly influences educational performance (the dependent variable) without involving an intermediary variable (individual performance).

In contrast, the indirect effect takes place when ICT appropriation (the independent variable) first impacts (a) individual performance (the mediating variable), which then influences (b) educational performance (the dependent variable). To build on this, while the indirect effect highlights how ICT appropriation influences educational performance via individual performance, it is crucial to further distinguish between the types of mediation at play.

In the case of full mediation, as outlined by Baron and Kenny (1986), the connection between the independent variable (X) and the dependent variable (Y) is entirely accounted for by the intermediary role of the mediating variable (M). In other words, once the mediating variable is included in the analysis, the direct effect (c') of the independent variable (X) on the dependent variable (Y) should become insignificant. This implies that ICT appropriation affects educational performance only indirectly through its influence on individual performance.

In the case of partial mediation, both the direct and indirect effects are significant. This means that the independent variable (X) not only has a direct impact on the dependent variable (Y) but also exerts an indirect influence through the mediating variable (M). As Zhao, Lynch, and Chen (2011) point out, while full mediation is often considered ideal, partial mediation is more frequently observed, where both the direct and mediated paths contribute to explaining the variance in the dependent variable (Y). The results presented below will clarify which form of mediation has been confirmed in this study.

Assessment of measurement model

Factor loadings were assessed for each item (Table 1). All items met Fernandes' (2012) thresholds of 0.5, except for the five individual performance items, Perf_individ_14 (CF=0.378), Perf_individ_15 (CF=0.339) Perf_individ_16 (CF=0.191), Perf_individ_17 (CF=0.246) and Perf_individ_18 (CF=0.235); which we decided to eliminate.

From a statistical point of view, the reliability of the constructs is assessed by calculating Cronbach's alpha and the composite reliability index (CR). As shown in Table 1, these indices greatly exceed the acceptability threshold of 0.7 Fernandes (2012); George and Mallery, (2003). To assess convergent validity, we examine the average variance extracted (AVE) of the constructs, with all three values exceeding Fornell and Larcker's (1981) required thresholds of 0.5. (see Table 1)

Discriminant validity is also ensured, firstly according to the criterion of Fornell and Larcker (1981), which consists of verifying that the square root of the AVE for each construct exceeds the correlations between the constructs and their measurement items are greater than the cross-correlations (see Table 2).

The results of the cross-loadings (Table 3) confirm that all the items significantly contribute to their respective variables when compared to other variables.

Table 1: Loadings, Reliability, and Convergent Validity

Construct	Items	Loadings	Alpha	CR	AVE
ICTE Approppriation	Approp_TICE_1	0,809	0,821	0,881	0,650
	Approp_TICE_2	0,820			
	Approp_TICE_3	0,778			
	Approp_TICE_4	0,817			
Educational Performance	Perf_educ_1	0,918	0,910	0,943	0,847
	Perf_educ_2	0,919			
	Perf_educ_3	0,924			
Individual performance	Perf_individ_1	0,734	0,942	0,950	0,593
	Perf_individ_2	0,805			
	Perf_individ_3	0,755			
	Perf_individ_4	0,823			
	Perf_individ_5	0,784			
	Perf_individ_6	0,773			
	Perf_individ_7	0,790			
	Perf_individ_8	0,801			
	Perf_individ_9	0,805			
Construct	**Items**	Loadings	**Alpha**	**CR**	**AVE**
Individual performance	**Perf_individ_10**	0,750			
	Perf_individ_11	0,738			
	Perf_individ_12	0,753			
	Perf_individ_13	0,685			
	Perf_individ_14	0.378			

	Perf_individ_15	0.339			
	Perf_individ_16	0.191			
	Perf_individ_17	0.246			
	Perf_individ_18	0.235			

CR: Composite reliability, Alpha : Cronbach Alpha
Source: (Smart PLS 4.0)

Tableau 2: Discriminant validity (Fornell et Larcker, 1981)

	.(1)	.(2)	.(3)
ICTE Approppriation (1)	*0,806*		
Educational Performance (2)	0,669	*0,920*	
Individual Performance (3)	0,772	0,716	*0,770*

The diagonal: the square roots of AVE
Source: (Smart PLS 4.0)

Table 3: Cross-loadings

Construct	Items	ICTE Approppriation	Educational Performance	Individual Performance
ICTE Approppriation	Approp_TICE_1	**0,809**	0,508	0,572
	Approp_TICE_2	**0,820**	0,489	0,611
	Approp_TICE_3	**0,778**	0,598	0,617
	Approp_TICE_4	**0,817**	0,553	0,679
Educational Performance	Perf_educ_1	0,637	**0,918**	0,677
	Perf_educ_2	0,604	**0,919**	0,615
	Perf_educ_3	0,606	**0,924**	0,682
Construct	**Items**	ICTE Approppriation	Educational Performance	**Individual Performance**
Individual performance	**Perf_individ_1**	0,559	0,575	**0,734**
	Perf_individ_2	0,645	0,582	**0,805**
	Perf_individ_3	0,550	0,565	**0,755**
	Perf_individ_4	0,728	0,696	**0,823**
	Perf_individ_5	0,518	0,585	**0,784**
	Perf_individ_6	0,569	0,518	**0,773**
	Perf_individ_7	0,601	0,547	**0,790**
	Perf_individ_8	0,574	0,526	**0,801**
	Perf_individ_9	0,596	0,535	**0,805**
	Perf_individ_10	0,597	0,500	**0,750**
	Perf_individ_11	0,493	0,457	**0,738**
	Perf_individ_12	0,554	0,476	**0,753**
	Perf_individ_13	0,673	0,546	**0,685**

Source: (Smart PLS 4.0)

With the psychometric specificities required for our model assured, we next examine the structure.

Assessment of structural model

During this stage, we have evaluated the structural fit of our model by initially examining the level of variance explained by the endogenous constructs, utilizing the R2 index. Subsequently, considering the validity of the research hypotheses, we assess each correlation coefficient associated with them. This assessment involves considering the value of the standardized beta coefficient (close to 0 indicating a weak link, and close to 1 indicating a strong link), the direction of the effect (positive or negative), the significance level (typically set at 1.96), as well as the probability of error (the p-value).

Table 4 and Figure 3 summarize the results of our overall research model, wherein all the hypotheses are corroborated.

Table 4: Hypothesis testing

Hypothesis	Beta	T statistics	P values	Validation
Approp_TICE -> Perf_educ	0,289	2,829	0,005	YES
Approp_TICE -> Perf_individ	0,772	20,898	0,000	YES
Perf_individ -> Perf_educ	0,493	5,243	0,000	YES

Source: (Smart PLS 4.0)

We then proceed to analyze the mediation.

Mediation analysis

A mediation analysis was performed to assess the mediating role of individual performance on the relationship between ICTE appropriation and educational performance. The results (Tables 5 and 6) reveal that the total effect between ICTE appropriation and educational performance is significant and positive (beta=0.669, t=13.209, p=0.000).

In the presence of the educational performance variable, the direct effect of ICTE appropriation on educational performance is always significant and positive (beta=0.289, t=2.829, p=0.005). As for the indirect effect of ICTE appropriation on educational performance through individual performance, it is both significant and positive (beta=0.381, t=5.027, p=0.000).

Based on these findings, we have found support for the hypothesis proposing the presence of a mediating effect of individual performance in the connection between ICTE adoption and educational performance. However, it is important to note that this mediation effect is partial rather than complete. This distinction becomes even clearer upon closer examination of the data.

Indeed, the results confirm the presence of partial mediation, as illustrated in the previous analysis (Figure 2). Even with the inclusion of the mediating variable, the direct relationship between ICT appropriation and educational performance remains significant. This indicates that the mediation

through individual performance does not entirely absorb the effect of ICT appropriation. This observation aligns with the concept of partial mediation described by Baron and Kenny (1986), as well as by Zhao, Lynch, and Chen (2011), where both direct and indirect effects simultaneously contribute to explaining the variance in educational performance. While individual performance plays a key role in the process, ICT appropriation still exerts a distinct and independent influence on educational performance. Thus, the observed mediation effect does not completely eliminate the direct impact, but rather reinforces the importance of individual performance as an intermediary in this relationship.

Table 5: Total and indirect effects

	Total effect		Direct effect	
	beta	P values	beta	P values
Approp_TICE -> Perf_educ	0,669	0,000	0,289	0,005

(Source: Smart PLS 4.0)

Table 6: Direct effect

	beta	moyenne	Ecart type	T statistics (|O/STDEV|)	P value
Approp_TICE -> Perf_individ -> Perf_educ	0,381	0,381	0,076	5,027	0,000

Source: (Smart PLS 4.0)

Figure 3: Results
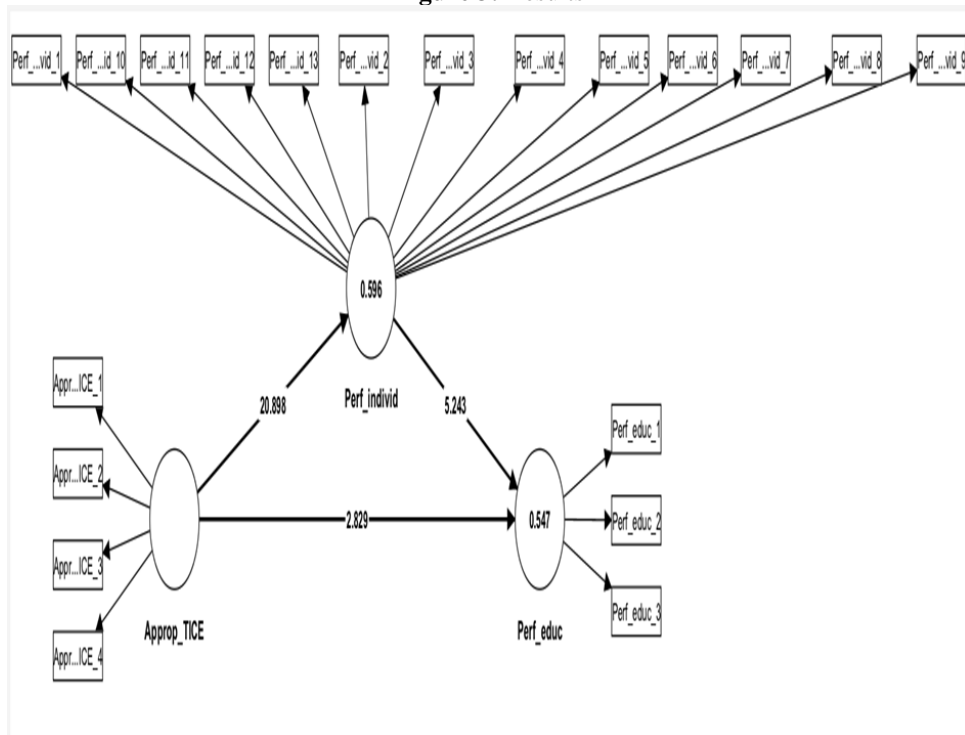
R² (individual performance) =0,596 ; R² (educational performance) =0,547
Source: (Smart PLS 4.0)

Discussion

This study is part of the ongoing debate on the impact of Information and Communication Technologies in Education (ICTE) on educational performance. It aims to shed light on the mediating role of individual performance in the relationship between ICT appropriation and educational performance. The results obtained demonstrate that students' individual performance is a key factor in improving educational performance, acting as a significant mediator between ICT appropriation and academic outcomes.

The contributions of this research are twofold: Firstly, it validates the measurement tools for ICT appropriation proposed by Pelletier et al. (2008), the educational performance tools proposed by Charlot et al. (1992), and the individual performance tools proposed by Koopmans et al. (2011) by assessing their explanatory capacities. Secondly, it validates the measurement tools that integrate individual performance to explain the nature of the impact of ICT appropriation on educational performance. The results demonstrate the validity and convergence of the models adopted in this research.

After analyzing the reliability and validity of various measurement scales, we eliminated five items deemed non-explanatory due to statistical results that did not meet the required threshold of 0.5. We confirm the validation of the research model. Respectively, the ICT appropriation by Pelletier et al. (2008), the educational performance by Charlot et al. (1992), and the individual performance by Koopmans et al. (2011) apply to students in public higher education in the Casablanca-Settat region.

The second objective of this study was to identify the role that individual performance plays in the relationship between ICT appropriation and individual performance. The results indicate that individual performance represents a mediating variable between ICT appropriation and educational performance. The results revealed, on the one hand, a significant and positive relationship between ICT appropriation and educational performance (beta=0.289, t=2.829, p=0.005). On the other hand, a significant and positive relationship was confirmed between ICT appropriation and educational performance (beta=0.381, t=5.027, p=0.000). This leads us to conclude that students' appropriation of ICTE largely explains the educational performance of public higher education institutions in the Casablanca-Settat region. Additionally, these students' performance in using ICT contributes to improving educational performance in the academic environment.

Indeed, the results of this study confirm that ICT appropriation promotes interactivity and student engagement, which has a positive impact on their educational performance, as noted by Barragán and Báquiro (2020), Burnett & Lisk (2021), and Hamzi et al. (2024). The increased engagement of students in using ICT also appears to foster the development of essential skills for their academic success, as supported by Kabore (2021) and Shé et al.

(2023). In this context, individual performance emerges as a key factor in maximizing the benefits of ICT appropriation.

Recent studies have demonstrated the importance of individual performance in achieving higher levels of educational performance related to the use of ICT, as noted by Saint-Onge & Magnan (2007), Frese & Sonnentag (2002), Abdel-Ouahed (2014), and Cabellos et al. (2024). Individual performance enables the full potential of ICT to be harnessed by facilitating the adoption of more effective learning strategies and fostering a deeper understanding of the subjects studied, according to Turienzo (2024).

The testing of the sub-hypotheses confirms that ICTE appropriation significantly and positively impacts individual performance, supporting sub-hypothesis (H1.1), and that individual performance significantly and positively impacts educational performance, supporting sub-hypothesis (H1.2). This summary is consistent with previous studies, particularly the findings of Vithal (2013), Basri et al. (2018), and Rahmi et al. (2023), which assert that the use and adoption of ICT for teaching and learning purposes improve students' academic performance. Barragán & Báquiro (2020) highlight that ICT appropriation is essential for pedagogical innovation and skill development among users. Boufarouj & Mdarbi (2022) also suggest that ICT appropriation enables users to maximize their knowledge. Therefore, we can conclude that individual performance mediates the relationship between students' ICT appropriation and educational performance (H1 confirmed).

The second hypothesis (H2) regarding the significant and positive effect of ICT appropriation on educational performance has been confirmed. Referring to the literature, Ben Youssef and Dahmani (2010) and Cosculluela et al. (2024) state that ICT appears to have a profound impact on the learning process in higher education by offering new opportunities to learners. Other authors, such as Ko et al. (2021) and Rad et al. (2024), affirm that the quality of platforms, task performance, and the feeling of self-determination have been shown to positively influence ICT appropriation, and consequently, significantly impact the performance of actors.

The literature on the impact of ICT on student performance is divided. On one hand, some studies show benefits such as greater autonomy in school tasks Silva et al. (2024), increased awareness of their program's updates Xu et al. (2024), and improved problem-solving skills in real-world scenarios Chen et al. (2024). ICT use is associated with better performance in subjects like science and mathematics Sun et al. (2022) compared to other disciplines such as humanities and social sciences Alieto et al. (2024). On the other hand, some research suggests a limited or negative impact of ICT on performance Kirkpatrick & Cuban (1998), Angrist & Lavy (2002), while others highlight negative consequences associated with its use Ioannou et al. (2024), especially when focused on entertainment Silva et al. (2024) Asad et al. (2023)

emphasize that the impact depends more on the quality rather than the intensity of ICT usage.

The factors influencing students' use of ICT are still underexplored, as noted by Silva et al. (2024). Some studies focus on sociodemographic factors, such as gender and family structure, Owan & Asuquo (2021). Others examine how these factors influence ICT adoption by teachers, Stumbrienė et al. (2024).

For a comprehensive overview of our study's findings, please refer to the table below:

Table 7: Summary of Results Achieved

Main and sub-hypotheses	Final Decision
H1 : Individual student performance mediates the relationship between ICT appropriation and educational performance	**Approved**
H1.1 : ICT appropriation significantly and positively impacts individual student performance	**Approved**
H1.2 : Individual student performance has a significant and positive impact on educational performance	**Approved**
H2 : Students' appropriation of ICT has a significant and positive impact on educational performance	**Approved**

Source: (Authors)

Conclusion

In this article, we have synthesized key findings from the literature review of theoretical and empirical studies on the ICT usage, ICT appropriation, educational performance, as well as the individual performance of university students. ICT has shown a significant impact on the learning process in higher education, providing new opportunities to learners and positively influencing their achievements and performance, Daouk & Aldalaien (2019), Zeng et al. (2020). Our findings affirm the presence of a direct relationship between ICT appropriation and educational performance, as well as an indirect relationship mediated by individual performance.

Recent literature has increasingly explored the link between ICT usage and student performance, specifically emphasizing the impact of online pedagogical activities, Rivero et al. (2017), Kuhfeld et al. (2020). Although some historical studies, Kirkpatrick & Cuban (1998), Angrist & Lavy (2002), minimized the impact of ICT on higher education, more recent research, Xiao & Hu (2019), Srijamdee & Pholphirul (2020), supports the idea of a significant impact on student performance. Notably, ICT appears to foster the development of skills such as collaboration and critical thinking, which are essential in an increasingly digitalized labor market, Hetmańczyk, (2024).

However, this study has its limitations. The results may be influenced by response bias, and the sample being restricted to the Casablanca-Settat region limits the ability to generalize findings to other contexts, Biagi & Loi

(2013), Zhai et al. (2019). Future research should further explore the factors that influence ICT appropriation and their effect on student performance, Silva et al. (2024). It is crucial to recognize that the individual remains central to measuring educational performance. The adoption of organizational innovations in higher education is a key factor in student success. The appropriation of ICTE contributes to the acquisition of skills relevant to today's professional landscape, by promoting autonomy, collaboration, and better adaptability to labor market demands, O'Brien et al. (2022), Hamzi et al. (2024), Stumbrienė et al. (2024).

Future research should therefore focus on a comprehensive analysis of individual performance among university students, particularly within the Moroccan context, to better understand its influence on overall educational performance. Such investigations could offer avenues for enhancing the higher education system, by more closely aligning learning methods with the real needs of students and market demands.

Authors' contributions

All the researchers namely—S. Mdarbi, L. Simour, C. Boufarouj, Z. Belkebir, K. Stili, M. Ennadi— contributed to conceptualizing the study, writing and revising the manuscript. L. Simour translated the article from French into English and revised the manuscript. C. Boufarouj, Z. Belkebir, K. Stili, M. Ennadi developed the questionnaire, collected the data, and carried out the data analysis. S. Mdarbi provided mentorship throughout the entire process.

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Data Availability: All data are included in the content of the paper.

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