INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN BUSINESS & SOCIAL SCIENCES

Vol 15, Issue 5, (2025) E-ISSN: 2222-6990

Mapping the Use of Ubiquitous Technology among Engineering Undergraduates: A Confirmatory Factor Analysis Perspective

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To Link this Article: http://dx.doi.org/10.6007/IJARBSS/v15-i5/25581 DOI:10.6007/IJARBSS/v15-i5/25581

Published Date: 30 May 2025

Abstract

Ubiquitous technologies—such as laptops, smartphones, and tablets—are commonly utilized by undergraduates in institutions of higher learning. However, limited research has been conducted to comprehensively examine the factors influencing their usage. A review of existing literature suggests that several key factors—namely, performance expectancy, effort expectancy, behavioural intention, facilitating conditions, and social status—play a significant role in determining technology adoption. Accordingly, this study aims to identify the factors contributing to the use of ubiquitous technologies among engineering undergraduates within the Malaysian Technical Universities Network (MTUN). Adopting a quantitative research design, data were analysed using Structural Equation Modelling (SEM) with AMOS. The study targeted third-year engineering students from four Malaysian Technical Universities (N = 4,247). A structured questionnaire was used as the research instrument, with 493 copies distributed and 400 valid responses collected for analysis. Findings from the Confirmatory Factor Analysis (CFA) validated four items each for the following constructs: performance expectancy (PE1, PE2, PE4, PE5), effort expectancy (EE1, EE2, EE3, EE4), social status (SS1, SS2, SS3, SS4), facilitating conditions (FC1, FC2, FC3, FC4), and behavioural intention (BI1, BI2, BI3, BI4).

Keywords: Ubiquitous Technology, Engineering Undergraduates, Confirmatory Factor Analysis, Unified Theory of Acceptance and Use of Technology

Introduction

In the 21st century, the rapid advancement of technology has fundamentally reshaped how undergraduate students perceive their learning environments. These digital-native learners expect an academic setting that mirrors their hyperconnected world—one that enables

learning anytime, anywhere, through ubiquitous technologies such as laptops, smartphones, and tablets (McHaney, 2023). These technologies are no longer luxuries; they are vital educational tools that support mobile, flexible, and self-paced learning while offering instant access to information and immediate feedback.

Despite their prevalence, the meaningful integration and utilisation of ubiquitous technologies in higher education remain inconsistent. This presents a critical gap, especially in engineering education, where such tools could significantly enhance both academic performance and professional readiness. Within this context, the Malaysian Technical University Network (MTUN) plays a pivotal role in preparing technically skilled graduates. However, limited research has been conducted to examine the specific factors influencing the effective use of these technologies among MTUN students.

This study is essential because it addresses a pressing need to understand not just whether students use these technologies, but why and how they engage with them. A deeper insight into these patterns is crucial for designing student-centered policies and learning environments that are equitable, inclusive, and aligned with national education goals. By investigating factors such as performance expectancy, effort expectancy, behavioural intention, facilitating conditions, and social status—rooted in the Unified Theory of Acceptance and Use of Technology (UTAUT)—this research offers a validated framework to enhance digital engagement among engineering students.

The significance of this study lies in its practical and theoretical contributions. Practically, it provides valuable insights for educators, curriculum designers, and policymakers to improve technology-driven learning strategies. Theoretically, it extends the UTAUT model and offers empirical evidence that can inform future research in the fields of educational technology, student engagement, and engineering education. Ultimately, this study benefits not only students but also institutions aiming to foster digital competencies and future-ready graduates.

The Role of Malaysian Technical University Network (MTUN)

In support of the national agenda to increase the number of technically skilled graduates, Phase 2 of the Malaysian Action Plan places significant emphasis on strengthening engineering and Technical and Vocational Education and Training (TVET). Within this initiative, the Malaysian Technical University Network (MTUN) plays a pivotal role. Comprising Universiti Teknikal Malaysia Melaka (UTeM), Universiti Tun Hussein Onn Malaysia (UTHM), Universiti Malaysia Pahang (UMP), and Universiti Malaysia Perlis (UniMAP), MTUN is committed to enhancing engineering and technical education.

These universities emphasize experiential and student-centred learning, supported by access to advanced tools such as ubiquitous technologies (Sedek, Mahmud, Jalil & Daud, 2015). Their programs are specifically designed to equip students with the technological skills and industry readiness required in the current global landscape.

Factors Influencing Ubiquitous Technology Utilisation

The effective use of technology by students is influenced not only by the hardware and software available but also by several other key factors that encourage continuous

engagement. Drawing from the Unified Theory of Acceptance and Use of Technology (UTAUT), five critical factors have been identified: performance expectancy, effort expectancy, behavioural intention, facilitating conditions, and social status (Venkatesh, 2022).

Performance Expectancy

Performance expectancy refers to the degree to which learners believe that using technology will enhance their academic performance. Research consistently highlights performance expectancy as the strongest predictor of technology acceptance within the UTAUT framework. For example, a study revealed that students' usage of tablets in higher education was significantly influenced by their expectations of improved learning outcomes (Venkatesh, Davis & Zhu, 2023). In Malaysia, the use of educational computer games (ECGs) on laptops was also perceived as effective due to their engaging and interactive features. Students found these tools beneficial, stating that ECGs enhanced their performance and made learning more enjoyable. Another study reported that performance expectancy significantly influenced students' adoption of newly developed software for subjects like Computer Graphics and Image Processing.

Effort Expectancy

Effort expectancy pertains to students' perception of how easy it is to use a given technology. Technologies that are perceived as user-friendly tend to have higher adoption rates. For instance, a study found that engineering students viewed tablets as efficient learning tools due to their ease of use. The minimal effort required to operate and understand these devices encouraged students to use them not just for learning, but also for communication and entertainment. Engineering and technical students are increasingly expanding their use of ubiquitous technology beyond classroom applications to support research-related tasks. For instance, these tools are widely used to capture categorical data, facilitate data analysis, and fill out digital forms designed for categorical inputs. A study also found that perceived ease of use—or effort expectancy—significantly affected the utilisation of newly developed software, particularly in subjects like Computer Graphics and Image Processing. In this context, effort expectancy recorded the second highest mean value after performance expectancy, highlighting its importance in influencing technology adoption.

Social Status

With ongoing modernisation and rapid technological advancement, students' learning behaviours and preferences have shifted notably. Social status refers to the degree to which an individual perceives that important others believe they should use a particular technology. Research suggests that social status has a strong impact in environments where technology usage is encouraged or mandated, especially during the initial stages of adoption. Its influence, however, may diminish over time (Rizqi, Budiman & Reza, 2023).

A study revealed that students who owned the latest technology perceived themselves as more capable of completing academic tasks and accessing information online, thereby increasing their motivation to use technology (Basar, Mansor, Jamaludin & Alias, 2021). Furthermore, smartphones and other digital tools often act as status symbols in higher education contexts. A study at Harvard University indicated that students frequently selected devices that mirrored those used by their lecturers, peers, and family—driven by the desire

to emulate respected individuals or to fit in socially [33]. This trend points to the dual function of technology as both a learning tool and a social asset. Students reportedly enjoyed showcasing their devices as it boosted their self-image and made them feel modern and relevant. They also noted that the recognition and respect received from peers and lecturers further motivated their continued use of such technologies.

Facilitating Conditions

Facilitating conditions refer to students' perceptions of the organisational and technical infrastructure that supports their use of ubiquitous technology. These conditions encompass various forms of institutional support. Lecturers and university administrators, for example, serve as change agents who promote and support effective technology usage among undergraduates. Additionally, access to responsive and reliable technical support—such as helpdesks and ICT services—plays a crucial role in assisting users when technical issues arise. This infrastructure not only enables technology use but also enhances students' satisfaction and confidence in using digital tools.

Behavioural Intention

Behavioural intention is a key mediating factor in the relationship between technological factors and actual usage. It reflects a student's willingness or plan to engage with a given technology. Research has shown that performance expectancy significantly influences behavioural intention, which in turn positively impacts the actual utilisation of technology (Sedek & Mohd, 2025).

In relation to effort expectancy, behavioural intention also serves as a mediating factor. For example, when students perceive technology (like tablets) as easy to use, they are more likely to form strong behavioural intentions to continue using it. Another study examining e-placement test adoption found that social status positively influenced behavioural intention, which subsequently led to higher levels of technology engagement. Students were motivated by the expectations and behaviours of their lecturers, peers, and family members, which played a critical role in shaping their intention to use educational technologies (Sedek, Amran, Kadir, Omar & Ahmad, 2025). This confirms the mediating role of behavioural intention in translating perceived social expectations into meaningful technology usage.

Statement of the Problem

Although various studies in Malaysia have examined the factors influencing technology usage among undergraduates, the majority have focused on general digital tools, learning management systems (LMS), or subject-specific software. These studies typically highlight constructs such as perceived ease of use, usefulness, motivation, and the learning environment as influential. However, despite the increasing presence of ubiquitous technologies—such as laptops, smartphones, and tablets—in higher education, limited research has been conducted specifically on their utilisation.

Within the Malaysian Technical University Network (MTUN), existing studies have primarily examined LMS and software adoption. Notably, issues such as unattractive interfaces have negatively impacted students' continued use of LMS platforms (Zhou, Zhang, Jiang & Freeh, 2011), while the perceived difficulty of educational software—such as those used for Calculus—has discouraged engagement due to the cognitive load required for understanding

complex systems. Therefore, a comprehensive investigation into the key factors contributing to the use of ubiquitous technologies within MTUN is timely and necessary. Drawing on the Unified Theory of Acceptance and Use of Technology (UTAUT), this study aims to validate five core factors: performance expectancy, effort expectancy, behavioural intention, facilitating conditions, and social status.

Objective of the Study

The primary objective of this study is to validate the factors influencing the use of ubiquitous technology—namely laptops, smartphones, and tablets—among engineering undergraduates within the Malaysian Technical University Network (MTUN).

Materials and Methods

A quantitative research design employing a survey method was used for this study. The target population comprised third-year engineering undergraduates from four MTUN institutions. Raosoft® software was used to determine the appropriate sample size, and proportional stratified random sampling was applied to ensure representation across the institutions.
A structured questionnaire was designed and distributed, comprising four sections:

- Section A: Demographic information
- Section B: Technology utilisation patterns
- Section C: Factors influencing technology usage (used in this analysis)
- Section D: Open-ended feedback (not discussed in this paper)

A five-point Likert scale was used in Section C, ranging from (1) Strongly Disagree to (5) Strongly Agree. The instrument was validated by four experts in educational technology and pedagogy. Out of 493 distributed questionnaires, 420 were returned. After data screening, 20 responses were excluded due to incompleteness or errors, resulting in 400 valid responses.

The internal consistency of the instrument was tested using reliability analysis, with Cronbach's alpha values ranging from 0.82 to 0.90, indicating a high level of reliability.

Structural Equation Modeling (SEM)

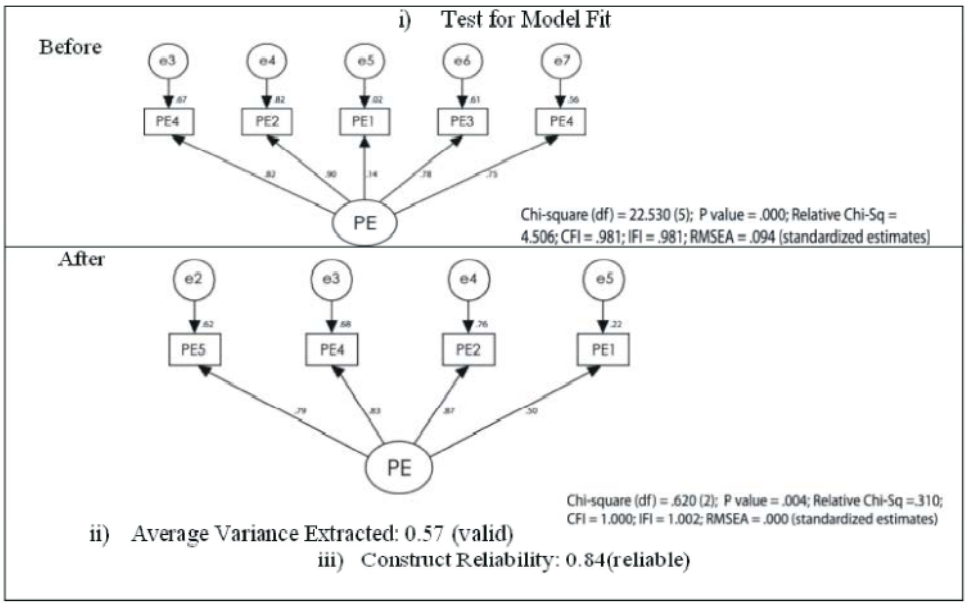
To analyse the relationships among the identified factors, **Structural Equation Modeling (SEM)** was employed using AMOS Version 20.0. SEM is a robust multivariate statistical technique that integrates several analytical components, including **Confirmatory Factor Analysis (CFA)** to validate the measurement model, as well as **measurement model analysis** to evaluate construct reliability and convergent validity. It also includes **structural model analysis** to examine the interrelationships among latent variables. SEM is particularly well-suited for this study due to its capacity to estimate multiple and interrelated dependency relationships simultaneously, incorporate observed variables to define constructs in detail, and assess overall model fit, thereby allowing for the effective testing and validation of theoretical frameworks.

Overview

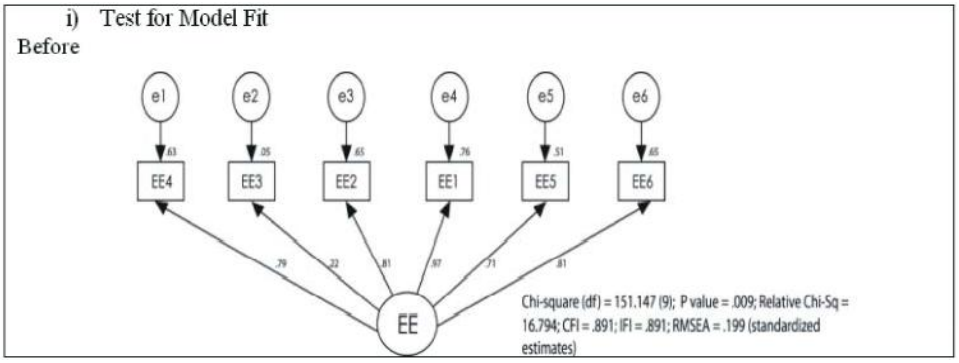
As this study aimed to construct a predictive model for ubiquitous technology utilisation, the R^2 values for each latent construct and the path coefficients between variables were taken

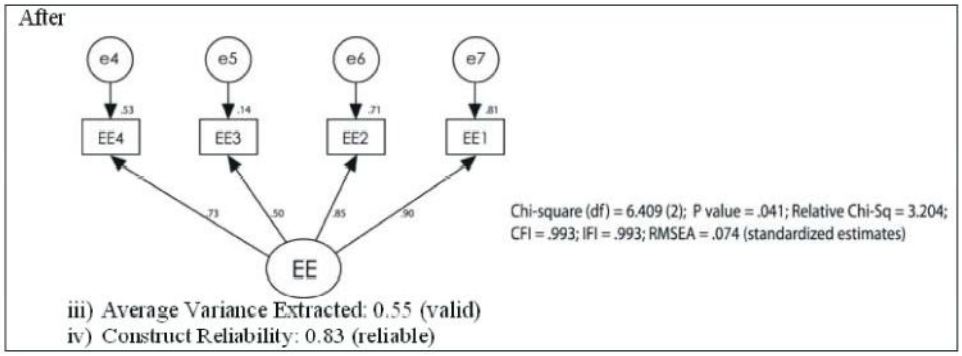
into account in the analysis. The use of CFA enabled the validation of the measurement model, confirming the relationships among the identified constructs.

Confirmatory Factor Analysis (CFA) was conducted as the initial step in data preparation prior to performing Structural Equation Modeling (SEM). The primary purpose of the CFA in this study was to define the individual constructs and evaluate the model in terms of three key criteria: (1) model fit, (2) convergent validity, and (3) construct reliability [46, 48, 49, 50]. To assess model fit, two indicators were examined: the fit indices and the factor loadings of individual items within each construct. The fit indices were evaluated based on established threshold values: Relative Chi-Square (CMIN/DF) < 5.0, Comparative Fit Index (CFI) ≥ 0.90, Root Mean Square Error of Approximation (RMSEA) ≤ 0.08, and factor loadings ≥ 0.50. Following the CFA, some items were removed to improve the model, resulting in a refined set of items for each construct. The validated items included four for **performance expectancy** (renumbered as PE1–PE4), four for **effort expectancy** (EE1–EE4), four for **social status** (SS1–SS4), four for **facilitating conditions** (FC1–FC4), and four for **behavioural intention** (BI1–BI4). These confirmed items were then used for further analysis in the SEM model. Below are the CFA analysis for each constructs.Performance Expectancy

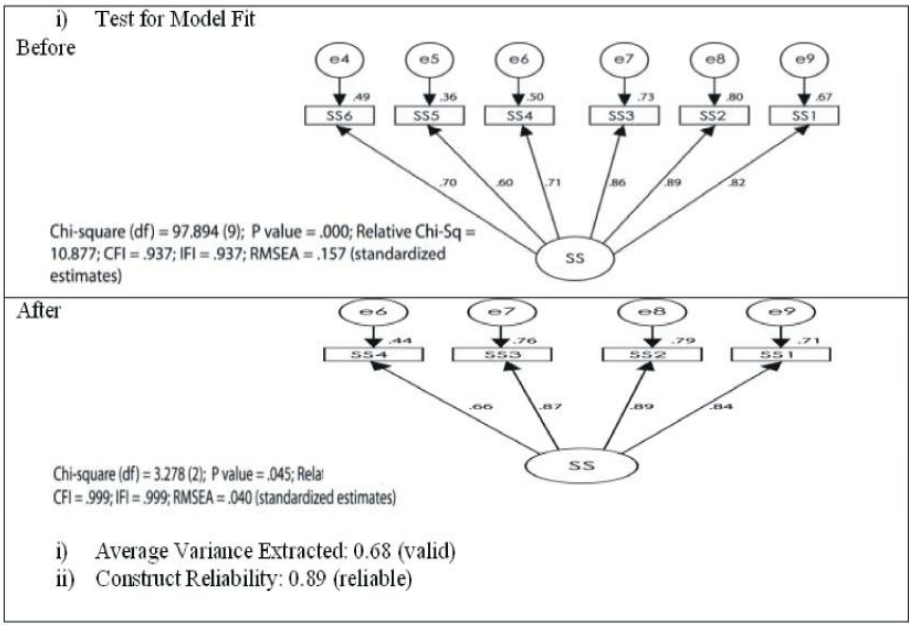


Effort Expectancy

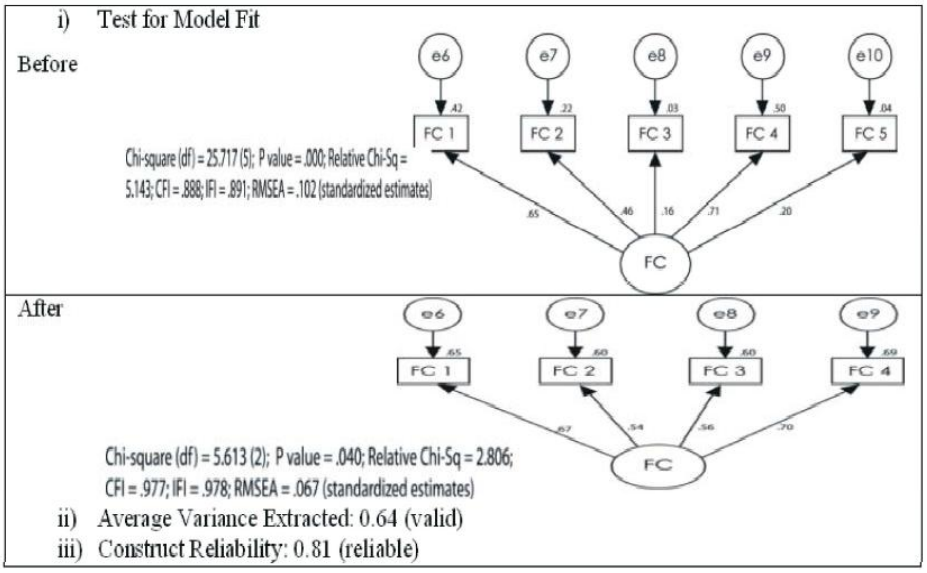




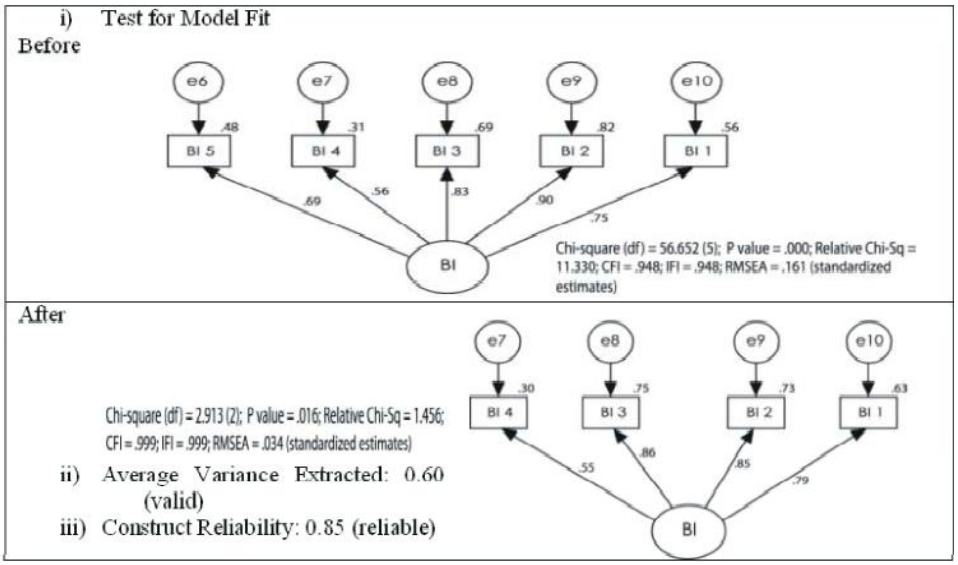
Social Status



Facilitating Conditions



Behavioural Intention



Implications and Recommendations

Theoretical Implications

This study reinforces the applicability of the Unified Theory of Acceptance and Use of Technology (UTAUT) as a foundational framework for understanding the variables that influence ubiquitous technology utilisation in higher education. Specifically, the study supports the theory's relevance within the context of Malaysian Technical University Network (MTUN) institutions. Furthermore, the model is extended through the inclusion of technology competency, a construct adapted from the Technology Acceptance Model (TAM), thus broadening the theoretical understanding of student engagement with ubiquitous technologies.

The proposed predictive model has provided a more comprehensive perspective on how MTUN undergraduates interact with ubiquitous technologies, particularly in relation to performance expectancy, effort expectancy, behavioural intention, facilitating conditions, social status, and their own technological competencies. This work contributes to bridging existing gaps in the literature by providing empirical evidence that supports a validated framework for predicting the effective use of ubiquitous technology among engineering students in Malaysian higher learning institutions.

Practical Implications

The findings of this study have important practical implications for university administrators, policymakers, and educators. It highlights the need for strategic planning and investment in technology initiatives, particularly in the provision of mobile and ubiquitous learning environments. University management, especially within MTUN, should allocate continuous support through resources such as up-to-date educational tools, structured training sessions, and readily available technical support to foster a technology-enriched learning experience.
Additionally, the insights gained offer guidance to curriculum planners and decision-makers to integrate ubiquitous technology more intentionally into teaching and learning practices. Recognising that the factors influencing technology usage manifest differently based on individual and environmental conditions, institutions must adopt flexible strategies that accommodate diverse learner needs. This study can serve as a catalyst for developing a

shared institutional vision focused on optimising the use of ubiquitous technologies to support 21st-century education goals.

Recommendations for Future Research

Given the limitations of this study—most notably its reliance on a quantitative, self-reported survey approach—future research should consider employing qualitative methods such as interviews, classroom observations, and focus groups to explore deeper insights into students' experiences and perceptions. Mixed-method studies could enrich the understanding of the contextual and behavioural dynamics of technology adoption.

It is also recommended that future research explore the relationship between ubiquitous technology utilisation and students' academic performance, such as GPA or standardized test results, through experimental designs (e.g., pre-test/post-test). Furthermore, while this study focused on engineering and technical undergraduates, future investigations should extend to students from diverse academic disciplines to determine how subject-specific needs influence the patterns and effectiveness of ubiquitous technology usage. Such comparisons may yield significant findings that contribute to a more tailored and inclusive integration of technology in higher education.

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