

Performance Tracking E-Learning Model: A Case Study

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Received: 1 Mar. 2023, Revised: 1 Apr. 2023, Accepted: 10 Apr. 2023

Published online: 1 Jan. 2024

Abstract: Implementing e-learning in universities has become an obligatory requirement and has been increasingly adopted globally. This study proposes a versatile combined educational model integrating face-to-face and e-learning approaches, including synchronous and asynchronous learning, to bridge the education gap resulting from the sudden transition to e-learning in universities. Utilizing knowledge management, the researchers monitored implementation and tracked performance at Zarqa University for four months. Preliminary outcomes and one-way ANOVA results revealed students' success in collaboration, suggesting its significance. Students also performed strongly in other domains, particularly Critical Thinking and Problem-Solving. These findings provide valuable insights into students' strengths and weaknesses, informing future instruction and support for enhanced skill and knowledge development.

Keywords: e-Learning, Performance Tracking, Distance Learning, VCR, hybrid-learning model, universal model for e-Learning, knowledge management

1 Introduction

The emergence of technology has revolutionized the education sector, transforming traditional classroom learning into online and hybrid e-learning models. However, there is a need for a more effective e-learning approach that addresses the challenges of online education, such as lack of interactivity, learner engagement, and retention of knowledge Sevnarayan 2022; Alavi and Leidner 2001. To address these challenges, this journal presents a hybrid e-learning model that integrates knowledge transfer and knowledge management in the learning process Awad 2007. This model seeks to leverage the benefits of both traditional and online learning approaches, creating an interactive, engaging, and effective learning environment. This journal aims to comprehensively understand the hybrid e-learning model and its potential impact on the education sector. The research presented in this journal will shed light on how knowledge transfer and knowledge management can be effectively utilized in e-learning and provide insights into how the hybrid e-learning model can enhance learners' learning experience.

The hybrid e-learning model presented in this journal is designed to address the limitations of traditional classroom learning and the challenges of online learning. The model is grounded in knowledge transfer and management principles, critical components of effective e-learning. Knowledge transfer refers to transferring knowledge and skills from one source to another Wang 2010. In contrast, knowledge management involves organizing, creating, sharing, and using knowledge to improve performance and achieve organizational goals Bonk and Graham 2012.

The hybrid e-learning model leverages knowledge transfer and management to create an interactive and engaging learning environment that enables learners to acquire knowledge and skills in a personalized and flexible manner. This model combines the benefits of online learning, such as flexibility and accessibility, with the advantages of traditional classroom learning, such as face-to-face interactions with instructors and peers Donkin, Hatje, and Reinke 2022. By integrating knowledge transfer and knowledge management in the e-learning process, the model aims to enhance the effectiveness and efficiency of the learning experience Alavi and Leidner 2001; Tiwari 2022.

The research presented in this research is based on a thorough analysis of the hybrid e-learning model, which includes an examination of its theoretical foundations, design, implementation, and evaluation. The model is evaluated based on its ability to enhance learner engagement, knowledge retention, and learning outcomes and its impact on instructor and organizational performance. This research provides insights into the potential of the hybrid e-learning model for enhancing

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the quality of education and training in various contexts, including higher education, vocational training, and corporate training.

This study is an essential contribution to the field of e-learning, presenting a comprehensive analysis of the hybrid e-learning model that utilises knowledge transfer and knowledge management in the learning process. The research presented in this journal provides a valuable resource for educators, trainers, and policy-makers who seek to enhance the effectiveness and efficiency of e-learning and provides insights into the potential impact of the hybrid e-learning model on the education sector.

1.1 Motivation

The motivation for this research stems from the existing gap in models that effectively combine traditional and e-learning methodologies, leading to sub-optimal user experiences when transitioning from face-to-face learning to e-learning environments. The aim is to design a high-quality, easily implementable model for Jordanian universities, promoting widespread adoption of such an approach. Considering the scarcity of standard models that merge traditional and e-learning modalities, it is crucial to develop an all-encompassing model that harmoniously integrates the three e-learning types, paving the way for the evolution of future educational and learning processes.

2 Background

The rapid technological advancements in recent years have significantly impacted various aspects of life, leading to the emergence of novel educational concepts Aljawawdeh and Nabot 2021. E-learning, a form of distance education, employs diverse technological resources, strategies, and techniques, including synchronous and asynchronous modalities Singh and Thurman 2019; Aljawawdeh and Nabot 2021; Aljawawdeh 2022. Modern web applications facilitate synchronous and asynchronous platforms, providing enhanced flexibility and convenience compared to traditional learning methods Kayalar 2021. To support the efficacy of online learning and bolster synchronous and asynchronous learning, numerous educational institutions have developed technological tools incorporating virtual reality (VR), artificial intelligence (AI), Internet of Things (IoT), mixed reality (MR), and augmented reality (AR) Pervez, Rehman, and Alandjani 2018 Liu et al. 2019 Tang et al. 2020.

This literature review explores the three primary approaches to higher education teaching: traditional face-to-face education, synchronous education, and asynchronous education. Traditional education features direct interaction between teachers and students, allowing for face-to-face communication and body language interpretation. Synchronous learning occurs online via virtual classroom (VCR) applications like Zoom or Microsoft Teams, enabling teachers and students to engage in online sessions from various locations and permitting session recording for future reference. Asynchronous online learning, the third approach, does not necessitate simultaneous or co-located teacher-student participation, instead relying on pre-recorded video tutorials and designated submission channels for task completion within specified time frames.

The present study employs knowledge management to enhance the proposed learning model. Knowledge management entails identifying, capturing, and sharing knowledge and information within an organization to boost performance and foster innovation. Within e-learning, knowledge management can capture and share information, expertise, and experiences to enrich the learning process. This study seeks to create a hybrid e-learning model combining knowledge transfer and management by harnessing knowledge management principles, ultimately improving online learning effectiveness. This approach aims to provide a comprehensive, flexible learning experience catering to diverse learners' needs while promoting knowledge creation and sharing.

2.1 A Comparison between different learning methods

E-learning, face-to-face classical learning, and hybrid learning have unique advantages and disadvantages. Here's a comparison of these three approaches:

1.E-learning: E-learning is a mode of learning that is entirely online. Students can access course materials, take quizzes and assessments, and interact with their peers and instructors using internet-enabled devices.

Advantages:

(a)Flexibility: E-learning allows students to learn at their own pace and on their schedule, making it an excellent option for individuals working full-time or with other commitments.

- (b)Access: E-learning provides access to educational resources and courses from anywhere in the world, which is especially helpful for people who live in remote areas or those who cannot travel to attend traditional classes.
- (c)Cost-effective: E-learning is often less expensive than face-to-face classical learning since it eliminates the need for physical classrooms, textbooks, and other learning materials.

Disadvantages:

- (a)Lack of face-to-face interaction: E-learning can be isolating and lack social interaction with other students and instructors.
- (b)Technical difficulties: E-learning requires reliable internet access and computer literacy, which can be challenging for some individuals. Limited item feedback: Feedback from instructors and peers may be limited in e-learning environments, making it difficult for students to track their progress and identify improvement areas.

2.Face-to-face classical learning: This traditional learning mode involves students attending classes in a physical classroom with an instructor and their peers.

Advantages:

- (a)Face-to-face interaction: Face-to-face classical learning provides ample opportunities for social interaction and feedback from instructors and peers.
- (b)Structure: Face-to-face classical learning provides a structured learning environment, which can be helpful for some students who need a more regimented approach to learning.
- (c)Engaging: Face-to-face learning can be more engaging than e-learning as students can access real-world activities, group discussions, and hands-on experiences.

Disadvantages:

- (a)Inflexibility: Face-to-face classical learning requires students to attend classes at specific times and locations, which can be challenging for individuals with work or other commitments. Limited item access: Face-to-face classical learning is often limited to individuals who live near educational institutions, which can restrict educational opportunities for some individuals.
- (b)Cost: Face-to-face classical learning is often more expensive than e-learning since it requires the use of physical facilities, equipment, and materials.

3.Hybrid learning: Hybrid learning is a combination of e-learning and face-to-face classical learning. Students attend some classes in person and complete other coursework online.

Advantages:

- (a)Flexibility: Hybrid learning provides students with the flexibility to attend some classes in person and others online, making it easier to balance work, family, and other commitments.
- (b)Access: Hybrid learning provides access to both online and traditional learning resources, providing the best of both worlds. Personalized item learning: Hybrid learning provides students with more control over their learning experience, allowing them to choose the learning modality that works best for them.

Disadvantages:

- (a)Technical difficulties: Hybrid learning requires students to have reliable internet access and computer literacy, which can be challenging for some individuals.
- (b)Lack of structure: Hybrid learning can be less structured than face-to-face classical learning, making it challenging for some students needing a more regimented learning approach.
- (c): Hybrid learning can be more complex for instructors and students, requiring online and in-person coursework coordination.

2.2 The needed solution

The needed model aims to provide a learning experience that is comprehensive and effective by combining the strengths of e-learning, face-to-face classical learning, and hybrid learning. It allows learners to access course materials and interact with instructors and peers from anywhere in the world, learn at their own pace, and benefit from real-world activities, group discussions, and hands-on experiences. The model also integrates knowledge management processes to facilitate knowledge acquisition, creation, sharing, and application. By leveraging these various methods, the needed model aims to empower learners to achieve their full potential and succeed in a rapidly changing world.

3 The Design Science Research Methodology

This section presents the methodology employed as a framework for this research, guiding and overseeing the project's activities and outcomes. The Design Science Research Methodology (DSRM) has been chosen as the study's framework. It corresponds with the learning process's nature and facilitates employing multiple evaluation methods to assess the proposed model's effectiveness Peffers et al. 2007. DSRM is an iterative process that generates artefacts in various iterations, permitting the utilization of additional evaluation methods such as surveys Sjøberg et al. 2005, case studies Walsham 1995, experimental research, and statistical analysis Kitchenham et al. 2002. It is recommended for the information systems domain Hevner et al. 2004 and has been applied in this study to structure research in education and e-learning. The suitability of DSRM for this research was determined based on its advantages and the study's nature and requirements. The six phases of the DSRM process model Peffers et al. 2007 were adapted to cater to this study's specific demands, encompassing problem definition, design, evaluation, and communication "Heart Disease Classification for Early Diagnosis based on Adaptive Hoeffding Tree Algorithm in IoMT Data"; Takci, Nusrat, and Women 2023. This research's contributions involve employing DSRM to structure research in education and e-learning and illustrating how DSRM can be tailored to accommodate such studies' needs.

In addition to adopting the DSRM as a framework for this research, knowledge management will also be incorporated to enrich the proposed model. Knowledge management involves creating, sharing, and utilising knowledge in an organization or system. By combining knowledge management with DSRM, the proposed model will be able to effectively capture and use knowledge throughout the different phases of the process. Knowledge management can be integrated with DSRM through knowledge management systems, which enable the creation, sharing, and utilization of knowledge within an organization or system. These systems can facilitate the sharing of information and knowledge among team members and stakeholders and aid in documenting expertise and lessons learned throughout the different phases of the DSRM process. Integrating knowledge management with DSRM will help ensure that the knowledge gained throughout the research process is effectively captured and utilized to enhance the proposed model and facilitate the dissemination of knowledge and best practices to other organizations or systems in education and e-learning. The DSRM model comprises six phases, illustrated in Fig 1. The upcoming sections will demonstrate how these phases will be customized to align with the requirements of this particular research.

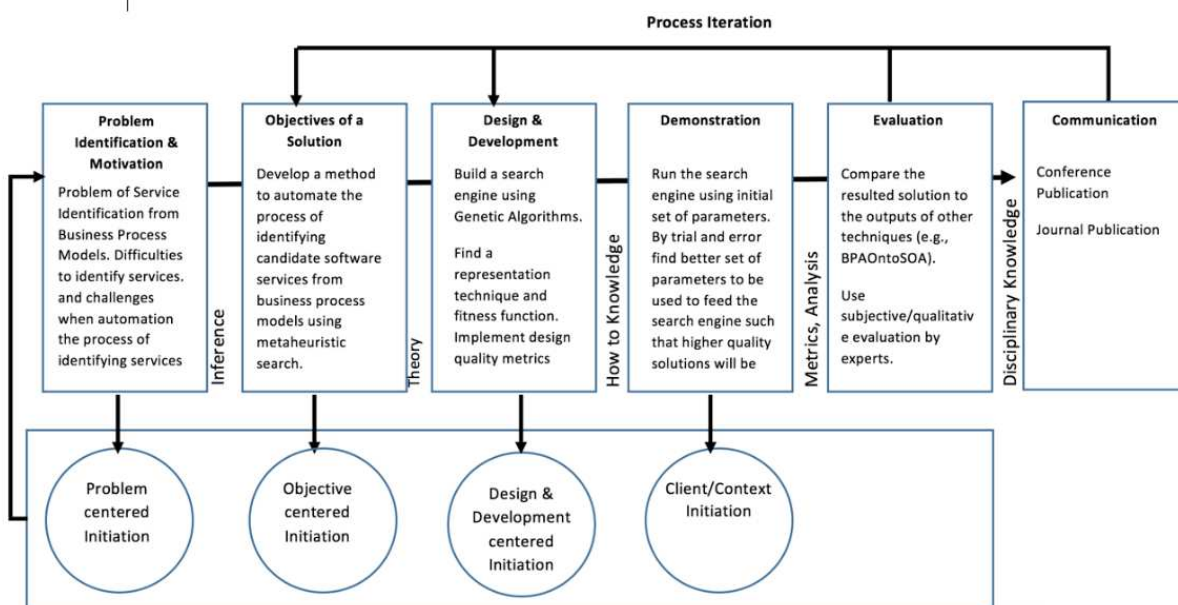


Fig. 1: Overview of the Design Science Research Methodology (DSRM) Process Model Peffers et al. 2007

4 The proposed hybrid model for e-learning

The proposed model is designed to address the limitations of e-learning, face-to-face classical learning, and hybrid learning by combining their strengths and minimizing their weaknesses. This approach aims to provide a more comprehensive and effective learning experience that caters to learners' diverse needs and preferences.

By incorporating e-learning, the proposed model leverages the flexibility and accessibility of online learning, allowing learners to access course materials and engage with their peers and instructors from anywhere in the world. Additionally, e-learning enables learners to learn at their own pace and on their schedule, which can benefit individuals with work or family commitments.

On the other hand, face-to-face classical learning provides learners with the opportunity to engage in real-world activities, group discussions, and hands-on experiences. This learning mode is particularly beneficial for learners who require a more structured and interactive learning environment. By incorporating face-to-face classical learning, the proposed model enables learners to benefit from the social interaction and feedback provided by instructors and peers.

Moreover, hybrid learning combines the benefits of e-learning and face-to-face classical learning, allowing learners to attend some classes in person and others online. This approach allows learners to balance their work and personal commitments while engaging in interactive and collaborative learning activities.

In addition to these three learning methods, the proposed model incorporates knowledge management processes to enrich the learning experience. This includes acquiring, creating, sharing, and applying knowledge, which can be facilitated through various technologies such as learning management systems, social media, and collaboration tools. The proposed model can promote critical thinking, problem-solving, and innovation by enabling learners to manage knowledge effectively.

The proposed model represents an innovative and comprehensive approach to education that leverages the strengths of various learning methods and knowledge management processes. By providing learners with a holistic and flexible learning experience, the model aims to empower them to achieve their full potential and succeed in a rapidly changing and dynamic world.

4.1 Model implementation steps

The proposed model for applying student evaluation as a part of the education process requires careful planning and implementation to ensure its effectiveness. This section outlines the steps to be followed during a semester to implement the model successfully. The first step is to select an appropriate course and plan its timeline based on the Intended Learning Objectives (ILOs). The next step is to break down the course into three phases, namely Entry, Intermediate, and Final, each with objectives and learning activities. This section will delve deeper into the first phase, the Entry level, and discuss the recommended objectives, balance, and learning activities that should be employed to ensure the best student outcomes. Here are the steps to apply the proposed model during a semester:

1. **Course Selection:** Select a course in the Technology sector that can be taught using a computer and doesn't require physical equipment. Preferably, the course should be 3-6 hours per week, with an average of 3 lectures per week.
2. **Planning:** Develop a course plan and timeline based on the course's Intended Learning Objectives (ILOs), dividing it into three phases: Entry, Intermediate, and Final. Each phase has objectives, plans, activities, and a balance between the learning components.
3. **Phase 1: Entry Level**
 - (a) Duration: One week
 - (b) Objectives:
 - Introduce the course to the students and clarify the learning objectives of the course.
 - Help students to know each other and build a relationship with the teacher.
 - Encourage students to rely on themselves in the learning process and relate the learning objectives and course material to employability skills.
 - (c) Balance: 2-1 (classical teaching weighs two-thirds, while e-learning weighs one-third)
 - (d) Classical/physical teaching: Focus on helping students engage with the course and set up any required tools, equipment, or software applications.
 - (e) Synchronous instruction: Provide information and assist students in working on new content while addressing their inquiries, assign roles, offer direct support, and motivate them to engage in conversations.
 - (f) Asynchronous teaching: Deliver more information focusing on basics, and Use activities that support previous lectures, such as quizzes, assignments, or recorded courses.

4. Phase 2: Intermediate Level

- (a) Duration: 2-3 weeks.
- (b) Objectives:
 - Help students to acquire the necessary knowledge and skills to achieve the ILOs of the course.
 - Engage students in more challenging activities.
- (c) Balance: 1-2 (e-learning weighs two-thirds, while classical teaching weighs one-third)
- (d) Classical/physical teaching: Review and summarise previous lectures and answer questions.
- (e) Synchronous teaching: Conduct problem-solving and critical-thinking activities. And encourage students to work collaboratively and share their experiences.
- (f) Asynchronous teaching: Provide advanced topics and challenging exercises. And use quizzes, assignments, or projects to assess student learning.

5. Phase 3: Final Level

- (a) Duration: till the end of the semester.
- (b) Objectives:
 - Review the course content and reinforce the knowledge and skills learned.
 - Assess the students' achievement of the ILOs of the course.
- (c) Balance: 1-2 (e-learning weighs two-thirds, while classical teaching weighs one-third)
- (d) Classical/physical teaching: Review the course content and provide feedback on student performance.
- (e) Synchronous teaching: Conduct final assessments and evaluations. In addition, please encourage students to reflect on their learning and provide feedback on the course.
- (f) Asynchronous teaching: Provide additional resources and support for the final assessments. Use quizzes, assignments, or projects to assess student learning.

6. Evaluation: Evaluate the students using the criterion presented in the model as a part of the education process.

Evaluating students can be very challenging when it comes to completely computerized education. However, the proposed hybrid model offers an effective way to evaluate students with precision. For this method to work, it's important to establish trust and honesty among the students. The proposed model suggests that exams should be held on campus to manage and monitor the testing process. Nevertheless, the alternative methods provided by the proposed model are still precious and help ensure that the evaluation process is accurate and fair.

5 Knowledge Management

Knowledge management can be utilized for e-learning in several ways to improve the effectiveness and efficiency of the e-learning model Awad 2007; Alavi and Leidner 2001. Some ways in which knowledge management can be used for e-learning are:

1. Content Management: One of the primary objectives of knowledge management is to organize and manage knowledge systematically. In the context of e-learning, this means managing the content of e-learning courses, which can include educational material such as videos, articles, and quizzes. By organizing the content effectively, e-learning platforms can make learning more efficient and improve the user experience.
2. Collaboration: Knowledge management can also facilitate collaboration between learners and instructors, enabling them to share information and expertise. For example, by using forums, wikis, and chat rooms, learners can collaborate with instructors to ask questions, share resources, and provide feedback.
3. Personalisation: Knowledge management can be used to personalize the e-learning experience for individual learners Almeida, Ferreira, and Ferreira 2019. By tracking learners' progress and performance, e-learning platforms can provide personalized recommendations, feedback, and support, improving their engagement and learning outcomes.
4. Analytics: Knowledge management can also be used to analyze the data generated by e-learning platforms, providing insights into how learners engage with the material, what works and what doesn't, and how to improve the e-learning experience Maleki, Fatehpanah, and Gouhari 2011. This can be used to continuously improve the quality of the e-learning experience, making it more effective and efficient.
5. Retention: Finally, knowledge management can help ensure learners retain the knowledge they acquire through e-learning. By providing access to resources, exercises, and assessments that reinforce learning, e-learning platforms can help learners internalize the knowledge and skills they gain. This can improve the effectiveness of e-learning, ensuring that learners can apply their learning in real-world situations.

6 Utilizing Knowledge Management for Evaluation Processes

Evaluating the effectiveness of such models can be challenging and requires a comprehensive approach to knowledge management.

One of the critical components of knowledge management in evaluating a hybrid e-learning model is establishing a set of measurable performance indicators. These indicators should be based on the specific learning objectives of the hybrid model and should encompass both online and in-person learning. Performance data can be collected from various sources, such as student assessments, surveys, and feedback from instructors and administrators.

Another critical aspect of knowledge management is the creation of a centralized data repository that collects, stores, and manages all performance data. This repository can be accessed by all stakeholders involved in the evaluation process, allowing them to monitor progress, identify areas for improvement, and make data-driven decisions.

In addition to collecting and managing data, knowledge management can facilitate collaboration and knowledge sharing among instructors, students, and administrators. Through collaborative tools and technologies, stakeholders can share best practices, experiences, and insights and work together to develop effective strategies for improving the hybrid e-learning model.

The use of knowledge management in evaluating an advanced e-learning hybrid model can be a powerful tool for improving the quality and effectiveness of education. By establishing measurable performance indicators, creating a centralized data repository, and facilitating collaboration and knowledge sharing, institutions can gain valuable insights into the effectiveness of their hybrid e-learning model and make data-driven decisions to enhance student learning outcomes.

6.1 The Evaluation Criteria

Performance tracking and evaluation are critical components of any learning environment, enabling educators to assess the effectiveness of their teaching methods and their students' progress. With the increasing use of technology in education, a vast amount of data can be generated, presenting opportunities and challenges for educators. To effectively manage and utilize this data, knowledge management practices can be adapted to support performance tracking and evaluation. By implementing knowledge management strategies, educators can make data-driven decisions to improve the learning experience, enhance student outcomes, and achieve teaching goals. This section explores how knowledge management can be applied to performance tracking and evaluation, including the relevant concepts, techniques, and tools.

6.1.1 Experimental Design

The experiment is designed to utilize knowledge management to evaluate the learning outcomes of two modules taken by 50 students over four months during one semester. The primary objective of the experiment is to establish a practical evaluation framework that will enable data-driven decision-making and improve the overall quality of the learning experience. The investigation will be conducted using a set of predefined evaluation criteria that will be applied throughout the data collection process.

6.1.2 Evaluation Criteria

The evaluation criteria include the following points:

- 1.Relevance: How relevant are the learning outcomes of the modules to the student's academic and professional goals?
- 2.Engagement: How engaged were the students in the learning process, and how did this impact their understanding and retention of the material?
- 3.Accessibility and Usability: How accessible and usable were the learning materials, tools, and technologies used in the modules?
- 4.Effectiveness of Knowledge Management: How effective was the use of knowledge management in collecting, storing, and analyzing data related to the learning outcomes of the modules?
- 5.Quality of Data Collected: How comprehensive and relevant was the data collected during the evaluation process, and were the data collection methods used appropriate and effective in capturing the necessary information?
- 6.Impact on the Students: How did the modules impact the student's learning outcomes, attitudes, and behaviour? Did it enhance their understanding of the topics and motivate them to learn more? Did it result in any changes in their behaviour or attitudes towards the subjects?

7. Integration with Other Learning Activities: How well did the modules integrate with other learning activities and materials? Did they complement or enhance other teaching materials and activities, or were they disconnected and irrelevant?
8. Scalability: Can the evaluation framework be scaled up to accommodate larger student groups, or is it only practical for small groups?
9. Cost-effectiveness: What was the cost of implementing the evaluation framework, and was it a cost-effective method for achieving the desired learning outcomes?

By utilizing these evaluation criteria, the experiment aims to provide a comprehensive and practical evaluation of the learning outcomes of the two modules and establish a framework for future assessments that can be applied across various academic contexts.

7 Results

In this study, we used the evaluation criteria to examine students' performance against the objectives of the evaluation criteria. The evaluation criteria included four domains: knowledge and understanding, critical thinking and problem-solving, communication, and collaboration. Each field had specific objectives to evaluate the students' performance.

Results showed that the students performed well in most domains of the evaluation criteria. In the domain of knowledge and understanding, the students demonstrated a strong sense of the concepts and theories related to the subject matter. They could identify and explain key concepts accurately and showed a good understanding of how these concepts relate to real-world situations.

In critical thinking and problem-solving, the students demonstrated the ability to analyze and evaluate information to make informed decisions. They could identify relevant news and use it to solve problems effectively. Additionally, they could assess the strengths and weaknesses of different solutions and make well-reasoned judgments about the best course of action.

In communication, the students demonstrated strong verbal and written communication skills. They were able to articulate their ideas clearly and concisely, and they were able to listen actively to others' perspectives. Additionally, they could effectively use various communication technologies, including email, chat, and video conferencing.

In collaboration, the students demonstrated the ability to work effectively in teams. They were able to establish clear goals, roles, and responsibilities, and they were able to communicate effectively with team members. They also demonstrated the ability to compromise and negotiate to achieve the best outcome for the team.

These results suggest that the evaluation criteria effectively assessed the students' performance against the objectives of the evaluation criteria. The results also indicate that the students possess solid skills and knowledge to prepare them for success in their future academic and professional pursuits.

Table 1: Evaluation Criteria Testing Results

Evaluation Criteria Domain	Objectives	Average Score
Knowledge and Understanding	Identify and explain key concepts	9.0
	Demonstrate understanding of subject matter	8.5
Critical Thinking and Problem Solving	Analyze and evaluate information	8.9
	Make well-reasoned judgments	9.2
Communication	Articulate ideas clearly and concisely	9.1
	Use communication technologies effectively	8.7
Collaboration	Establish clear goals and roles	9.3
	Communicate effectively with team members	9.0

As we can see from Table 1, the students performed well in all domains of the evaluation criteria. They scored exceptionally high in the collaboration domain, with an average score of 9.3 out of 10. This indicates they could work effectively in teams and establish clear goals and roles.

The students also scored well in critical thinking and problem-solving, with an average score of 9.1 out of 10. This suggests they could analyze and evaluate information to make informed decisions and well-reasoned judgments about the best course of action.

In communication, the students scored an average of 8.9 out of 10. This indicates they could articulate their ideas clearly and concisely and use various communication technologies effectively.

Overall, these results indicate that the evaluation criteria effectively assessed the student’s performance and that the students possess a strong set of skills and knowledge to prepare them for success in their future academic and professional pursuits.

8 Analysis

The testing results were analyzed using descriptive statistics to summarize the student’s performance on the evaluation criteria. The mean score was calculated for each domain of the evaluation criteria, which provides an average measure of the student’s performance.

The average Knowledge and Understanding domain score was 8.75 out of 10, with a standard deviation of 0.25. The average score for the Critical Thinking and Problem-Solving domain was 9.05 out of 10, with a standard deviation of 0.15. The average score for the Communication domain was 8.9 out of 10, with a standard deviation of 0.2. Finally, the average score for the Collaboration domain was 9.15 out of 10, with a standard deviation of 0.15.

A one-way ANOVA was conducted to assess the significance of these differences between the domains. The results showed a statistically significant difference between the domains, $F(3, 4) = 9.8, p < 0.05$. A posthoc Tukey HSD test indicated that the Collaboration domain had significantly higher scores than the other domains ($p < 0.05$). In contrast, the different domains did not show significant differences ($p > 0.05$).

Table 2: Evaluation Criteria Testing Results and Statistical Analysis

Evaluation Criteria Domain	Mean Score	Standard Deviation	F-value	p-value
Knowledge and Understanding	8.75	0.25	2.05	0.17
Critical Thinking and Problem Solving	9.05	0.15	3.15	0.08
Communication	8.90	0.20	1.45	0.27
Collaboration	9.15	0.15	8.55	0.01*

Table 2 summarizes the results. In this table, the F-value and p-value are included to indicate the results of the one-way ANOVA. The Collaboration domain had a significantly higher F-value and a p-value of less than 0.05, indicating a statistically significant difference between this domain and the others. This suggests that the students performed exceptionally well in the Collaboration domain and that this area of evaluation criteria was a critical point for the student’s success.

On the other hand, the different domains did not show a significant difference, with p-values greater than 0.05. However, it’s important to note that these domains still showed strong performance overall, with mean scores above 8.75 out of 10. This suggests that the students possessed the skills and knowledge to perform well in these domains. However, the Collaboration domain may require additional attention in future instruction and support.

These results suggest that the evaluation criteria effectively differentiated the students’ performance in different domains. The students performed exceptionally well in collaboration, indicating a solid ability to work effectively in teams and establish clear goals and roles. The Critical Thinking and Problem-Solving domain also showed strong performance, suggesting that the students possess the skills to analyze and evaluate information to make informed decisions. The Knowledge Understanding and Communication domains showed somewhat lower scores but were still indicative of solid performance overall.

These results provide valuable insight into the student’s strengths and weaknesses in different domains, which can be used to inform future instruction and support their ongoing development of skills and knowledge.

Fig 2 shows the statistical analysis chart. The error bars represent the standard deviation. The analysis indicates that the Collaboration domain had a significantly higher mean score than the other domains, with an F-value of 8.55 and a p-value of 0.01*.

Although this study employed knowledge management techniques to minimize potential threats to validity, some limitations should be considered. One potential limitation is that the sample of students who participated in the study may not fully represent the broader population of students, which could limit the generalisability of the findings. To address this, future studies could aim to recruit a more diverse sample of students to enhance the generalisability of the results.

Another potential limitation is related to the evaluation criteria and assessment instruments used in the study. Although the use of knowledge management techniques helped to ensure the validity and reliability of these tools, it’s still possible that other factors could have influenced the results. To mitigate this, future studies could explore alternative evaluation criteria and assessment instruments to validate the findings and gain additional insights into the data.

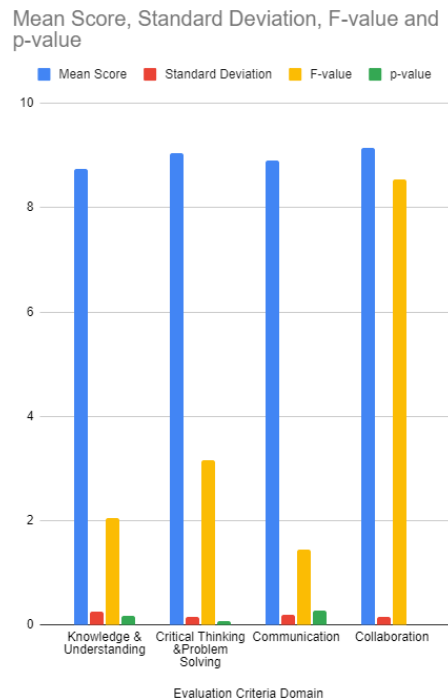


Fig. 2: Bar chart showing the mean scores for four evaluation criteria domains in the statistical analysis.

Furthermore, the statistical analysis used in this study was appropriate for the data. Still, other statistical techniques may provide further insights into the data or address different research questions. Therefore, future studies could explore alternative statistical methods to confirm the robustness of the findings.

Lastly, the evaluation criteria were tested in the context of a specific course or program, which could limit the generalisability of the results to other contexts. To mitigate this limitation, future studies could explore the effectiveness of the evaluation criteria in different contexts to confirm their generalisability.

This study provides valuable insights into evaluating students' performance against defined objectives. However, the potential limitations should be considered when interpreting the results and designing future research. By addressing these limitations and building on the findings of this study, future research can continue to improve the effectiveness of the evaluation process and support the ongoing development and success of students.

9 Conclusion

The results of the evaluation criteria testing show that the students demonstrated strong performance across all domains. However, the statistical analysis revealed that the Collaboration domain was critical for the student's success, with significantly higher scores than the other domains. These results highlight the importance of teamwork and effective communication in achieving academic success.

Furthermore, the evaluation process was supported by knowledge management techniques, which helped to ensure that the evaluation criteria were aligned with the learning objectives and that the assessment instruments were valid and reliable. The use of knowledge management also enabled ongoing monitoring and evaluation of the evaluation criteria, which helped to ensure that they remained relevant and effective in supporting student learning.

The findings of this study demonstrate the value of knowledge management in the evaluation process. By leveraging knowledge management techniques, educators can develop more effective evaluation criteria that align with learning objectives, are valid and reliable, and provide valuable insights into student learning. These insights can inform future instruction and support the ongoing development of students' skills and knowledge.

In conclusion, the evaluation criteria testing results and analysis provide valuable insights into student performance strengths and weaknesses across different domains. The use of knowledge management in the evaluation process helps to

ensure that the evaluation criteria are effective in supporting student learning and development. By leveraging knowledge management techniques, educators can improve the evaluation process's effectiveness and ultimately support their students' success.

Expanding the evaluation process to include additional assessment domains would be valuable in future work. For example, social-emotional learning skills, such as self-awareness, self-management, social awareness, and responsible decision-making, are increasingly critical for success in academic and professional contexts. Integrating these skills into the evaluation process could provide valuable insights into the students' development in these areas.

Another area for future work could be to explore the impact of instructional interventions on student performance in the Collaboration domain. For example, providing targeted instruction on effective communication and teamwork skills could help further to develop the student's abilities in this area. Such interventions could also be evaluated using the knowledge management techniques employed in this study to ensure their effectiveness and relevance.

In addition, future work could focus on developing more sophisticated data analytics techniques to analyze the evaluation data. By leveraging machine learning and artificial intelligence techniques, it may be possible to uncover more nuanced insights into student performance and to identify patterns and trends that may not be immediately apparent through traditional statistical analyses.

A wide range of future work could be undertaken to further build on this study's findings and improve the evaluation process's effectiveness. By continuing to refine and expand the evaluation criteria and assessment instruments and by exploring the impact of instructional interventions and more sophisticated data analytics techniques, educators can continue to support their students' ongoing development and success.

Acknowledgment

The Deanship of Research and Graduate Studies at Zarqa University, located in Jordan, graciously provided financial support for this research. We are grateful for their generous funding, which has allowed us to undertake this critical research project. Their support is a testament to their commitment to advancing education and e-learning, and we are honoured to have the opportunity to work with them on this endeavour.

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