Proc. of the 8th International Conference on Engineering and Emerging Technologies (ICEET) 27-28 October 2022, Kuala Lumpur, Malaysia

A Hybridized Framework for Designing and Evaluating E-Learning Students' Performance in Medical Education

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2022 International Conference on Engineering and Emerging Technologies (ICEET) | 978-1-6654-9106-8/22/$31.00 ©2022 IEEE | DOI: 10.1109/ICEET56468.2022.10007231

***Abstract*—The COVID-19 pandemic resulted in the hurried adoption of e-learning with no proper need analysis to inform the design and subsequent evaluation of students' performance in e-learning in medical education. Consequently, several studies evaluating performance in e-learning in medical education do so by conducting pre-test and post-test with no defined framework or model to guide the evaluation. This makes the findings from these studies subjective and biased since factors that possibly impact students' performance were neither considered in the design of the course nor measured and reported in the evaluation studies. We, therefore, introduce an essential pedagogical e-learning concept by developing a framework to inform the design and evaluation of students' performance in e-learning in medical education via the thoughtful fusion of the Task-Technology Fit Model and the Kirkpatrick Evaluation Model. Our hybrid framework was piloted at the University of KwaZulu-Natal, Durban, South Africa and findings emphasize the need for alignment between learning tasks, technology infrastructures, individual traits, and contextual limitations of students as key factors in determining how well students perform in the classroom and their clinical practices at work. This study advances the body of knowledge by providing a well-brainstormed and intricately designed framework to guide the design of courses and evaluation of student's performance in an e-learning context in medical education.**

Keywords— e-learning, individual performance, Kirkpatrick evaluation model, medical education, organizational performance, task-technology fit model.

I. INTRODUCTION

The dissemination of educational content using digital devices like computers, laptops, tablets, or smartphones has become a reality by leveraging internet technologies [1]. The internet has many tools for enhancing learning and performance [2]. E-learning facilitates learning in medical education by ensuring that Health Care Professionals (HCP) acquire knowledge, skills, and attitude relevant for optimal performance and professional development [3] without necessarily taking them out of their work environment [4]. In particular, Learning management systems (LMS) have features including online collaboration, distributing learning materials, and training and has grown in popularity and usage in higher education to manage, support, and improve teaching-learning processes [5] in traditional, multimodal, and online contexts.

E-learning is appraised for encouraging individualized learning [6], independent and insightful thinking [7], efficient transfer of knowledge from course content to practice [8], and flexible self-paced learning [9]. According to studies comparing the two, e-learning is equally effective as traditional face-to-face learning in a variety of subjects at both the undergraduate and graduate levels [9-11]. In contrast, some argue that e-learning provides better learning outcomes than traditional teaching methods [12]. Despite the acclaimed benefits of e-learning, it is crucial to understand that the adoption of e-learning may present several obstacles that could prevent learning. These include the isolation of students, instructors' incapacity to explain tasks and concepts in detail when compared to traditional techniques, the absence of assessment quality assurance and the negative social-emotional effects on students, inability to support hands-on learning in fields such as engineering and medical education [13-17].

There isn't a single invention in software development that would lead to an order-of-magnitude gain in productivity, according to Fred Brooks' original paper, No Silver Bullet. [18]. In this context, e-learning should not be considered a magical silver bullet that can be fired at e-learning in medical education to increase students' performance. Therefore, before implementing e-learning in medical education, a well-thought-out plan should be created. Need assessment, which forms the requirements for the e-learning system and dictates its subsequent use cases [19], is pivotal. A thorough requirement analysis, as well as procedure and result evaluation of a program, ensures the best possible student success in e-learning interventions.

There is an urgent need for designing and analyzing e-learning in medical education while maintaining a laser-like focus on student performance given the broad adoption of e-learning in medical education as a result of COVID-19. Few studies have looked at performance-based outcomes of e-learning in medical education, although many have evaluated its acceptance and use. Therefore, by combining a model for evaluating the fit of technology for particular activities, individuals, and settings with another well-known model for performance evaluation, this study gives a framework for developing and evaluating student performance in e-learning in medical education. Combining these two models reveals the ambiguities in how to assess students' success in online medical education.

II. RELATED WORKS

Performance is the capacity of an individual to accomplish predetermined objectives and produce outcomes with a restricted amount of resources [20]. We refer to this as "technical wizardry" since it appears that designing and evaluating e-learning interventions is fully or largely focused on the technology and the task requirements for which the technology was selected. However, other factors may influence students' performance at individual and organizational levels. Hence, we present a framework derived through the strategic fusion of two existing theories; the Task-Technology Fit model [21] and the Kirkpatrick evaluation model [22, 23]. Our framework hypothesizes that the requirements of a learning task, the technology provided to assist in completing the task requirements, the student's abilities, and their contextual factors will determine their performance in the e-learning program and work organization.

A. *Task-Technology Fit Model*

Task-technology fit refers to the degree to which technology offers functionalities and features that match or appropriately align with the requirements of people, thereby assisting them in carrying out their duties [24]. According to the task-technology fit model in Figure 1, for technology to be effective, it must be easily adopted and perfectly matched with the users and the tasks they carry out. Adopting technology that is appropriate for the task at hand improves performance at the individual and organizational levels. The compatibility of the task with the technology is a crucial element that influences students' ongoing happiness with online learning. [25].

Tariq and Akter in [26] outlined seven variables that affect how community health care professionals (HCPs) perceive task-technology fit in the context of mobile health. These variables include "the task characteristics, individual characteristics, technological characteristics, contextual characteristics, perceived task technology fit, utilization, and performance of community HCPs". Although we will not consider the Utilization construct because we envisage that this model will be used for designing and evaluating fully online programs without any option of traditional or blended approaches, we decompose the Performance construct using Kirkpatrick Evaluation Model.

Even though Tariq and Akter in [26] used the task-technology fit framework from the mobile-health perspective, the factors identified could be adopted and adapted for the broader e-learning context. Table 1. shows our operational definition of the constructs of the Task-Technology fit framework

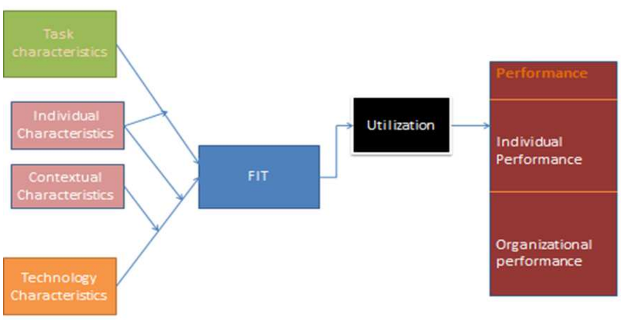

Figure.1: Task-Technology Fit Model [26, 27]

Table 1: Operational Definition Of Task-Technology Fit Constructs [21]

Concept	Definition
Task Characteristics	The series of actions taken by students, as instructed by the lecturers, to ensure that pre-determined learning objectives are accomplished.
Technology Characteristics	The features of the entire tools, e-learning applications, facilitating infrastructure, and services that help students execute their learning tasks.
Individual Characteristics	Students' abilities, proficiencies, or competencies that impact how well they use the provided e-learning technologies to execute their learning tasks.
Contextual Characteristics	The cultural and social circumstances that impact students' perceptions of the suitability of e-learning.
Performance/ Task-Technology Fit	Results of the alignment between students' task requirements, individual abilities, contextual factors, and the functionalities of the available e-learning technologies.

The Task Technology Fit framework would not suffice as a lone e-learning performance evaluation framework in medical education due to its perceived inadequacies. Dishaw and Strong in [28] critiqued the task-Technology Fit model for being generic and not addressing any specific task or technology. However, we suggest a thorough analysis needs be conducted to understand what tasks are required to be carried out so that learning is achieved for any medical education program. Afterward, we recommend assessing the technology infrastructures required to facilitate and support learning tasks. An 'as-is' versus 'to-be' technology mapping correlates existing technology infrastructures to the required technological infrastructure to determine which system, application, or devices need to be procured to make a success of e-learning programs.

Judith and Mark in [29] further critiqued the Task-Technology Fit model as providing little direction on defining and operationalizing Task-Technology Fit. Therefore, to mitigate this limitation, we operationalize Task-Technology Fit using the Kirkpatrick evaluation model, which offers measurable constructs to evaluate students' when participating in an e-learning course. We suggest that the Task-Technology Fit model be adopted and modified according to the particular task for which it is needed.

B. *The Kirkpatrick Evaluation Model*

The Kirkpatrick evaluation model depicted in Figure 2 includes four levels of evaluations of the outcomes of e-learning which include reaction, learning, behavior, and result. The Kirkpatrick Evaluation stipulates that the effectiveness of training can be evaluated via four constructs.

These are students' reactions to the program, their learning of knowledge, skills, and attitudes acquired from the course, their transfer of knowledge, skills, and attitude gained from the course to practices in the workplace, and the measurable impacts of the transferred knowledge, skills, and attitudes in their workplace. Notably, these constructs are applicable generically to evaluate any training. However, in an e-learning context, the constructs do not embrace the technological dynamics of e-learning and the impact of technology on students' performance.

Hence, the fusion of the Kirkpatrick evaluation model into the Task-Technology fit model yields a symbiotic relationship where one model makes up for the shortcoming of the other.

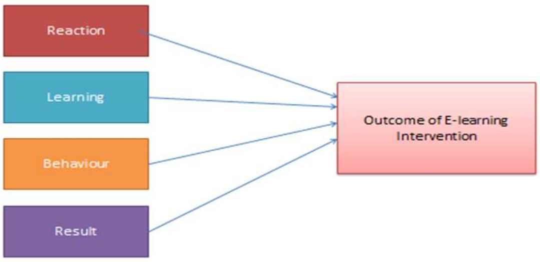

Figure 2: Kirkpatrick Evaluation Model [22, 23]

Reaction and learning, the first two constructs in Figure 2, are used to operationalize students' individual performance because these constructs evaluate the impact of the course directly on students. While behavior and result; the last two constructs evaluate the impact of the course on external parties; specifically in organizations where students work. Hence, we use the last two constructs to evaluate organizational performance. Since its first publication, Kirkpatrick's four-level evaluation framework has seen extensive use and has quickly established itself as a standard method for assessing training programs. We employ Lahti's operational description of the four Kirkpatrick Evaluation Model constructs. [30], as shown in Table 2.

Table 2: Definition Of Kirkpatrick Evaluation Model Constructs [30]

Levels	Construct	Definition
1	**Result**	Student's Satisfaction with and Utility judgment of an e-learning course.
2	**Learning**	Enhanced knowledge and skills because of students' participation in an e-learning course.
3	**Behavior**	Knowledge transfer from course to daily practice from students' point of view
4	**Result**	Impact of an e-learning course on students' Work Organization.

The Kirkpatrick evaluation Model has also been critiqued in the literature. Sufflebeam [31] did not mention Kirkpatrick in his evaluation and narrative of 22 program evaluation methods, even though the Kirkpatrick model has been extensively employed in training program evaluation. Criticisms of the Kirkpatrick model also draw attention to the fact that, although not meeting the standard criteria for a model, the Kirkpatrick framework is frequently referred to as a model. Holton in [32] expressed a similar viewpoint and put up a fresh model that complied with the model requirements. The Kirkpatrick evaluation model for training evaluation is still useful and appropriate for many contexts even after sixty years since its inception and research using the model continues to be an actively growing area[33]. Oluwadele [34] and Ajenifuja and Adeliyi [35] opined that combining the Task Technology Fit Framework with the Kirkpatrick Model will make up for the shortcoming of both models. Hence, because the Kirkpatrick model's elements may be used to assess the process and outcome of e-learning in medical education, this study operationalizes the performance construct of the Task-Technology Fit framework using the Kirkpatrick evaluation model.

III. Materials and Methods

A. Methods: The Hybridized Framework for Designing and Evaluating E-learning in Medical Education

Our hybridized framework fuses the constructs of the two models by employing the Task-Technology Fit Model to explore the technological dynamics flaws of the Kirkpatrick evaluation model and the Kirkpatrick evaluation model to operationalize the performance construct of Task-Technology Fit. The Task-Technology Fit model's function is to show technological circumstances that might have an impact on the course design and evaluation. The Kirkpatrick model's function is to provide quantifiable dimensions that identify the individual (process) and organizational (outcome) performance of e-learning courses in medical education.

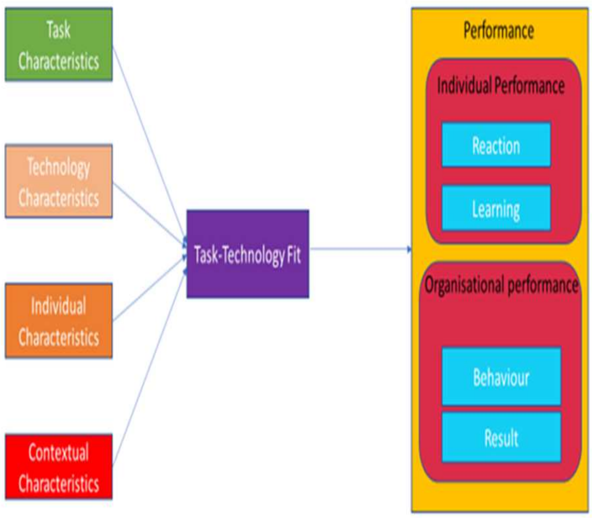

Figure 3: The Hybridized Framework for students' performance evaluation in e-learning in medical education

Our hybridized framework shown in Figure 3 hypothesizes that the alignment (fit) between the learning tasks, technology infrastructures, individual traits, and the contextual factors of medical students participating in e-learning in medical education will directly impact their individual and organizational performance. Individual performance evaluates if students enjoyed the e-learning program and acquired knowledge, skill, and attitudes presented as the program's outcome to a satisfactory extent. While organizational performance evaluates if students could transfer the knowledge and skills acquired from the program to practice at their workplaces and if knowledge transfer at the workplace yields value in their work organization.

B. *Materials: Student Performance Evaluation at the University of KwaZulu-Natal (UKZN) School of Medicine using the Hybridized Performance Evaluation Framework*

We evaluated the performance of medical at the University of KwaZulu-Natal (UKZN) School of Medicine using the Hybridized performance evaluation framework. We assessed the course HLSC 804W1; Antibiotic Stewardship and Conservancy, a Moodle-hosted online course that was required for the 2015 academic year's first semester of the Master of Pharmacy program offered by the School of Pharmaceutical Sciences. This course was taken by postgraduate medical students resident in Malawi and Mozambique. HLSC 804W1 is a cooperative research initiative under NORHED includes (The Norwegian Programme for Capacity Development in Higher Education and Research for Development).

We evaluated the performance of students who participated in the HLSC 804W1 course with the following objectives:

- To comprehend how the task's characteristics affect students' performance.
- To comprehend how the features of the technologies utilized affected students' academic achievement.
- To assess the influence that students' individual characteristics have on their performance.
- To determine the effect of students' contextual characteristics on their performance.

Due to the low enrolment (9 students), a qualitative approach was chosen. To ensure the complete inclusion of all students, census sampling was utilized to choose samples of the students. The study included seven students who were also practicing HCPs. Semi-structured in-depth interviews conducted over Skype were used to gather data, and the new framework's building blocks were used to create the interview schedule. Thematic analysis was used to examine the collected data. The University of KwaZulu-Natal's (UKZN) Research office's standards were satisfied through the adoption of fundamental research ethical principles.

IV. Findings

We present the summary of our findings according to the research objectives below:

- Study objective one; To analyze how the task's characteristics affect students' performance: We discovered that the task characteristics of the course had a significant impact on how well students performed both individually and organizationally. The course's content was deemed valuable by the students, who also expressed satisfaction with the program as a whole. Additionally, they picked up knowledge and abilities that they could apply to their clinical work. Likewise, it was claimed that the HCPs' workplace clinical practices had benefited from the transfer of knowledge and skills.
- Study objective two; To comprehend how the features of the technologies utilized affected students' academic achievement: We discovered a significant correlation between technological characteristics and how the course's task-technology fit is perceived. According to UKZN Moodle, the chosen learning management system, HCPs' learning tasks can be supported by it, which helped both their individual and organizational performance. HCPs reported that they enjoyed carrying out their learning assignments on Moodle. Additionally, students developed their technological and research abilities while using Moodle, which helped them comprehend the material in their curriculum. They claimed that their employer placed a great value on these abilities. Additionally, they had an impact at work thanks to the knowledge and abilities they learned in the course. An interesting finding was that students did not believe that technology had the greatest impact on their performance rather, factors that directly relates to the quality, relevance, and structure of the course material, the lecturers' and facilitators' expertise and experience, and the technological support offered by the course facilitators were all aspects of the course task characteristics that positively influenced performance.
- Study objective three; To assess the influence that students' individual characteristics have on their performance: We discovered that the abilities, proficiencies, and competence of HCPs slightly influenced their perception of Task-Technology Fit of UKZN Learning Management System; Moodle for their learning tasks only at the early phase of their study. However, as they progress, HCPs stated that they were able to level up and acquire the essential skills to complete their tasks. This is clear from the fact that HCPs' varied prior experience and other personality traits did not affect how well they completed the curriculum or how well they were able to learn new information and skills from it. Additionally, it did not affect their organizational performance in terms of their capacity to apply their knowledge and expertise to their clinical practices and add value to their respective workplaces. Instead, they all believed that the technology-related aspects of the course had an impact on their personalities because taking the course online had aided in the development of personality traits like self-control, task organization, prioritization, and the capacity for autonomous work. Individual traits, therefore, exhibit a poorer relationship with students' evaluation of task-technology fit and their individual and organizational performance when compared to

other dimensions like task characteristics and technology features.

- Study objective four; To ascertain the impact of students' contextual characteristics on their performance, we looked at how well they perceived the task-technology fit and how that linked with both their individual and collective performance. Three separate sub-Saharan African countries (two that speak English and one that speaks Portuguese) were able to engage across borders thanks to e-learning, but it also created difficulties due to language, economics, and infrastructure. These obstacles had a detrimental impact on how well students thought technology complemented their academic tasks. However, they emphasized that the course facilitators made accommodations for the contextual variation by funding the Portuguese-speaking students to take English classes, and they felt that this was very beneficial. Additionally, NORHED employed a translator who worked jointly and individually with the Mozambique group. The barrier caused by the teaching language was purportedly eliminated by this remedy. Students also stated that they were self-motivated to overcome financial and infrastructure obstacles to improve their performance.

V. DISCUSSION

E-learning has the potential to improve the performance of students in medical education [36] and increase the capabilities of healthcare professionals, enabling a decrease in the burden of disease [34]. However, the design of e-learning courses and programs must be undertaken painstakingly [35]. To ensure a "FIT" or alignment between learning tasks and technology, program coordinators and academic leaders in medical education must carefully analyze learning tasks and technology relative to their context. To ensure that learning is customized to fit the context, it is also expedient to conduct a proper need analysis and map the need to students' individual capabilities, technology, and context of students. When properly done, learners will be satisfied, learning objectives will be met, knowledge will be acquired and applied, and employers of students will observe considerable benefits.

The e-learning course evaluated helped students achieve both intended and unintended learning outcomes. Asides from passing the course reasonably, students acquired technical capabilities which enabled them to be global citizens and lifelong learners. Stakeholders in medical education should be wary of technology determinism, which perceive that rather than individuals and social circumstances of students influencing how technology is used, technological advances and developments are the major agents of societal change. Contextual factors are crucial to how well e-learning fits or is appropriate. This includes language, internet accessibility, and cost and may interfere with learning outcomes if not considered in the design of e-learning programs. The course material, the lecturers' and facilitators' expertise, and the e-learning pedagogies used are some task characteristics that were reported as the main factors that influenced students' perception of Fit and determined performance.

When the individual and contextual diversity of students is taken into account relative to the particular tasks and technology, the chances of improved students' performance in e-learning are very high. To support the investment in such programs, medical school stakeholders may need to reconsider the design of, and frequently evaluate the process and outcome of their e-learning programs to understand students' performance.

VI. CONCLUSION

The hybridized framework for designing and evaluating students' performance in e-learning in medical education was designed by deliberately infusing two models – The Task Technology Fit Models and the Kirkpatrick evaluation model. These two models make up for the inadequacies of each other, resulting in a novel hybrid framework that specifically focuses on the performance evaluation of students in an e-learning context in medical education.

The hybridized framework was piloted at the University of KwaZulu-Natal, Durban, South Africa, and the results imply that students' individual and organizational performances exceeded expectations. Notably, students accidentally acquired technical competencies and the ability to curate content through extensive digital research. This was echoed by students to be of huge benefit to the organizations where they work and to position them as global citizens.

Hence, when e-learning courses are designed with the careful alignment of technology to the specific task requirements, students' individual capabilities, and contextual limitations, students' performance can be expected to increase and possibly exceed expectations.

The potential of increased students' performance at individual and more so, organizational levels via e-learning in medical education will be appreciated when linked to the need for increased capacity in human resources for healthcare, especially in sub-Saharan African countries where the burden of diseases remains high.

Designing e-learning and evaluating students' performance in medical education is complicated. This is due to the lack of consensus on the indicators of performance and the lack of properly designed and validated tools [37] and frameworks. In this context, this study is of significant contribution. However, additional studies utilizing contemporary data science and machine learning methods to gather statistical evidence on the suitability of our hybridized framework for assessing students' performance in e-learning in medical education are recommended.

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