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ASSESSING INSTRUCTIONAL DESIGN PRINCIPLES INTEGRATION IN ENGINEERING DIGITAL MODULES

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Abstract: This study aimed to assess the extent to which ID principles were implemented within modules and challenges that encountered module coordinator while implementing ID principles. The study followed a mixed method research design. The instruments of the study included a checklist of ID principles used to review 125 digital engineering modules and an interview. The sample of the study consisted of ten module coordinators from different engineering departments. The results showed variation of instructors' application of ID principles in different departments but, overall, implementation of the of ID principles in digital modules was medium in engineering departments. The study also showed that the most frequent issues were lack of time, limited technical skills or knowledge, difficulty in engaging student online, busy teaching schedule, not enough professional development, and last-minute changes in department projects plan. Based on the results of the study, the researchers recommended faculty training programs to invest more in developing academic staff knowledge and skills about instructional design and educational technologies tools to improve their digital modules.
Keywords: Instructional Design, Instructional Design Principles, Engineering Education, Digital Modules

INTRODUCTION

Higher education institutions (HEIs) have integrated digital technologies in the educational process and used the digital platforms to support student Elearning (Alshammary & Alhalafawy, 2023). Digital platforms are networks that provide an effective learning environment and interactive support for students. Digital platforms developed significantly in the last decade, especially in engineering HEIs. They support sustainable education and motivate students to continue learning at anytime and anywhere. Digital platforms usually used to manage digital modules that enriched with a set of learning tools to allow synchronous and asynchronous interaction and communication between students themselves on one hand, and between the teachers and their students on the other (González & Quiroz, 2019). There is a link between digital platforms and their relationship with educational theories. It is important to consider the constructivist because digital learning platforms are based on the principles of constructivist, which enable the users to build content, and modify and adapt it to support participation and discussion in the digital platform environments where it will be possible for users to build and open forums, start group discussion, and close it at a specific time for the purpose of specific educational activities(Secundo et al., 2021).

Digital modules contain a set of tools that support students' learning, such as videos, discussion forums, chat forums, games, external resources, assignments, quizzes and students' gradebook (Simanullang & Rajagukguk, 2020). Zimmerman et al. (2020) identified other features and tools of course design in digital learning including authentic and relevant course materials, multimedia resources, activities for digital content to be collaboratively created by learners, opportunities for learners to reflect on their own learning, and the instructor's explanation of the purpose of activities, technologies, and assessments in the online course.

Instructional design (ID) principles offer structured techniques to enhance learning effectiveness by incorporating cognitive, behavioral, and constructivist learning strategies (Işman, 2011). These principles aim to optimize the teaching-learning process, ensuring that students not only grasp theoretical knowledge but also develop problem-solving and critical-thinking skills essential for real-world applications. Instructional design focuses on instruction from a learner perspective rather than a content perspective which is a traditional approach. The major goal of the instructional design is to demonstrate planning, developing, evaluating, and managing the instructional process (Işman, 2011).

In traditional classrooms, learners have information on how to navigate to their physical classrooms and know what to do once they arrive, which is different from online learning where instructors need to provide enough information on how to get them start and to get students through 'the door' to the content clearly, shortly and easily (Martin & Bolliger, 2023). Andrews and Goodson, (1980) mentioned that instructional design models serve four main purpose which are: (1) improving management of instructional design and development by using tools that monitor and control functions of the systematic approach, (2) improving learning and instruction through problem-solving and feedback characteristics of the systematic approach, (3) improving evaluation processes via feedback and revision events, inherent in models of systematic instructional design, (4) testing or building learning of instructional theory by using theory-based design within a model of systematic instructional design. (Baris SEZER et al. (2013) highlighted seven characteristics of ID principles that instructors must consider while designing learning materials which are (1) learner-centered, (2) a goal-oriented process, (3) a creative process, (4) focused on performance, (5) implies measurable, safe and valid results, (6) empirical, iterative and self-correcting, and (7) a team effort. According to Işman (2011), the success of these characteristics relies on the instructional designer's ability to collaborate with the other participants.

The integration of ID principles in engineering courses has gained increasing attention due to the growing emphasis on active learning, student engagement, and learning outcomes. Based on that, professional development in designing instructional materials is considered by HEIs. Teachers' participation in the ID process is critical to design flexible learning environments that allow all students to fulfill their potential and experience of 21st century skills. Teachers who act as instructional designers strengthen the link between plan and implementation, thus ensuring that high-level skills are delivered to students efficiently (Altun et al., 2021). Işman (2011) defined four important principles to consider while developing digital materials which are (1) begin the planning process by clearly identifying the general goals and specific objectives students will be expected to attain, (2) plan instructional activities that are intended to help students attain those objectives, (3) develop assessment instruments that measure attainment of those objectives, (4) revise instruction in the light of student performance on each objective and student attitudes towards instructional activities.

ID models provide a well-structured approach for developing digital instructional materials. They provide systematic approaches for structuring course content and delivery. An ID model gives clear guidance to design instruction. The ID process helps educators to visualize the problem within teaching process. Some experts use them as frameworks to guide them efficiently to integrate instructional tools wisely (Ng et al., 2019). ID models help educators design curricula that cater to diverse learning styles, promote hands-on experience, and enhance knowledge retention.

There are several models of ID identified clear principles for designing learning materials. The most common ID model is the ADDIE model which includes analysis, design, development, implementation, and evaluation phases. The second ID model is ASSURE model which includes analyze learners, state standards and objectives, select strategies, technology, media and materials., utilize technology, media and materials, require learner participations, evaluate and revise (Al-Kattatl et al., 2019). The third ID model is Dick and Carey model which includes identify instructional goals, conduct instructional analysis, identify entry behaviors, write performance objectives develop criterion-referenced tests, develop instructional strategy, develop and select instructional materials, develop and conduct formative evaluation, revise instruction, develop and conduct summative evaluation. The Fourth ID model is Gagné's Nine Events of Instruction which includes gaining attention, informing the learner of the objective, stimulating recall of prerequisite learning, presenting the stimulus material, providing learning guidance, eliciting the performance, providing feedback, assessing the performance, and enhancing retention and transfer (Khadjooi et al., 2011). All the four models can be applied to develop online digital materials. González and Quiroz (2019) mentioned that instructors should take advantage of the resources of the technology platforms and the characteristics of each ID model. Chen and Carliner (2021) found that instructors did not use ID principles precisely. However, they followed a similar process as illustrated in ID models by posting existing resources; structured courses based on semester length, class size, and content; aligned topics by weeks and revised courses based on student feedback.

In digital modules, learners are pleased with a well-structured course (Zimmerman et al., 2020). This includes dividing the content into asynchronous weekly modules with introductory guidelines, the material presented via comment-enriched slideshows and problem-oriented activities. Some digital tools that facilitate interaction are required too such as chats and forums in an LMS can enhance instructor-to-student contact (Adanır et al., 2020). Students are more satisfied when both interactions are enhanced through communication tools (e.g., a virtual classroom, forums), audiovisual content, and multidimensional material (Konstantinidou & Nisiforou, 2022).

The development of e-learning materials and the provision of e-learning opportunities are one of the most rapidly expanding areas of education and research. There have been several attempts to generate sets of criteria for assuring quality of e-learning materials in eLearning environment (Attwel, 2006).

assessing digital modules based on ID principles is crucial for ensuring their effectiveness, accessibility, and engagement. A well-structured evaluation process ensures that the course aligns with learning objectives, enhances student motivation, and facilitates meaningful learning experiences (Andrews & Goodson, 1980). Assessment of digital modules must consider key ID principles to determine their instructional quality, usability, and overall impact on learning outcomes(Senadheera et al., 2024). Assessing the extent of ID principles' integration in engineering courses continuously is essential to identify modules gaps, measure module

effectiveness, and provide recommendations for improvement in terms of learning materials, module organization and students performance(Chen & Carliner, 2021).
There are numerous challenges that limit instructors applying ID principles in teaching process; time (workload) and involvement in research and innovation, understanding and keeping pace with leading edge technology, meet deadlines and negotiations with subject matter experts, documenting and sharing best practices of utilizing ID principles in education(Sharif & Cho, 2015). There are some challenges faced by educators is deciding on a suitable ID model to achieve an effective and high-quality digital teaching and learning process (Branch & Kopcha, 2014) .This is mainly because they are unaware of the factors that can influence the selection of an ID model, the ID models that are available for digital learning and the impact of each ID model on the success of digital learning (Senadheera et al., 2024b)
Military Technological College (MTC), which as a HEI specialized in Engineering education in Muscat, applies e-learning via MOODLE platform. There are five engineering majors which are Systems Engineering, Aeronautical Engineering, Civil Engineering, Marine Engineering and Geomatics Engineering. Instructors use the platform mainly to deliver the course modules. Digital engineering modules are structured to include delivery plan, module descriptors, module overview, announcement, contact details, multimedia, and assessment. Therefore, this study seeks to assess the alignment of engineering course modules with ID principles. In addition, it aims to identify challenges associated with their implementation of ID principles in developing their digital modules. There are two main research questions.
1.To what extent do engineering digital modules align with the instructional design principles?
2.What challenges do teachers face in implementing these principles?

1. RESEARCH METHODOLOGY

The study followed mixed method research by doing Quantitative analysis of 125 course modules and qualitatively analyzing the interviews with the instructors (module's coordinators).
The population of the study included all engineering module coordinators in the Military Technological College (MTC) and the sample consisted of 10 module coordinators from various engineering departments who were randomly selected to participate in the study.
An ID principles checklist was designed by researchers based on the literature review and was presented to instructional design experts with master's degrees in Instructional and Learning Technologies from Sultan Qaboos University, Ministry of Education and Military Technological College. Based on their feedback, the checklist shortened to be 9 main ID principles (Demonstration Video, Updated Module Descriptor, Delivery Plan, Announcement form, Module coordinator name, contact information, Active Online Quiz, Multimedia, Interactive Content) that fit with the nature of the assessed modules. The checklist was piloted, and the Cronbach's alpha was 0.80 which is good for the purpose of the study. Semi-structured interview: the 10 module coordinators were interviewed online and individually due to their preferences. The interview focused on the challenges of implementing the ID principles in the design and development of their modules.
The researchers used statistical software and analyzed the data measuring descriptive statistics of means and standard deviations to answer research question 1. The researchers depended on the following interval equation (2-1)/3= 0.33, thus the judgment of the mans will be High (0.67-1), middle (0.34-0.66) and low (0.00 -0.33).
To answer research questions 2, the researchers analyzed the data thematically to find out the key challenges of implementing ID principles from the perspectives of the module coordinators. The researchers followed the six steps (familiarization with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, producing the report) of (Braun & Clarke, 2008) to analyze the qualitative data.
The researchers completed ethical checklist before starting the study and submitted the research proposal and the ethical checklist to the Ethical Committee Research (ERC) at the college to get the official approval form the Directorate of Applied Research Director (DAR) to conduct the study. The approval was also obtained from the module coordinators to assess the 125 modules.

2. RESULTS AND DISCUSSION

This study aimed to assess the alignment of engineering course modules with ID principles. In addition, it aims to identify challenges associated with their implementation of ID principles in developing their digital modules.
3.1 The alignment of engineering course modules with ID principles.
To answer the first research question: To what extent do engineering digital modules align with the instructional design principles? The researchers calculated the means and the standard deviations of the assessed module. Table 1presents the results of all departments' implementation of ID principles in digital modules.

Table1: Implementation of ID principles in digital modules

Department	M	SD	Level

Aeronautical	0.79	0.074	High
Marine	0.66	0.073	Medium
Systems	0.61	0.06	Medium
Geomatics	0.55	0.19	Medium
Civil	0.75	0.09	High
Overall	0.65	0.028	Medium

Table 1 shows that that the overall implementation of ID principles in digital modules was medium in engineering departments with a mean (M) score of 0.65 and a Standard Deviation (SD) of 0.028. The Aeronautical and Civil departments got High level of implementation of ID principle, M (0.79), SD (0.074) and M (0.75) SD (0.09) respectively which reflects that both are homogeneous. Additionally, Marine, Systems and Geomatics departments got medium level as shown in table 1. The Geomatics department got the lowest score among medium level of implementation of ID principles in digital modules with M (0.55) and SD (0.19).

The researchers interpret the medium level of the ID principles in digital modules due to the professional development sessions held by the instructional designers in the Educational Technology Department who usually send an email to module coordinators to update their digital modules with video tutorials that guide them to organize their modules based on ID principles. Another reason is the long teaching experience of the instructors in Aeronautical and civil departments compared to other departments. Also, the nature of the modules in these departments which require instructors to use more features available in the digital platform could be another reason that affects the implementation of ID principles in digital modules. Regarding the Geomatics department, which got the lowest level of implementation of ID principles in digital modules, the reason might be that the department has currently been initiated at MTC. Instructors may need more time to adapt their skills and knowledge to develop their learning materials based on ID principles.

The results, align with the study of Chen and Carliner (2021) found that instructors do not follow ID principles precisely, but they followed a similar process as illustrated in ID models by posting existing resources; structured courses based on semester length, class size, and content, aligned topics by weeks and revised courses based on student feedback. The medium level of ID implementation reflects that instructor followed the key ID principles identified by Işman (2011) regarding the planning of general goals and objectives, instructional activities, and assessment instruments. The high and medium levels of ID implementation within different engineering departments at MTC may manage the instructional design and development, improve learning and instruction, and improve evaluation processes via feedback and revision events as claimed by Andrews and Goodson (1980). That means that instructors are the ones who decide which principles of ID are worked with their digital modules from others which can be acceptable if instructors presented their digital modules clearly.

3.2 Challenges are associated with their implementation of instructional design principles.

To answer research question 2, what challenges do teachers face in implementing these principles? The researchers analyzed the interviews, and the results showed that instructors face key challenges when implementing ID principles in digital modules. All participants mentioned challenges in following ID principles for developing digital modules learning materials. The most frequent issues were lack of time, limited technical skills or knowledge, difficulty in engaging students online, busy teaching schedule, not enough professional development, and last-minute changes in department projects plan.

The most critical challenge is lack of time that significantly affects the instructors' implementation of ID principles in their digital modules. Due to the large teaching load and administrative tasks, instructors are unable to implement the ID principles properly. The second most important challenge is limited technical skills or knowledge. When instructors lack skills and knowledge on how to implement ID principles in the design and development of their modules, the design of their modules may not reflect appropriate teaching and learning strategies. Another issue faced by teachers is engaging students in an online environment. It's important to consider ID principles in the design of the digital modules to reinforce students' learning, active engagement and motivation. Also, instructors raised concern about their teaching schedule which is usually full. This may decrease their chances to develop their module design skills. Also, instructors faced a change related to lack of professional development. The absence of professional development may result in module design which lacks the best teaching practices. Some instructors expressed that changes in project plans keep changing making it difficult for them to think of innovative module design based on ID principles, thus they adapt their current modules to meet the teaching needs without any implementation of ID principles because they are not fully aware of the importance of ID principles in module design.

These results are in line with the study of Martin and Bolliger (2023), who believe that if the course organization is not clear and attractive to online learners, it is difficult to retain them in the course. The workload, the lack of skills in leading edge technology, the lack of training in ID principles in education (Sharif & Cho, 2015), and the lack of knowledge of the ID model (Senadheera et al., 2024) can affect the success of design and development of digital modules in engineering department. Barriers can be broken by drawing a clear plan includes improving digital modules, improving instructors in ID knowledge and skills.

3. CONCLUSIONS

Current study aimed to assess to what extent do teachers implement ID principles within their digital modules and obstacles they face to implement ID principles. Implementation of ID principles in learning and teaching process is highly relevant in today's rapidly evolving educational landscape. As engineering education increasingly incorporates digital learning, understanding the extent to which ID principles are applied is crucial for enhancing student engagement, knowledge retention, and overall learning outcomes. The results showed variation of instructors' application of ID principles in different departments but, overall, implementation of the of ID principles in digital modules was medium in engineering departments. The study also showed that most frequent issues were lack of time, limited technical skills or knowledge, difficulty in engaging student online, busy teaching schedule, no enough professional development, and last minute changes in department projects plan".
Researchers recommend faculty training programs to invest more in developing academic staff knowledge and skills about instructional design and educational technologies tools to improve their digital modules.

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