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Article

An intelligent online human-computer interaction tool for adapting educational content to diverse learning capabilities across Arab cultures: Challenges and strategies

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Abstract: Students from different cultures possess varying levels of skills in learning, remembering, and understanding concepts. Some terms and their explanations may seem easy for one group of students but difficult for another. Therefore, delivering educational content that aligns with student's learning capabilities is a challenging task based on cultural orientations. This study addresses the learning challenges by developing a Thesaurus Glossary E-learning (TGE) framework method. This study introduces the TGE method which is a multi-language tool with visual associations that adapts to students' capabilities. It also examines cultural differences and native languages, particularly aiding Arab Native to visualize appropriate terms (thesaurus) and their explanations (glossary) based on students' learning capabilities. TGE learns from students' term selection behavior and displays terms at a simple or advanced level that matches their learning ability. Additionally, TGE demonstrated its effectiveness as an e-learning tool, accessible to all students anytime and anywhere. The study analyzed 314 records related to student performance, out of which 114 students were surveyed to evaluate the effectiveness of the TGE method. This work presents TGE as a novel e-learning tool designed to enhance conceptual thinking within the context of modern educational practices during the digital transformation. TGE is based on artificial intelligence algorithms and associative rules that simulate the human brain, establishing logical connections between related key terms and sketching associations among diverse facets of a situation. An experiment was conducted at a private university in the Sultanate of Oman to assess the effectiveness of the proposed TGE tool. TGE was integrated with selected subjects in information systems and used by the students as a resource for e-learning methods and materials. The results show that 85% of students who used TGE improved their performance by 19%. We believe this work could establish a new smart e-learning teaching method and attract modern and digital universities to enhance student learning outcomes linked with conceptual thinking.

Keywords: e-learning; glossary; higher order thinking skills (HOTS); interactive educational system; thesaurus

1. Introduction

The preparation of high-level specialists necessitates the active incorporation of pedagogical technologies that foster the development of higher-order thinking skills within higher education institutions (Gradini et al., 2024). However, developing and testing technologies to promote critical thinking in higher education in Arab regions, where university programs are delivered in English as mandated by the Ministry of Education and quality authorities, present significant challenges (Shannaq, 2024a).

This issue is particularly pronounced in the Sultanate of Oman (Shannaq, 2024b; (Shannaq, 2024c).

This study demonstrates the need and feasibility of fostering critical thinking in an information systems program at a university for non-native English-speaking students from Arab regions. University of Buraimi, College of Business, and Management Information Systems Department was used as the center of the experiment for the case study.

University learners must comprehend advanced English texts to access academic and global knowledge, especially where English is the primary medium of education (Pratiwi et al., 2024). However, higher-order thinking skills (HOTS) such as analyzing, evaluating, and synthesizing information vary among learners. Previous research has primarily examined the role of HOTS in instructional materials for reading comprehension, but explicit taxonomic modeling of learners' HOTS in reading comprehension remains limited (Alkiyumi, 2024; Karwadi et al., 2024). In a developing educational system like Oman, the use of English is the primary medium of communication in all higher education levels, often relying on superficial scoring which ultimately contributes to stagnated low skills performance. However, the learners' HOTS levels in information system skills have not been thoroughly modeled (Segumpan and McAlaney, 2023) to mitigate this performance.

This study models the university learners' HOTS levels in computer skills, using Bloom's revised taxonomy (ElJishi et al., 2024), to identify strengths and weaknesses. Understanding these levels is crucial for developing targeted remedial programs and improving learner performance. Research in developed countries has highlighted the importance of engaging learners in cognitive activities to enhance reading comprehension (Darwis et al., 2024; Habeeb, 2024; Khalil et al., 2023; Khurma and Zein, 2024). However, studies in developing countries, particularly Oman, have focused less on modeling learners' HOTS levels (Arif and Aldosary, 2023; Cairns, 2023; Shannaq and Al Shamsi, 2024; Sadriwala et al., 2024; Taderera, 2024).

Linking HOTS with curriculum design can benefit learners by providing teachers with valuable insights into cognitive strengths and weaknesses, enabling targeted remedial measures and authentic assessment designs (Badoi-Hammami, 2023; Wang, 2024). This study also combines visual skills analysis which provides a clearer picture of Omani university learners' HOTS that are essential for educational reforms.

1.1. HOTS-based Curriculum for effective learning

Effective learning in various educational programs is crucial for non-native English speakers, particularly Arab Native, for both academic and professional success. In most developing countries like Oman, where English language is the primary medium of instruction, proficiency in English educational materials is vital for academic engagement and future opportunities (Alkhateeb and Alhawsawi, 2023; Amanzhol et al., 2023). Higher-order thinking skills (HOTS)—analyzing, evaluating, and creating—are essential for online learning (Musliha et al., 2021; Salihah and Prayudha, 2022). Research indicates that integrating HOTS in teaching improves reading performance (Ness, 2019; Nappu and Hambali, 2022). However, traditional

education systems often fail to explicitly incorporate HOTS into learning interactions, which could motivate students to explore, learn more, and innovate.

Research has shown the lack of cultural factors in motivating students to be innovative and apply new skills and knowledge. This is particularly true for Arab native students who complete their education in the Arabic language and then join universities where the medium of instruction is English. These students face the challenges of spending considerable time translating English materials into Arabic to understand scientific concepts across disciplines.

Modeling learners' HOTS levels can provide valuable insights for targeted skill improvement and better performance (Arviani et al., 2023). Explicit HOTS assessment aligns with cognitive diagnostic assessment, offering systematic information for enhancing learners' reading abilities (Darwis et al., 2024; Rachmawati et al., 2023). This study also proposed visual learning to improve the proposed Framework for modeling HOTS levels.

1.2. Insightful Analysis of Higher-order Thinking Skills (HOTS)

Research has shown that gaps still exist in understanding Higher-Order Thinking Skills (HOTS), especially in areas of e-learning and Human-Computer Interaction (HCI) (MoldStud, n.d.; Zhu and Tahir, 2023). Firstly, there is a dearth of recent studies that combine e-learning tools with a comprehensive thesaurus glossary approach which has the potential to improve students' cognitive capacities. Most of the current research concentrates on conventional teaching strategies or disjointed technology interventions rather than a seamless integration of advanced language resources.

Secondly, there is a lack of research on how dynamic and engaging HCI tools can be to promote HOTS. Although a large body of research has been done on interactive learning environments, relatively little of it has focused on the creation and performance of intelligent HCI tools intended to enhance HOTS. There is still not enough research on how these technologies may be used to provide tailored, flexible learning experiences that meet the needs of each learner. Moreover, there is a lack of new research into how e-learning tools affect HOTS development over time. Most current research only offers short-term assessments, which leaves a vacuum in our knowledge of the therapy's possible downsides and long-term advantages. Furthermore, there is also a lack of recent research on how different learner demographics—like cultural background and past knowledge—affect how successful HCI-based HOTS improvement tools are considered.

Finally, the swift advancement of technology is an ongoing challenge for this field of study. Research must continue to keep up with evolving educational paradigms and technology improvements as many studies become out of date very rapidly.

To create efficient e-learning systems that use HCI to improve HOTS and provide students with the skills they need for the current and future AI-based century, these gaps must be filled.

E-learning tools are also essential for knowledge transfer and skill development. Beyond knowledge acquisition, they should foster critical thinking, enabling learners to analyze and evaluate information. They also help identify relationships between objects and phenomena for evidence-based conclusions. The study is structured to

include thesaurus glossary e-learning (TGE), an AI-driven tool designed to enhance conceptual thinking that addresses the gaps in the literature by introducing the thesaurus glossary e-learning (TGE) method. The TGE is therefore a multi-language tool with visual associations linking ideas and concepts. TGE adapts to students' learning capabilities by displaying terms at varying difficulty levels. Unlike existing solutions, TGE considers cultural differences, understanding levels, and native languages, particularly aiding Arab native students.

2. Materials and methods

2.1. Design

Competence-based and mixed-methods approach was utilized in this study to enhance the delivery of educational content tailored to each student's learning capability. The main research methods included the analysis of scientific literature from both the Sultanate of Oman and foreign sources, as well as diagnostic methods such as experimental, quantitative, and observational techniques.

2.2. Participants

An experimental study was conducted at the University of Buraimi from 2018 to 2020 involving the installation, ascertaining, training, and control stages included four courses: MISY 304 in spring 2018/2019, and MISY 316, MISY 403, and MISY 407 in the Fall of 2019–2020. The study analyzed 314 records related to student performance. 114 students were surveyed to evaluate the effectiveness of the thesaurus glossary E-learning (TGE) method.

2.3. Research instruments

In the experiment, we collected data about the Management Information Systems (MIS) students' previous information and academic performance. Then, we request the students to use the thesaurus glossary e-learning (TGE) as a learning method to assess their understanding of the subject matter. Subsequently, we presented a new teaching method intended to improve their conceptual thinking and problem-solving skills.

Figure 1 illustrates the experimental research design.

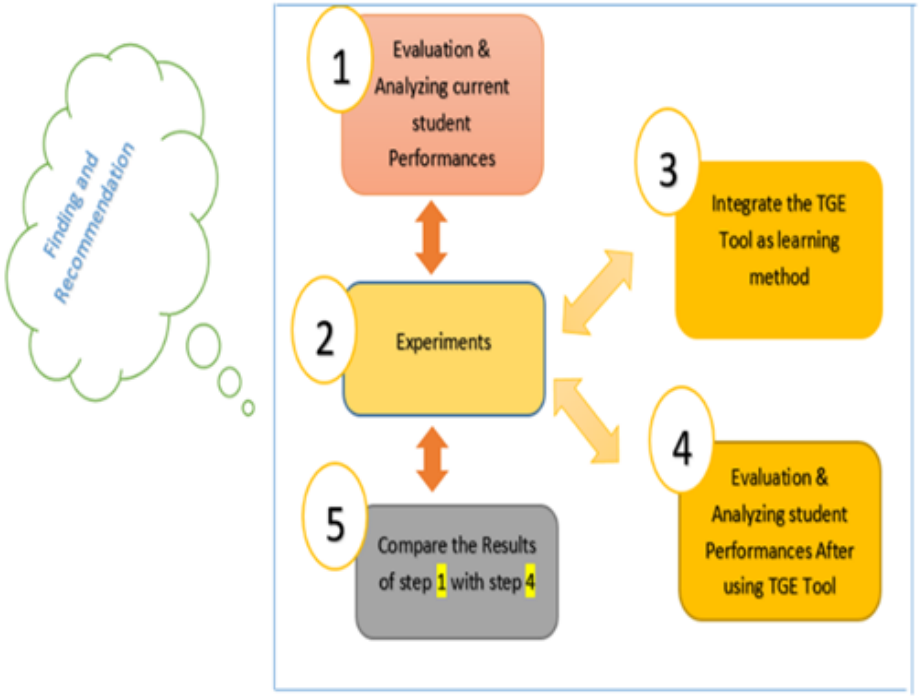

Figure 1. The proposed research methodology.

Figure 2 shows the organizational design and steps of the proposed system.

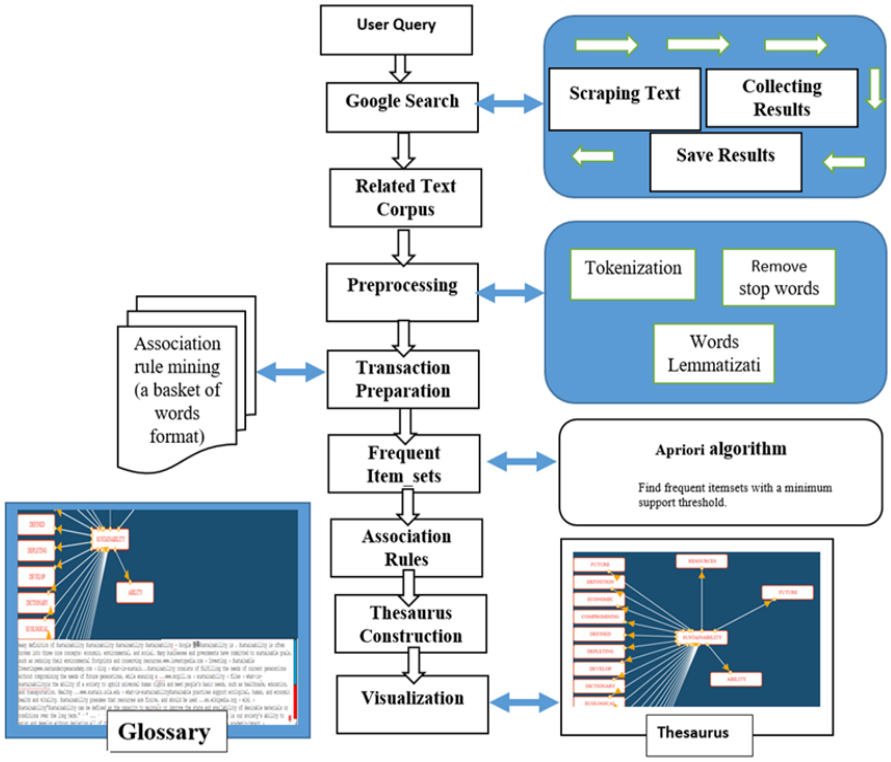

Figure 2. The proposed system organizational design and steps.

2.4. Procedure

In the experiment testing phase, we developed the smart interactive web application as described in **Figure 2**. In the quantitative testing phase, descriptive and

inferential statistical analyses were conducted on the quantitative data collected from data collected to evaluate student feedback about the thesaurus glossary e-learning (TGE) as a learning method. Statistical testing using descriptive statistics was first obtained to address the research objective. In the qualitative testing phase, data values operationalized from interviews underwent thematic analysis to gain insights into learners' opinions and perceptions regarding thesaurus glossary e-learning (TGE) modeling as a learning method.

2.5. Analysis

2.5.1. Experiment process

A real live demo system of the proposed TEG Tool was set up for implementation in the following link: https://taerproject.com/.

Figures 3 and **4** illustrate the functionality of the proposed TGE tool. For instance, if a user or student wishes to learn about the term "database," it can be challenging due to its broad nature, resulting in an overwhelming number of search results in search engines. To address this, the TEG tool employs a conversation session to gather user feedback and determine their specific query. This interactive conversation enables users to explore and discover other terms related to their interests, enhancing memory and concept retention skills.

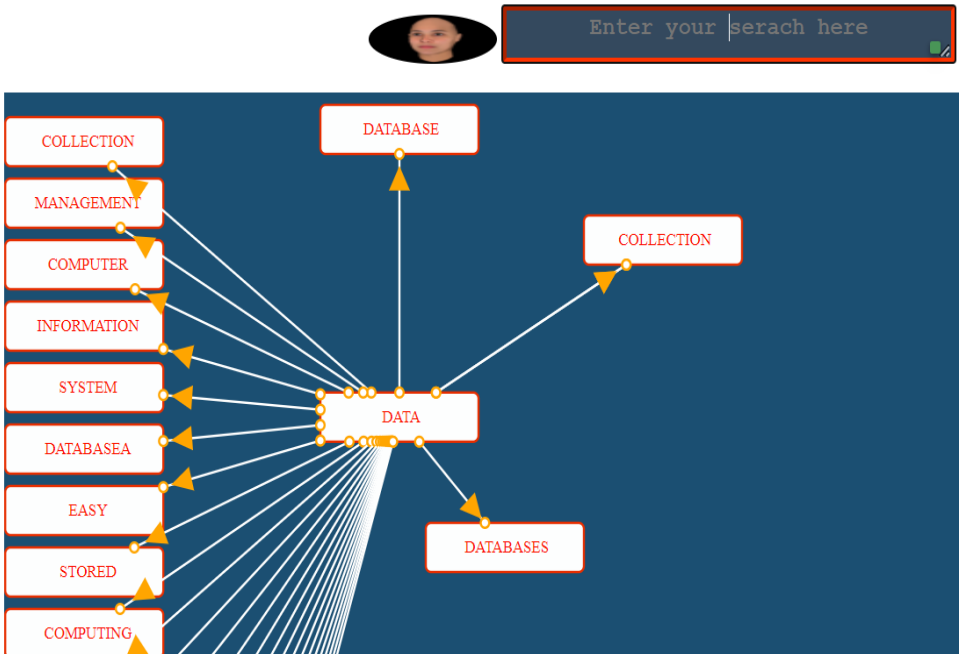

Figure 3. The user intends to learn about database management.

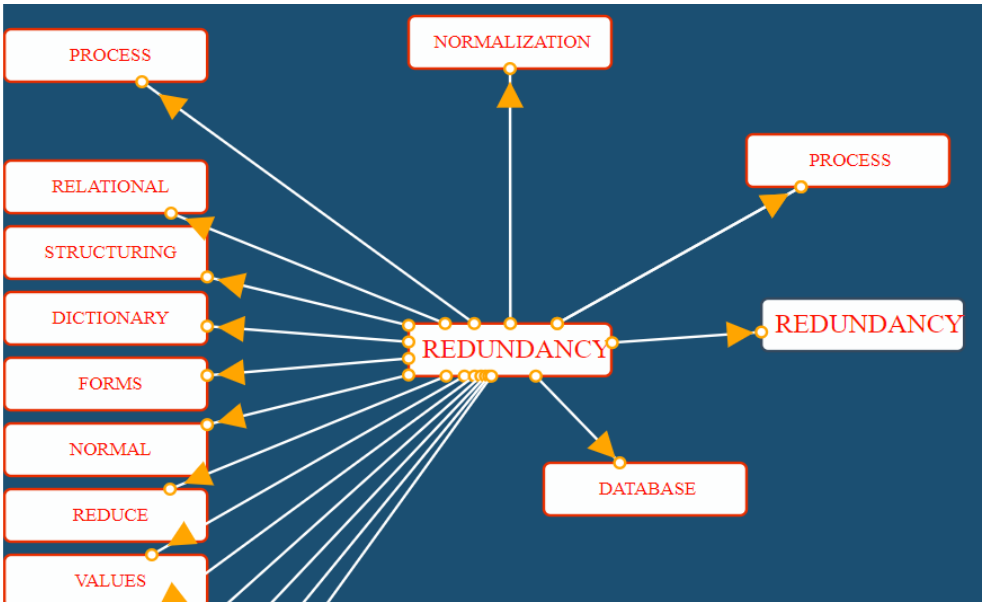

Figure 4. The system suggests more terms to interact with the user.

The research study evaluated the performance of the student participants for the experiment by conducting both pre-assessment and post-assessment to measure the knowledge, skills, and dispositions students bring to learning tasks with the TGE tool. In addition, surveys and interviews were administered to gather qualitative data on the participants' perceptions and attitudes toward the new teaching method.

In addition, a specialized smart web application information system was developed to measure and oversee all processes of the proposed TGE tool. This application effectively monitors the interaction events between students and instructors.

Figure 5 provides a sample view of the application, showcasing the statistics and progress of each participating instructor and student in the experiments.

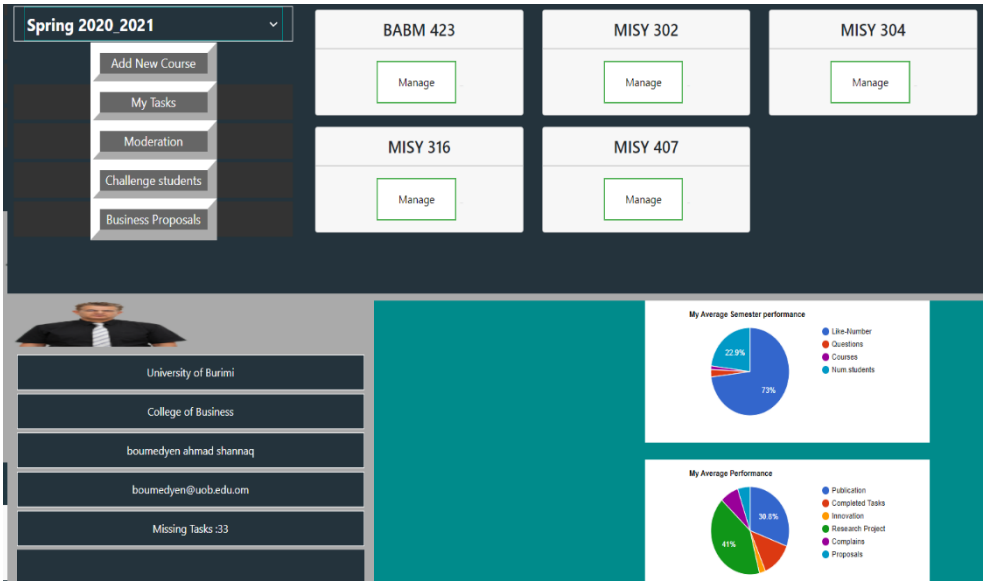

Figure 5. The smart application interface.

To evaluate the effectiveness of the proposed tool, a dataset comprising 314 records was used to capture student performance before and after implementing TGE as a learning method.

Figure 6 provides a sample view of the dataset. It consists of 11 variables, including academic semester, course title, instructor, before per semester, after per semester, school study type, graduate year, average of high school, completed hours, and current CGP. To prioritize student privacy based on college policy, the field size for student ID was minimized. Colorful group highlights are used to separate the same student. For example, the records highlighted in blue depict a student who registered for four courses: MISY 304 in Spring 2018/2019, MISY 316, MISY 403, and MISY 407 in Fall 2019–2020.

Academic Semest	Studen	course Title	instructor	GPA_Befo	GPA_Afte	HIGH_SCH	HIGH_SCH	HIGH_SCH	Current E	Current CGP
Spring 2018-2019	1E+06	MISY 304 Ent	Boumedy	1.88	2.02	Literature	2011	78.9	131	2.31
Fall 2019-2020	1E+06	MISY 316 Intr	Boumedy	2.08	2.17	Literature	2011	78.9	131	2.31
Fall 2019-2020	1E+06	MISY 403 Wel	Boumedy	2.08	2.17	Literature	2011	78.9	131	2.31
Fall 2019-2020	1E+06	MISY 407 Infc	Boumedy	2.08	2.17	Literature	2011	78.9	131	2.31
Spring 2018-2019	1E+06	BABM 417 Co	Boumedy	2.85	2.95	Literature	2013	74	131	2.98
Spring 2018-2019	1E+06	BABM 417 Co	Boumedy	2.14	2.09	Literature	2013	69.3	131	2.11
Spring 2018-2019	1E+06	BABM 419 Im	Boumedy	2.14	2.09	Literature	2013	69.3	131	2.11
Spring 2018-2019	1E+06	MISY 306 Dat	Boumedy	2.07	2.23	Literature	2013	72	131	2.26
Spring 2018-2019	1E+06	MISY 316 Intr	Boumedy	2.07	2.23	Literature	2013	72	131	2.26
Spring 2018-2019	1E+06	BABM 417 Co	Boumedy	3.12	3.16	Literature	2013	74	131	3.18
Spring 2018-2019	1E+06	BABM 418 IT	Boumedy	3.12	3.16	Literature	2013	74	131	3.18
Summer 2018-201	1E+06	BABM 417 Co	Boumedy	2.57	2.63	Literature	2013	73	131	2.63
Summer 2018-201	1E+06	BABM 423 Mc	Boumedy	2.57	2.63	Literature	2013	73	131	2.63
Spring 2018-2019	1E+06	BABM 417 Co	Boumedy	2.08	2.09	Literature	2013	56.3	131	2.12
Spring 2018-2019	1E+06	BABM 417 Co	Boumedy	2.38	2.41	Literature	2013	68	131	2.45
Spring 2018-2019	1E+06	BABM 206 IT I	Boumedy	1.9	2.05	Literature	2013	71.5	68	2.11
Spring 2018-2019	1E+06	BABM 418 IT	Boumedy	2.99	3.02	Literature	2013	66.9	131	3.04
Spring 2018-2019	1E+06	BABM 206 IT I	Boumedy	1.81	1.82	Literature	2013	72	68	1.82
Spring 2018-2019	1E+06	BABM 206 IT I	Boumedy	2.25	2.27	Literature	2013	68	68	2.27
Spring 2018-2019	1E+06	MISY 306 Dat	Boumedy	2.47	2.57	Literature	2014	75	131	2.62
Spring 2018-2019	1E+06	BABM 417 Co	Boumedy	2.99	3.02	Literature	2014	68.6	131	3.05
Spring 2018-2019	1E+06	BABM 418 IT	Boumedy	2.99	3.02	Literature	2014	68.6	131	3.05

Figure 6. Sample of the dataset.

The findings indicated a significant improvement in students' academic performance when using the new learning method, as demonstrated by higher scores in the post-tests.

2.5.2. Quantitative analysis

The analysis of 141 survey responses revealed a more positive attitude among students towards the new learning method. Participants found it engaging and effective in enhancing their learning experience.

Figure 7 delivers a complete overview of the survey results, capturing student feedback after utilizing the TGE tool as a learning method.

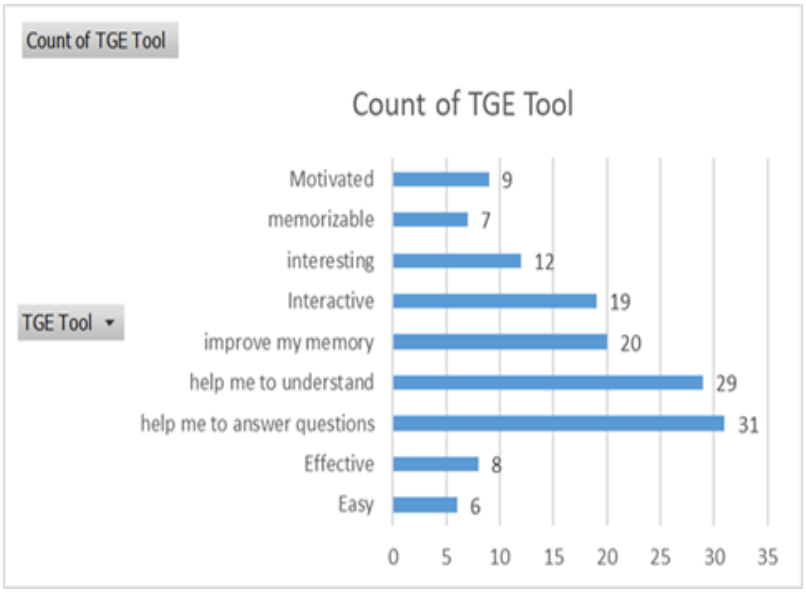

Figure 7. The survey results on the effectiveness of utilizing the TGE tool.

The survey results indicate that thirty-one students responded positively that the TEG tool helped them answer questions more effectively than other tools such as YouTube media when compared. Twenty-nine students stated that TEG helped them understand course concepts better than traditional teaching methods. Twenty students reported that TEG improved their long-term memory retention of educational materials compared to other media technologies. Nineteen students found TEG interesting and motivating, encouraging them to engage more and explore additional ideas and knowledge through its interactive and visual techniques. Twelve students praised TEG's presentation of information, calling it very interesting. Nine students found TEG highly motivating. Eight students considered TEG more effective as a learning method than traditional approaches. Seven students described TEG as an impressive learning tool, and six students noted that it was easy to use.

Overall, this analysis provided a valuable understanding of the effectiveness of using the TGE in attracting students' conceptual thinking and problem-solving skills. The results could have significant consequences for the design and implementation of instructional practices in various educational settings.

3. Discussion

Arabic is the most widely spoken language in many Middle Eastern countries. Despite numerous dialects, a unified version is taught in schools and used by the media. As a Semitic language, Arabic's alphabet, grammar, and vocabulary differ significantly from that of the English Language leading to potential interference errors when Arabic speakers learn a subject in English (Lucente, 2023). Many foreign educators who work in Middle Eastern countries, often find teaching a subject in English challenging due to these differences (Hines, n.d.; Mihret et al., 2024). The study by Moshtari and Safarpour, 2023 examines the importance of internationalization for underdeveloped countries in addressing poverty, climate change, and educational inequalities. Despite its significance, research on higher education internationalization in less developed African countries is limited. In this

qualitative study, twelve (12) main challenges in East Africa were identified, categorized into policy, organized into structures, financial, and competency issues, and finally, internal and external strategies for higher education institutions were recommended to address these challenges.

Most students use word lists also known as glossaries to record and remember vocabularies. These glossaries are often found at the end of textbooks, but students can create personalized ones in their notebooks to keep track of new vocabulary. While this is useful, traditional word lists have limitations such as providing only translations without additional context. Some students struggle to memorize the lists and even those who succeed may quickly forget the words and fail to use them in writing or speaking.

For effective vocabulary development, students need repeated exposure to words and opportunities to use them. If new vocabularies are not revisited, they are likely to be forgotten. Educators should incorporate activities that allow students to review and apply new vocabulary. The thesaurus glossary e-learning (TGE) tool developed in this study also examines these challenges by smartly developing students' vocabulary and tracking their learning progress.

TGE acts as a dynamic notebook where students can:

- Record new vocabulary/words with detailed information.
- Note memorable contexts where they encountered the word.
- Add words to a visual association.
- Include example sentences.
- List related words.

TGE facilitates vocabulary retention by providing opportunities for review and application, both inside and outside the classroom. By using TGE, students can reflect on their learning progress, compare their usage with peers, and become independent learners. This innovative tool ensures continuous vocabulary development tailored to each student's capability level.

This work addresses a critical gap in the literature by introducing multi-language tools with visual associations that link ideas and concepts. Students from different cultures possess varying levels of skills in learning, remembering, and understanding concepts. Some terms and their explanations may seem easy for one group of students but difficult for another.

While existing literature offers various solutions, they often overlook cultural differences, students' levels of understanding, and native languages. Typically, users must translate terms into English before using available tools. In contrast, TGE addresses these gaps, particularly benefiting Arab natives and potentially applying them to other regions with different languages.

3.1. Related work on conceptual thinking

Technology-based Arabic language learning enhances quality, accessibility, flexibility, and resource diversity (Rani et al., 2023). However, this study indicates several challenges such as uneven content quality, internet access, and limited social interaction. Efforts to maximize benefits are essential. E-learning employs ICT to facilitate teaching through multimedia materials accessible globally. Arabic language

education covers vocabulary, grammar, reading, writing, and speaking, promoting interaction via forums or virtual classrooms, offering flexibility, and enhancing teacher-learner engagement (Wahyuni et al., 2023). This study explores effective methods for improving Arabic listening and speaking skills among Indonesian learners. Using a qualitative approach, data was gathered from literature, expert insights, and analysis via Publish or Perish and Vosviewer. The study (Wahyuni et al., 2023) emphasizes the importance of listening skills in interpersonal communication and outlines various techniques for practicing listening and speaking across different proficiency levels, contributing unique insights to the field.

Other studies by (DiNapoli and Miller, 2022) examine the importance of the significance of conceptual thinking in problem-solving and argue that individuals must develop a profound understanding of a problem's underlying concepts and principles to solve it effectively. Similarly, Shanta and Wells (2022); Thornhill-Miller et al. (2023) claimed that conceptual thinking is a critical element of creativity, as it allows individuals to generate new ideas and solutions by connecting disparate concepts and ideas. A study by Santana et al. (2022) establishes that conceptual thinking is completely associated with academic achievement and (Hommel et al., 2022) cognitive flexibility.

Their study also recommends the crucial factor in preparing students for success in the 21st-century workplace. Moreover, other revisions have underlined the role of conceptual thinking in several fields such as science education (Hurt et al., 2023), mathematics education (Monteleone et al., 2023), and engineering education (Sharma and Kumar, 2023). Overall, conceptual thinking is an energetic skill that plays a critical role in problem-solving, creativity, academic success, and success in the workplace (Li et al., 2023). A study by Santana et al. (2022) and Taslidere and Yıldırım (2023) also evaluates the conceptual thoughtful and conceptual change in education sciences. These assessments examine the role of conceptual understanding and conceptual change in learning, highlighting the importance of conceptual thinking in knowledge acquisition and problem-solving.

Conceptual revolution through guided thought—This assessment emphasizes the process of guided abstraction, which involves breaking down complex ideas into more manageable parts to encourage conceptual understanding and rationale (Jokela et al., 2022). Conceptual thinking and individual variances—this review examines individual differences in conceptual thinking, comprising the role of cognitive and personality factors in shaping this cognitive skill. Overall, these recent literature reviews highlight the continuing importance of conceptual thinking in a variety of contexts, including education, psychology, and science. The studies also point to the need for continued research to better recognize the factors that shape this critical cognitive skill and how it can be efficiently developed and useful in practice.

3.2. E-learning and glossary

The studies indicated in the literature also investigated the Glossary effect in online learning and the relationship between the number of terms in a glossary and learning outcomes in an online learning environment (Gökçearslan et al., 2023; Haddaway et al., 2023; Stevens et al., 2023). Results showed that the use of a glossary

improved learning outcomes, particularly for students who were struggling with the course content (Tekin et al., 2020). This revision discovers the application of the flipped classroom model in an online medical terminology course. Learners engaged in asynchronous activities with interactive multimedia content and applications, and synchronous activities focused on collaborative learning, problem-solving, and discussion. Quantitative data on system usage, questionnaire responses, and academic achievement, along with qualitative data on learners' opinions, were collected.

The results revealed a significant relationship between learners' academic achievement, perceptions of deep learning, and time spent on learning activities. However, learners also identified challenges with time expectations, instructional materials, and instructor guidance in the flipped classroom (Davies et al., 2023).

The 'Erasmus + -Health-EDU' project aims to understand oral health professional education in Europe using web surveys and online toolkits, while Articulate aims to create a shared European language for OHP education terms and concepts. Glossary improved learners' understanding of course materials and their overall science knowledge (North et al., 2022).

A shared effort by the 'neuromodulation 'the Institute of 'neuromodulation', and the International 'neuromodulation society also provides an updated glossary for the 'neurostimulation' community. The glossary includes 91 defined terms, expanded to cover spinal cord, peripheral nerve, dorsal root ganglion, deep brain, and motor cortex stimulation, which is available in print and online to help facilitate communication, and prevent misuse of 'neurostimulation' terms and will continue to be expanded in web editions (Haddaway et al., 2023). A strategy for improving education in the Gulf and India was proposed in (Rashid Al-Shamsi and Shannaq, 2024), emphasizing the need for new interactive tools to enhance student learning. Another study suggested investigating and implementing these tools and methods through mobile applications, recognizing the integral role mobile devices play in our lives (Shakir et al., 2024; Shannaq, 2024c). A glossary is provided to aid review authors in selecting appropriate methods, justifying and reporting them, and ensuring consistent nomenclature. This resource aims to assist authors, editors, reviewers, and readers in understanding and evaluating reviews based on their intended use. More Information related to E-learning can be found in Al-Shamsi et al. (2023); Maulana et al. (2023); Shannaq et al. (2023); Shannaq et al. (2023); Shannaq et al. (2019); Shannaq (2020).

The literature review reveals a lack of integration between glossary and e-learning tools. Additionally, no real online systems were found except for the mentioned work: https://taerproject.com/.

The significance of the chosen topic lies in addressing one of the most crucial issues in the modern information society: the production, storage, processing, structuring, and sale of information. These challenges are among the most prominent today, necessitating a thorough examination of not only the process of cognition but also the essence, structure, and functioning of information. In most Gulf region universities, the English language is the formal language of instruction. The role of an instructor teaching Arab natives in English whether in technical subjects or literature, includes the development of speech and vocabulary enrichment, often with the aid of dictionaries. English language lessons for non-native speakers, such as Arab Native, focus on expanding vocabulary.

Vocabulary, by definition, is a set of words representing objects, phenomena, and concepts that a person knows, forming their lexicon. Integrating semantic dictionaries into the process of teaching English and incorporating them into the educational and methodological framework across various subjects, is crucial for acquiring lexicographic information. Educators need to provide students with accessible information about dictionaries and teach them how to use these "helper dictionaries" effectively, ensuring they accumulate relevant experience. In the current educational process, the linguistic essence of dictionaries is diminishing, with dictionaries being used less frequently.

3.3. Analysis and viability of the study

The focus of this study is based on the electronic thesaurus TGE in teaching English to non-native speakers, particularly Arab natives. Using definitions from semantic thesauri and glossaries helps expand students' active vocabulary, clarify their understanding of word meanings, teach them to use words in new contexts, and improve literacy. However, vocabulary words used in textbooks are often limited to covered topics and only appear in vocabulary dictations, which limits their effectiveness. A single encounter with a vocabulary word, even with independent study yields little effect.

The structure of TGE, while generally consistent, shows some variations examined during our experiment. Key differences between a thesaurus and a semantic dictionary include:

- A thesaurus includes lexical units and presents meanings through a tree structure with single keywords.
- A semantic dictionary consists of words and semantic units, revealing concepts with multiple words and meanings.

Our analysis of TGE revealed that it encompasses a wide range of concepts, including both every day and scientific terms. Everyday words are typically more understandable with superficial and easily accessible meanings. In contrast, scientific terms contain deeper meanings, posing comprehension challenges for students.

When using TGE in education, the following approaches should be considered:

- Individual and differentiated approach: This approach creates varied learning conditions for different classes and groups, considering their unique characteristics.
- Personal-activity approach: This approach revolves around the student, emphasizing their motivations, objectives, and psychological characteristics.
- Systematic approach to pedagogy: This approach views pedagogy as a system—a set of well-structured, interconnected elements.

The research highlights the informatization of society, the education system, teaching activities, and the essence of information technologies in education. The study utilized theoretical analysis, including observation, description, classification, and an analysis of TGE's structure. This work evaluates the application of electronic TGE in the educational process.

3.4. Examining the significance of conceptual thinking and study results

It is important to note that the current e-learning technologies available do not integrate both a thesaurus and a glossary into a single tool, making direct comparisons challenging. Additionally, implementing other tools in our educational system would require significant resources and permissions from the university's institutional effectiveness. Therefore, our presented work, "An intelligent online human-computer interaction tool for adapting educational content to diverse learning capabilities across Arab cultures: challenges and strategies" stands as a novel and innovative approach. It addresses unique issues than other learning tools, particularly by considering the varying capabilities of Arab natives who study in a university setting where English is the primary medium of instruction. This tool is designed to provide tailored educational content, which is crucial for improving learning outcomes for this specific student population.

Through the provision of an engaging and dynamic learning environment, the TGE tool dramatically improves conceptual thinking. According to the results of our study, students who used TGE significantly improved their understanding and application of complicated concepts—as demonstrated by an 85% improvement in performance. This enhancement highlights how well the tool promotes deeper cognitive involvement, which is essential for conceptual thinking.

How higher-order thinking skills are promoted by TGE—The TGE tool incorporates characteristics that are in line with Bloom's new taxonomy to encourage HOTS. These features include:

- Analyzing: TGE helps students identify patterns, dissect material into its constituent parts, and comprehend underlying structures. As an example, the tool offers associative maps that create links between similar phrases and concepts, assisting students in understanding the relationships between various bits of information.
- Evaluating: By contrasting various sources and viewpoints, TGE enables students to evaluate and critically analyze material. Different definitions and points of view are presented via the interactive thesaurus and glossary functions, which promote critical analysis.
- Creating: TGE encourages creativity by letting students combine new concepts with previously learned information. Students' ability to solve problems creatively is enhanced by the tool's AI-driven recommendations, which assist them in making new connections and hypotheses.

Connecting the results of research to HOTS theories - The results of our study support well-established HOTS hypotheses, including those put forth by Bloom and Anderson. The development of these abilities is reflected in the observed improvement in student learning outcomes. According to student feedback, for instance, TGE made difficult topics more approachable and interesting. This is in line with the theory that more interactive and adaptable learning resources might improve cognitive processing.

An illustration of TGE in operation - Take an information system subject where the notion of database normalization is required of the students. With TGE, pupils can:

- Examine the normalization process with interactive graphs that deconstruct each stage.
- Compare definitions and examples from various sources to assess various normalization forms.

- With the help of generative AI recommendations that guarantee logical coherence, they construct their database structures.
- These exercises foster critical and imaginative thinking in addition to improving comprehension.

The TGE tool's design and functionality directly contribute to the development of HOTS by offering a comprehensive and interactive learning experience.

4. Conclusion

The TGE tool's design and functionality directly contribute to the development of HOTS by offering a comprehensive and interactive learning experience. The major goal of this study which was to design the thesaurus glossary e-learning (TGE) technique to solve the learning obstacles faced by students from varied cultural backgrounds, was effectively accomplished. The TGE tool efficiently illustrates, according to students' learning capacities, relevant concepts (thesaurus) and their definitions (glossary). Through the process of learning from students' word selection behavior, TGE modifies term complexity to make sure each student is provided with the material at an appropriate level. Additionally, TGE has shown to be a successful online learning resource that can be used by any student at any time and from any location, which improves the quality of the learning process overall.

This work highlights the significance of e-learning tools in facilitating knowledge transfer and emphasizes the need for these tools to go beyond knowledge acquisition by promoting critical thinking skills. The TGE tool, developed in this work, to enhance conceptual thinking in up-to-date educational practices. Through research conducted at a private university in Oman, integrating the TGE tool in designated information systems subjects resulted in a significant enhancement in the performance of 85% of students, with an average growth of 19%. The investigation of 141 survey responses confirmed that students had a significantly more positive attitude towards the new learning method. A statistical significance indicates that it was attractive and effective in enhancing their overall learning experience.

The results suggest that the presented work can serve as a novel and intelligent e-learning teaching method. It has the competence to attract traditional, smart, and digital universities leading to improved student outcomes, particularly in the development of conceptual thinking skills. These discoveries suggest that the TGE tool has the potential to serve as an innovative and effective e-learning teaching method, benefiting modern digital universities and enhancing student outcomes related to conceptual thinking skills.

5. Future research

It is important to highlight that current e-learning technologies do not integrate both a thesaurus and a glossary into a single tool making direct comparisons very challenging. Additionally, implementing alternative tools in our educational system would require significant resources and permissions from the university's quality departments. Therefore, our study presents an innovative approach with unique challenges and considerations. In the future, this work will extend and integrate the

proposed TGE by incorporating voice services to facilitate voice interactions for students.

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References

Alkhateeb, A., & Alhawsawi, S. (2023). Challenges in Incorporating English as the Medium of Instruction at King Saud bin Abdulaziz University for Health Sciences. Arab World English Journal, 14(3), 110–123. https://doi.org/10.24093/awej/vol14no3.7

Alkiyumi, M. (2024). New Classification of Higher-Order Thinking Skills (HOTS). Onomázein, 62, 1053–1064.

Al-Shamsi, I. R., Shannaq, B., & Devarajanayaka, K. M. (2023). A Comparative Analysis of the Service Quality in Public and Private Company Telecommunication Services. In: Arai, K. (editor). Advances in Information and Communication. Springer Nature Switzerland. pp. 167–186. https://doi.org/10.1007/978-3-031-28076-4_15

Amanzhol, N., Amanova, A., Kerimbekova, B., et al. (2023). "My expectation did not meet reality": challenges of undergraduate students in English-medium instruction in Kazakhstan. Asian Education and Development Studies, 13(1), 31–44. https://doi.org/10.1108/aeds-06-2023-0062

Arif, M., & Aldosary, A. S. (2023). Urban Spatial Strategies of the Gulf Cooperation Council: A Comparative Analysis and Lessons Learned. Sustainability, 15(18), 13344. https://doi.org/10.3390/su151813344

Arviani, F. P., Wahyudin, D., & Dewi, L. (2023). The Effectiveness of Problem-Based Learning Model in Improving Students' Higher Order Thinking Skills. JPI (Jurnal Pendidikan Indonesia), 12(4), 627–635. https://doi.org/10.23887/jpiundiksha.v12i4.65606

Badoi-Hammami, M. (2023). Utilizing neuroscience research to enhance learning strategies and optimize curriculum design. International Journal of Advanced Research, 11(09), 797–811. https://doi.org/10.21474/IJAR01/17588

Cairns, D. (2023). Understanding of Environmental Issues Across Two Gulf Countries: Do Girls Know More Than Boys in UAE Schools? In: Dickson, M., McMinn, M., & Cairns, D. (editors). Gender in STEM Education in the Arab Gulf Countries. Springer Nature Singapore. pp. 173–194. https://doi.org/10.1007/978-981-19-9135-6_7

Darwis, R. H., Alimuddin, & Patimbangi, A. (2024). Higher Order Thinking and Critical Thinking Skills in Problem-Based Learning Environments: A Systematic Review. Journal of Learning and Development Studies, 4(2), 21–33. https://doi.org/10.32996/jlds.2024.2.2.3

Davies, J. R., Field, J., Dixon, J., et al. (2023). Articulate: A European glossary of terms used in oral health professional education. European Journal of Dental Education, 27(2), 209–222. https://doi.org/10.1111/eje.12794

DiNapoli, J., & Miller, E. K. (2022). Recognizing, supporting, and improving student perseverance in mathematical problem-solving: The role of conceptual thinking scaffolds. The Journal of Mathematical Behavior, 66, 100965. https://doi.org/10.1016/j.jmathb.2022.100965

ElJishi, Z., Abdel-Hameed, F. S. M., Khuddro, A., et al. (2024). Translating Bloom's Taxonomy Action Verb List into Arabic for Teacher Preparation Programs: Challenges/Problems and Solutions. International Journal of Education and Literacy Studies, 12(1), 295–303. https://doi.org/10.7575/aiac.ijels.v.12n.1p.295

Gökçearslan, Ş., Yildiz Durak, H., & Esiyok, E. (2023). Emotion regulation, e-learning readiness, technology usage status, in-class smartphone cyberloafing, and smartphone addiction in the time of the COVID-19 pandemic. Journal of Computer Assisted Learning, 39(5), 1450–1464. https://doi.org/10.1111/jcal.12785

Gradini, E., Umar, A., Firmansyah, F., et al. (2024). Fostering Higher Order Thinking Skills in Mathematics Learning: A Scoping Review of Teacher Development Initiatives. Unram Journal of Community Service, 5(1), 9–14. https://doi.org/10.29303/ujcs.v5i1.570

Habeeb, K. (2024). Assessing the role of methods in teaching courses in improving student/teachers' instructional skills and attitudes toward STEAM education in kindergartens. Education and Information Technologies. https://doi.org/10.1007/s10639-024-12541-1

Haddaway, N. R., Lotfi, T., & Mbuagbaw, L. (2023). Systematic reviews: A glossary for public health. Scandinavian Journal of Public Health, 51(1), 1–10. https://doi.org/10.1177/14034948221074998

Hines, M.G. (n.d.). Teaching English Abroad in the Middle East. Available online: https://www.transitionsabroad.com/listings/work/esl/articles/teaching-english-abroad-in-the-middle-east.shtml (accessed on 7 July 2024).

Hommel, B. E., Ruppel, R., & Zacher, H. (2022). Assessment of cognitive flexibility in personnel selection: Validity and acceptance of a gamified version of the Wisconsin Card Sorting Test. International Journal of Selection and Assessment, 30(1), 126–144. https://doi.org/10.1111/ijsa.12362

Hurt, T., Greenwald, E., Allan, S., et al. (2023). The computational thinking for science (CT-S) framework: Operationalizing CT-S for K-12 science education researchers and educators. International Journal of STEM Education, 10(1), 1. https://doi.org/10.1186/s40594-022-00391-7

Jokela, M., Meriläinen, J., Tukiainen, J., et al. (2022). Personality Traits and Cognitive Ability in Political Selection. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.4166034

Karwadi, K., Zakaria, A. R., & Syafii, A. (2024). A review of the effects of active learning on high order thinking skills: A meta-analysis within Islamic education. Journal of Education and Learning (EduLearn), 18(1), 97–106. https://doi.org/10.11591/edulearn.v18i1.20895

Khalil, R. Y., Tairab, H., Qablan, A., et al. (2023). STEM-Based Curriculum and Creative Thinking in High School Students. Education Sciences, 13(12), 1195. https://doi.org/10.3390/educsci13121195

Khurma, O. A., & Zein, F. E. (2024). Inquiry skills teaching and its relationship with UAE secondary school students' critical thinking: Systematic review of science teachers' perspectives. Eurasia Journal of Mathematics, Science and Technology Education, 20(2), em2397. https://doi.org/10.29333/ejmste/14155

Li, X., Li, Y., & Wang, W. (2023). Long-Lasting Conceptual Change in Science Education: The Role of U-shaped Pattern of Argumentative Dialogue in Collaborative Argumentation. Science & Education, 32(1), 123–168. https://doi.org/10.1007/s11191-021-00288-x

Lucente, A. (2024). The Pros & Cons of Teaching English in the Middle East. Available online: https://www.internationalteflacademy.com/blog/the-pros-and-cons-of-teaching-english-in-the-middle-east (accessed on 2 June 2023).

Maulana, F. I., Febriantono, M. A., Raharja, D. R. B., et al. (2023). Twenty years of e-learning in health science: A bibliometric. Procedia Computer Science, 216, 604–612. https://doi.org/10.1016/j.procs.2022.12.175

Mihret, G., Negussie, D., & Joshi, J. (2024). The Challenges of Teaching English as a Foreign Language in Higher Education: A Systematic Literature Review. Zenodo, 11, 1253–1258. https://doi.org/10.5281/zenodo.11090367

MoldStud. (n.d.). The Role of Human-Computer Interaction in Computer Science Education. Available online: https://moldstud.com/articles/p-the-role-of-human-computer-interaction-in-computer-science-education (accessed on 6 July 2024).

Monteleone, C., Miller, J., & Warren, E. (2023). Conceptualizing critical mathematical thinking in young students. Mathematics Education Research Journal. https://doi.org/10.1007/s13394-023-00445-1

Moshtari, M., & Safarpour, A. (2023). Challenges and strategies for the internationalization of higher education in low-income East African countries. Higher Education. https://doi.org/10.1007/s10734-023-00994-1

Musliha, S., Sudana, D., & Wirza, Y. (2021). The Analysis of Higher Order Thinking Skills (HOTs) in the Test Questions Constructed by English Teachers. Advances in Social Science, Education, and Humanities Research. https://doi.org/10.2991/assehr.k.211119.095

North, R. B., Lempka, S. F., Guan, Y., et al. (2022). Glossary of Neurostimulation Terminology: A Collaborative Neuromodulation Foundation, Institute of Neuromodulation, and International Neuromodulation Society Project. Neuromodulation: Technology at the Neural Interface, 25(7), 1050–1058. https://doi.org/10.1016/j.neurom.2021.10.010

Pratiwi, I., Regina, R., Wardah, W., et al. (2024). Reading Strategies Used by the Students of English Language Education Study Program. Aditya: Journal of Teaching and Education, 6(1), 113–132. https://doi.org/10.30650/ajte.v6i1.3790

Rachmawati, D., Suharno, S., & Roemintoyo, R. (2023). The Effects of Learning Design on Learning Activities Based on Higher Order Thinking Skills in Vocational High Schools. Open Education Studies, 5(1), 20220202. https://doi.org/10.1515/edu-2022-0202

Rani, S. A., Zikriati, Z., Muhammady, A., et al. (2023). Arabic Language Learning Based on Technology (Opportunities and Challenges in the Digital Era). International Journal of Education, Language, and Social Science, 1(1), 1.

Rashid Al-Shamsi, I., & Shannaq, B. (2024). Leveraging clustering techniques to drive sustainable economic innovation in the India–Gulf interchange. Cogent Social Sciences, 10(1), 2341483. https://doi.org/10.1080/23311886.2024.2341483

Sadriwala, K. F., Shannaq, B., & Sadriwala, M. F. (2024). GCC Cross-National Comparative Study on Environmental, Social, and Governance (ESG) Metrics Performance and Its Direct Implications for Economic Development Outcomes. In: Awwad, B. (editor). The AI Revolution: Driving Business Innovation and Research. Springer Nature Switzerland. pp. 429–441. https://doi.org/10.1007/978-3-031-54383-8_33

Salihah, N. M., & Prayudha S, J. (2022). Analysis of Higher Order Thinking Skills (HOTS) in Online Learning by English Teacher. Journal of Language Intelligence and Culture, 5(1), 75–94. https://doi.org/10.35719/jlic.v5i1.114

Santana, A. N. D., Roazzi, A., & Nobre, A. P. M. C. (2022). The relationship between cognitive flexibility and mathematical performance in children: A meta-analysis. Trends in Neuroscience and Education, 28, 100179. https://doi.org/10.1016/j.tine.2022.100179

Segumpan, R. G., & McAlaney, J. (2023). Challenges and Reforms in Gulf Higher Education: Confronting the COVID-19 Pandemic and Assessing Future Implications. Taylor & Francis.

Shakir, M., Al Farsi, M. J., Al-Shamsi, I. R., et al. (2024). The Influence of Mobile Information Systems Implementation on Enhancing Human Resource Performance Skills: An Applied Study in a Small Organization. International Journal of Interactive Mobile Technologies (iJIM), 18(13), 37–68. https://doi.org/10.3991/ijim.v18i13.47027

Shannaq, B, Saleem, I., & Shakir, M. (2023). Maximizing Market Impact: An In-depth Analysis of the Market Penetration Strategy and its Effective Tools for Sales Growth and Brand Expansion in the E-commerce Markets of Oman and Bahrain. In: The AI Revolution: Driving Business Innovation and Research, 2nd ed. Springer.

Shannaq, B. (2020). Machine Learning Model-Ensuring Electronic Exam Quality using Mining Association Rules. International Journal of Advanced Science and Technology, 29(3), 12136–12146.

Shannaq, B. (2024a). Digital Formative Assessment as a Transformative Educational Technology. In: Arai, K. (editor). Advances in Information and Communication. Springer Nature Switzerland. pp. 471–481. https://doi.org/10.1007/978-3-031-54053-0_32

Shannaq, B. (2024b). Enhancing Human-Computer Interaction: An Interactive and Automotive Web Application—Digital Associative Tool for Improving Formulating Search Queries. In: Arai, K. (editor). Advances in Information and Communication. Springer Nature Switzerland. pp. 511–523. https://doi.org/10.1007/978-3-031-54053-0_35

Shannaq, B. (2024c). Unveiling the Nexus: Exploring TAM Components Influencing Professors' Satisfaction with Smartphone Integration in Lectures: A Case Study from Oman. TEM Journal, 2365–2375. https://doi.org/10.18421/TEM133-63

Shannaq, B., & Al Shamsi, I. (2024). Integrating Digital Transformation: Analyzing New Technological Processes for Competitiveness and Growth Opportunities in the Oman Economy. In: Awwad, B. (editor). The AI Revolution: Driving Business Innovation and Research. Springer Nature Switzerland. pp. 443–454. https://doi.org/10.1007/978-3-031-54383-8_34

Shannaq, B., Al Shamsi, I., & Majeed, S. N. A. (2019). Management information system for predicting quantity materials. TEM Journal, 8(4), 1143–1149.

Shannaq, B., Devarajanayaka, K. M., Shakir, M., et al. (2023). Generating an integrated SWOT strategy from the SERVQUAL survey results-the need for a comparative assessment of telecommunication companies in Oman. AIP Conference Proceedings. https://doi.org/10.1063/5.0188360

Shanta, S., & Wells, J. G. (2022). T/E design-based learning: Assessing student critical thinking and problem-solving abilities. International Journal of Technology and Design Education, 32(1), 267–285. https://doi.org/10.1007/s10798-020-09608-8

Sharma, G. V. S. S., & Kumar, S. (2023). Thinking Through Art—A creative insight into mechanical engineering education. Thinking Skills and Creativity, 49, 101341. https://doi.org/10.1016/j.tsc.2023.101341

Stevens, E. A., Leroux, A. J., Mowbray, M. H., et al. (2023). Evaluating the Effects of Adding Explicit Vocabulary Instruction to a Word-Problem Schema Intervention. Exceptional Children, 89(3), 275–293. https://doi.org/10.1177/00144029221112290

Taderera, F. (n.d.). Looking at Oman and Global Higher Education in terms of Quality, Assessment, and Employability. Available online: https://irjems.org/irjems-v3i6p122.html (accessed on 6 July 2024).

Taslidere, E., & Yıldırım, B. (2023). Effect of Conceptual Change–Oriented Instruction on Students' Conceptual Understanding and Attitudes Towards Simple Electricity. International Journal of Science and Mathematics Education, 21(5), 1567–1589. https://doi.org/10.1007/s10763-022-10319-w

Tekin, P. S., Ilgaz, H., Afacan Adanir, G., et al. (2020). Flipping e-Learning for Teaching Medical Terminology: A Study of Learners' Online Experiences and Perceptions. Online Learning, 24(2). https://doi.org/10.24059/olj.v24i2.2030

Thornhill-Miller, B., Camarda, A., Mercier, M., et al. (2023). Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. Journal of Intelligence, 11(3), 54. https://doi.org/10.3390/jintelligence11030054

Wahyuni, S., Ritonga, M., & Afrianti, W. (2023). Systematic Review of Learning Method for Teaching Arabic Listening and Speaking Skills. Al-Hayat: Journal of Islamic Education, 7(1), 30. https://doi.org/10.35723/ajie.v7i1.321

Wang, L. (2024). A Systematic Literature Review of The Effective of Problem-Based Learning in Blended Learning Environment. Educational Administration: Theory and Practice, 9877–9892. https://doi.org/10.53555/kuey.v30i5.1183

Zhu, X.W., & Tahir, S. (2023). A Study of Differences in Higher-order Thinking Skills among Higher Education in Blended Learning. International Journal of Academic Research in Progressive Education and Development, 12(4), 674-684. https://doi.org/10.6007/IJARPED/v12-i4/19886