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Exploring Chemistry Teachers' Views on the Opportunities and Constraints of Using Graphically Enhanced Teaching in Cycle 3 Classes in the UAE

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Abstract

Background/purpose. This study investigates the perceptions of Chemistry teachers and students in UAE public schools regarding the use of graphically enhanced teaching (GET) in grade 12 Chemistry classes. The study addresses the need to explore the benefits, challenges, and opportunities of integrating visual aids, simulations, and other graphical elements into Chemistry education.

Materials/methods. Data were collected using a quantitative approach from 71 Chemistry teachers and 81 students. Surveys were designed to assess the effectiveness of GET in enhancing student interest and understanding of Chemistry topics, with specific attention to gender differences and educational tracks (General and Advanced streams).

Results. Findings reveal that Chemistry teachers generally perceive GET as effective in improving student engagement and comprehension. Advanced track students reported greater benefits from GET than their General track peers. Teachers identified challenges such as resource limitations and the need for professional development.

Conclusion. GET demonstrates significant potential for enhancing Chemistry education in UAE public schools. Addressing the identified challenges can further amplify its benefits, supporting more engaging and effective teaching practices.

1. Introduction

Technological advancements have significantly transformed teaching and learning techniques in recent years, with the COVID-19 pandemic further accelerating the shift toward technology in mainstream education. This paradigm shift has led educators to explore innovative approaches for addressing the challenges high school chemistry students face, particularly in fostering meaningful learning experiences. Students often struggle with conceptual understanding of the subject, while teachers face obstacles in facilitating effective instructional strategies.

Stojanovska et al. (2020) identified several factors that influence chemistry education, including teacher motivation, laboratory resources, teaching methods, and opportunities for professional development. To overcome these challenges, graphically enhanced teaching (GET)—which incorporates visual aids such as images, animations, and graphical representations to support learning—has emerged as a promising pedagogical tool. Research has demonstrated its efficacy across diverse disciplines.

Teplá et al. (2022) demonstrated that 3D models, animations, and other visual aids significantly enhance students' intrinsic motivation and engagement, particularly in science subjects such as chemistry. Educators can promote deeper engagement with the material by integrating these visual elements, helping students better understand complex chemistry topics.

The UAE education system, characterized by rapid development and a dynamic environment, offers a unique context for exploring innovative teaching strategies (Abazar, 2021). The UAE government has sought to integrate research-based evidence into its educational reforms by aligning its educational philosophy and strategic plans with global standards. However, there is limited research on the perceptions of chemistry teachers and students regarding the benefits and challenges of GET in the UAE public schools. This gap in the literature provides an impetus for further investigation into the impact of GET on chemistry teaching and learning in the UAE.

1.1. Statement of the Problem

Image- and graphics-based teaching methods have gained prominence in chemistry education (Bobek & Tversky, 2016). Ali (2012) emphasized the critical role of mastering chemistry concepts for student engagement and effective learning. Therefore, chemistry educators should implement effective teaching strategies to convey essential knowledge. Among these strategies, GET stands out as it incorporates graphically enriched instructional approaches, including real-life examples and probing questions, to actively engage students (Bobek & Tversky, 2016).

Despite these efforts, PISA assessments have consistently shown that UAE students perform below the global average in science education. According to the 2022 PISA report, the performance of UAE students in science, including chemistry, will remain below international benchmarks (OECD, 2022). Edelsztein et al. (2020) advocated context-based teaching methods that emphasize real-world applications to improve conceptual understanding in chemistry. Similarly, Teplá et al. (2022) highlighted the advantages of visual aids, 3D models, and animations for achieving educational objectives across scientific disciplines.

Although the existing body of research provides valuable insights into the benefits of GET in science education, there is a lack of empirical evidence regarding its specific impact on chemistry education in the UAE This underscores the need for further research to explore the implementation of GET in cycle three chemistry classes within UAE public schools, and its potential to improve student engagement and performance.

1.2. Purpose of the Study

The purpose of this study was to:

Investigate the perspectives of chemistry teachers and students on the advantages and challenges of implementing GET methods in cycle three chemistry classes in UAE public schools.

Examine the impact of teachers' gender on their views on implementing GET methods.

To explore the influence of students’ educational paths (General or Advanced) on their perceptions of the effectiveness of visual aids and graphical elements in teaching and learning processes.

1.3. Research Questions

To achieve the aforementioned objectives, the study addressed three key research questions:

1. What are the perceptions of chemistry teachers and students regarding the advantages and challenges of implementing graphically enhanced chemistry teaching?
2. How do teachers' genders affect their views on implementing graphically enhanced chemistry teaching?
3. How does a student's educational path (General or Advanced) influence their views on using visual aids and graphical elements in chemistry teaching?

1.4. Significance of the Study

This study is significant because it explores the benefits, challenges, and opportunities of integrating GET into chemistry education within UAE public schools. By addressing the identified research gaps, this study offers valuable insights into three key questions related to the effectiveness of GET methods in fostering student engagement and comprehension.

Drawing from extensive experience in teaching cycle three chemistry, this study highlights the effectiveness of visually enhanced teaching methods, particularly when explaining complex topics such as chemical bonding and acids and bases. Visual aids, such as diagrams and graphs, have proven instrumental in clarifying intricate concepts, such as acid-base distinctions, pH scale applications, and various bond types. In addition, this approach helps address language barriers, making learning more accessible.

The findings of this study are expected to contribute to the field of chemistry education by underscoring the importance of visual teaching methods in improving student learning outcomes. Visual representations, including graphs and images, simplify abstract concepts and foster a deeper understanding of the materials. The results of this study have the potential to enhance both instructional practices and student performance in cycle three chemistry classrooms.

1.5. Theoretical Framework

This research is grounded in two primary theories: the Visual Learning Style theory and Ausubel's Meaningful Learning Theory, both of which provide valuable insights into the ways in which graphical enhancements in instruction can influence learning outcomes in chemistry.

1.6. Visual Learning Style Theory

Visual Learning Style theory suggests that visual learners process and retain information more effectively when presented with diagrams, charts, or other visual formats. In chemistry, where abstract concepts, such as atomic structures and reaction mechanisms, are often difficult to grasp, GET can translate these ideas into more accessible visual representations. Visual learners benefit from this approach because it simplifies complex chemical processes into formats that are easier to understand (Kirby, Moore & Schofield, 1988).

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1.7. Ausubel's Meaningful Learning Theory

Ausubel's Meaningful Learning Theory emphasizes the role of prior knowledge in new learning experiences—that is, new information is best understood when it is related to concepts that the learners already know. GET facilitates this process by organizing new information and linking it to existing knowledge structures. For instance, conceptual diagrams in chemistry can help students integrate new knowledge of chemical reactions into their understanding of molecular structures (Blanton & Tuinman, 1973).

2. Literature Review

Edelsztein et al. (2020) contended that context-based teaching integrating real-life applications can significantly enhance students' comprehension of chemistry. Visual aids such as concept maps, extension diagrams, and object-based methodologies are particularly effective in helping students grasp chemistry concepts (Rahmawati et al., 2019). Teplá et al. (2022) further emphasized the advantages of GET in science education, noting that these strategies increase student interest, comprehension, and retention of chemistry topics. The integration of visual aids simplifies complex subjects and enhances the overall educational experience by accommodating various student preferences and learning styles through multimedia and interactive teaching methods.

Students often struggle with comprehending fundamental scientific concepts, such as vectors, owing to both formal and informal learning challenges (Tairab et al., 2020). The incorporation of practical instructional tools is essential for meeting educational goals in chemistry. Stammes et al. (2020) highlighted the critical role of instructional design in improving learning outcomes, although its benefits have not always been fully recognized. Edelsztein et al. (2020) suggested that teachers should utilize clear and accessible methods, such as guided lab-based exercises and common materials, to help students cope with the changing demands of applied learning.

Indriyanti et al. (2020) proposed that multiple representations, including graphs, diagrams, tables, texts, animations, sounds, and videos, should be incorporated into chemistry education to explain scientific concepts effectively. Permatasari et al. (2022) supported this view, arguing that using various representations improves students' conceptual understanding. Their review of 11 studies (2012-2021) shows that using multiple representations in chemistry positively impacts students' comprehension and performance (Lee et al., 2021). Furthermore, Stull et al. (2018) added that this approach reduces cognitive load, improves self-efficacy, and minimizes misconceptions among chemistry students.

Ulva et al. (2021) argued that examining different display options, such as pictures and graphical representations, can provide critical insights into chemistry learning processes. According to Abarro and Asuncion (2021), multiple representations, particularly graphical ones, play key roles in introducing scientific concepts.

Research has demonstrated that graphical representations in chemistry improve students' ability to interpret and comprehend chemistry concepts (Chan et al., 2021). However, student understanding can be affected by their ability to interpret the visual aids used by teachers. Idika (2021) examined how a Visualized Case-Based Learning (V.C.B.L.) approach affected Grade 12 chemistry students' academic achievement in Ibadan, Nigeria. A sample of 145 students was assessed and the study concluded that the V.C.B.L. method improved students' understanding and facilitated learning transfer.

Monnot et al. (2020) reviewed previous studies and found that GET can significantly contribute to achieving educational goals in chemistry (Holme, 2020). The literature highlights several key findings, particularly regarding the positive impact of visual aids and graphical tools on student comprehension of complex concepts in chemistry. Rahmawati et al. (2019) and Teplá et al. (2022)

emphasized the potential of graphical tools to boost student engagement, understanding, and retention.

However, most studies in this field employ qualitative and descriptive approaches, frequently utilizing case studies, experiments, and surveys to gather insights from teachers and students. While these methods provide rich contextual data, there remains a need for more robust quantitative research to validate these findings across broader and more diverse educational settings. Another notable gap in the literature is the limited exploration of the teachers' challenges in implementing GET methods. Although the benefits are well documented, there is less focus on practical constraints such as the need for additional resources, time, and training. Furthermore, the literature lacks a deeper understanding of how students with varying learning preferences, including variations influenced by gender, respond to these methods (Tairab et al., 2020; Edelsztein et al., 2020).

In conclusion, the literature broadly supports the effectiveness of graphically enhanced and system-based teaching methods in improving chemistry education. However, it also highlights the significant gaps in understanding the full scope of implementation challenges and the need for quantitative studies to assess the scalability of these strategies across diverse educational contexts. Future research should address these gaps by investigating the practical obstacles and differential impacts on diverse student groups to provide valuable insights for enhancing educational strategies in chemistry classrooms.

3. Methodology

3.1. Context

This study focuses on public schools in the UAE, which have undergone substantial educational reforms to improve outcomes. One such major initiative was the 2006 Public-Private Partnership (PPP) School Improvement Project in Abu Dhabi. In collaboration with the Abu Dhabi Education Council (ADEC), this project involved private education providers sharing international best practices to elevate the quality of teaching and learning (Thorne, 2011).

A significant reform in public education was the establishment of a "New School Model" in 2010. This model introduced a student-centered curriculum enriched with technology, aligned with research-based methods, and delivered in modern facilities. It emphasized critical thinking and was tailored to accommodate various learning styles, while also promoting the cultural and national identity of Emirati youth (Eranpalo, Jorgenson, & Woolsey, 2016).

Furthermore, in 2021, the establishment of Emirates Schools was formed to advance public education in line with the UAE's vision of the future. This initiative underscores the government's commitment to implementing development programs across public schools and kindergartens to ensure high-quality education for all students (Emirates School Establishment n.d.).

3.2. Research Design

This study adopted an exploratory descriptive design to investigate the perspectives of chemistry teachers and students in UAE public schools on the integration of GET methods. The exploratory aspect aims to gain insight into how cycle three chemistry teachers incorporate visual aids into their instruction, whereas the descriptive element captures teachers' attitudes and challenges.

Quantitative data collection methods such as surveys and structured observations were employed to gather comprehensive insights from teachers regarding the use of visual aids. This design allows for flexibility and adaptability, which are crucial for studying the complexities of chemistry education in the UAE. The exploratory nature of this study serves as a pilot study to refine the data collection methods and identify challenges that will guide further research.

3.3. Participants and Selection Process

The primary participants in this study were chemistry teachers and students from the UAE public schools. Public schools in the UAE were selected because they adhere to the standardized curriculum and assessment system set by the Ministry of Education. This consistency ensures that the data collection is reliable and comparable across schools. In addition, public schools serve students from diverse socioeconomic backgrounds, providing a more representative sample for understanding broader educational trends. This focus also facilitated access to schools for research purposes.

Convenience sampling was used to select participants. As described by Philip (2013), convenience sampling is a non-random and non-probability sampling method that is frequently chosen because of its ease of implementation. In this study, 71 chemistry teachers from various public schools and 81 Grade 12 students from a single public school were selected.

The teacher sample included those currently teaching the cycle three chemistry curriculum and with at least one year of teaching experience. Following ethical guidelines, teachers and students were contacted via email after obtaining their contact information from school administrators. Informed consent was obtained from all the participants. The teacher sample consisted of 41 females and 30 males, while the student sample included students from both General and Advanced tracks in grade 12.

3.4. Instruments

The researchers developed two separate surveys to gather opinions on the advantages and challenges of graphically enhanced chemistry teaching. Based on empirical evidence, one survey was designed for teachers and the other for students. These surveys aimed to collect information on the effectiveness of graphical tools in enhancing student engagement and understanding of chemistry lessons. Sixteen items were included in the teachers' questionnaire and twelve in the students' questionnaire, capturing various perspectives on the effectiveness of GET tools. The questionnaire used a five-point Likert scale ranging from "strongly disagree" to "strongly agree".

The instrument-development process focused on ensuring content and construct validity. A thorough literature review informed the creation of the questionnaire items, ensuring alignment with existing research on chemistry education and GET methods. The validity of the instruments was tested by administering questionnaires to a panel of experts including teachers, curriculum developers, and consultants from the Ministry of Education (M.O.E.). The experts evaluated the relevance and clarity of each item and offered recommendations for refinement. Their feedback helped improve the instrument's overall validity by revising vague items and adding new ones whenever necessary.

3.5. Data Collection and Analysis

The primary data collection tool was an online questionnaire distributed to teachers and students. In an initial explanatory session, the researchers clarified key concepts, such as GET, to ensure that the respondents fully understood the questionnaire content. The student survey was emailed to Grade 12 students at a public girls' school, resulting in 81 responses. The teacher survey was sent to chemistry teachers across various emirates with support from the Emirates Schools Establishment, yielding 71 responses. Respondents were given a four-week period to complete the surveys.

After data collection, the data were meticulously screened and cleaned for inconsistencies or missing values that could affect the analysis validity. Data were analyzed using Statistical Package for the Social Sciences (SPSS). Descriptive statistics were computed to summarize the participants' responses, while independent sample t-tests were performed to compare group differences, specifically between male and female teachers and between general and advanced-stream students concerning the effectiveness of GET in enhancing student engagement and achievement.

3.6. Students' Questionnaire

The student questionnaire comprised two sections: the "perceived benefits of G.E.T." and the "challenges of using G.E.T." in chemistry lessons. Students rated their agreement with each statement on a five-point Likert scale. The thematic grouping of the questionnaire items ensured that each section measured a distinct construct, which was further validated by input from subject matter experts. The "perceived benefits of G.E.T." section focused on items designed to measure the perceived advantages of using graphical tools—such as improving conceptual understanding, boosting engagement, and enhancing laboratory work—while the "challenges of using G.E.T." in chemistry learning focused on the difficulties encountered, including the effectiveness of visual aids and the student's ability to utilize these tools effectively. Both scales demonstrated acceptable reliability, with Cronbach's alpha coefficients above .70, indicating internal consistency.

3.7. Teachers' Questionnaire

The teacher questionnaire comprised two sections. Section 1, titled Advantages and Challenges of GET, included 10 items that focused on three main aspects: the perceived effectiveness of GET, the challenges and barriers to its implementation, and the factors supporting its effective use. For instance, items in this section evaluated how graphical tools influence students' understanding of complex concepts, engagement, and collaboration in Chemistry education, as well as obstacles such as curriculum constraints, student readiness, and teacher proficiency in using graphical tools. Additionally, it assessed the availability of digital resources and collaboration with technology experts to facilitate the effective implementation of GET Section 2, titled Suggestions for Improvement, focused on gathering teachers' perspectives on strategies to enhance the use of GET, such as professional development, improved resource access, and the integration of tailored graphical tools into the curriculum.

3.8. Data Analysis

Data were analyzed using descriptive and inferential statistics. Means and standard deviations were calculated for each item to summarize participants' responses and provide insight into their overall perceptions and variability. Furthermore, a t-test for independent samples was performed to test for statistically significant differences, which may be due to the teachers' gender and student educational paths. The effect size was also calculated for each comparison to estimate the educational value.

4. Results

Research Question 1: What are the perceptions of chemistry teachers and students regarding the advantages and challenges of implementing graphically enhanced chemistry teaching?

4.1. Teachers' Perspectives

Table 1 summarizes the descriptive statistics (mean and standard deviation) for the three domains used to measure teachers' perspectives.

Table 1. Descriptive statistics of the perceived effectiveness, challenges, and GET support

Teacher's Gender	N	Effectiveness of G.E.T.		Challenges of G.E.T.		Support	
		M	SD	M	SD	M	SD
Total	71	4.23	0.73	3.86	0.91	4.16	0.74
Female	41	4.23	0.74	3.71	0.96	4.19	0.77
Male	30	4.22	0.73	4.08	0.82	4.11	0.70

4.2. Perceived Effectiveness of GET.

Teachers rated the effectiveness of GET methods relatively highly, with a mean score of 4.23 (SD = 0.73). This suggests that teachers generally perceive the benefits of these methods in chemistry instruction. Figure 1 illustrates the percentage of responses for each item regarding perceived benefit.

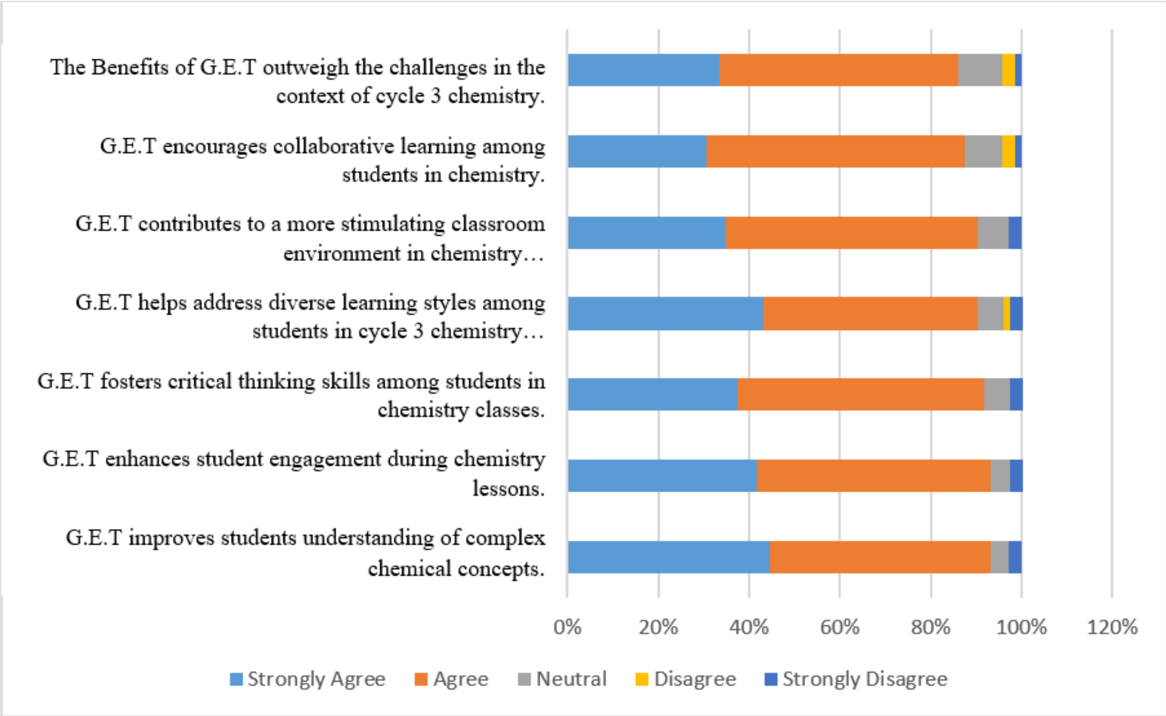

Figure 1. Percentage of responses to perceived benefit

4.3. Challenges and Barriers to Implementing GET.

The average rating for challenges was 3.86, indicating a moderate perception of obstacles in implementing these methods. The variability in responses (SD = 0.91) suggests that perceptions varied more widely compared to Scale 1. Figure 2 shows the percentage of responses for each item on Scale 2.

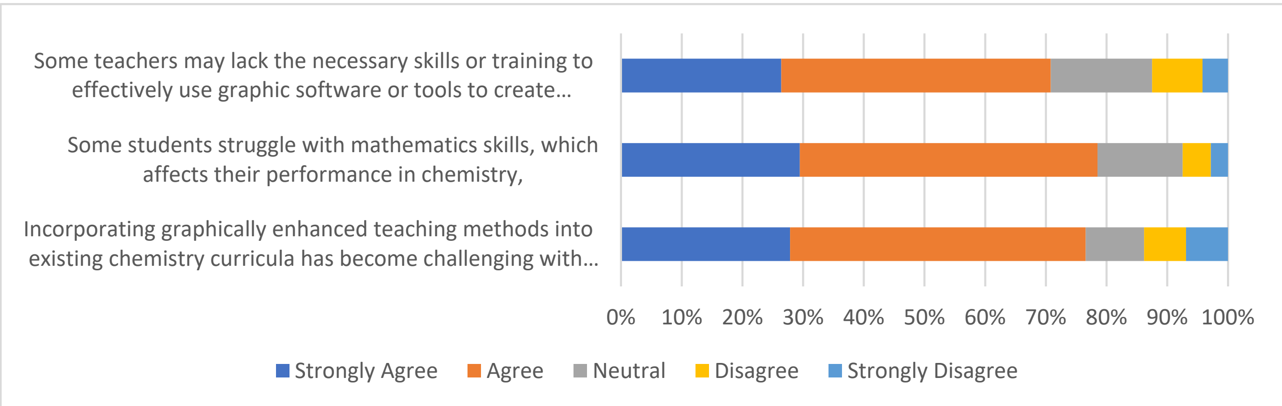

Figure 2. Percentage of responses to items of Scale 2.

4.4. Factors Supporting the Effectiveness of GET.

Participants also rated the supporting factors highly, with a mean of 4.16 (SD = 0.74), suggesting that the conditions supporting these teaching methods are favorable. The following graph provides a breakdown of the responses for Scale 3. Figure 3 provides a breakdown of the responses to Scale 3.

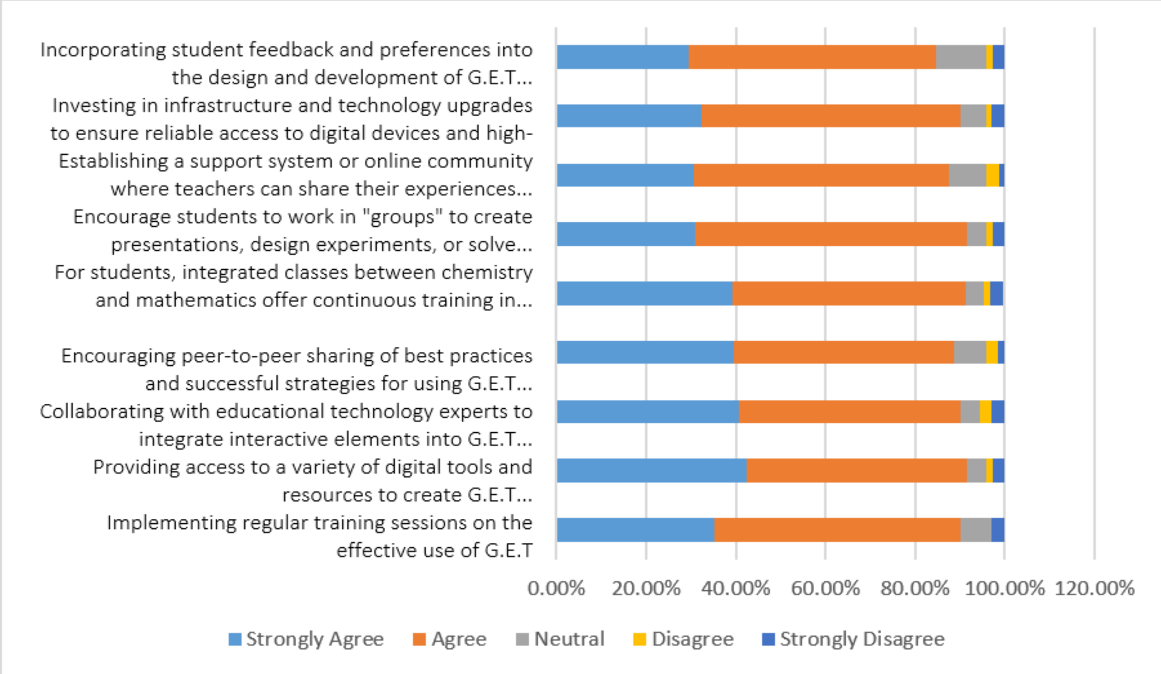

Figure 3. Breakdown of the responses for Scale 3.

4.5. Students' Perspectives

The descriptive statistics for the student questionnaire are as follows:

Table 2. Descriptive statistics of students' perceptions of the effectiveness and challenges of GET.

Group	N	Effectiveness		Challenges	
		M	SD	M	SD
Students	81	4.35	0.52	3.09	0.90

4.6. Perceived Effectiveness of GET.

The mean score of 4.35 suggests that students find graphically enhanced learning highly beneficial. A standard deviation of 0.52 indicates that most students agree on the advantages. Figure 4 displays the percentage of responses for each item on Scale 1.

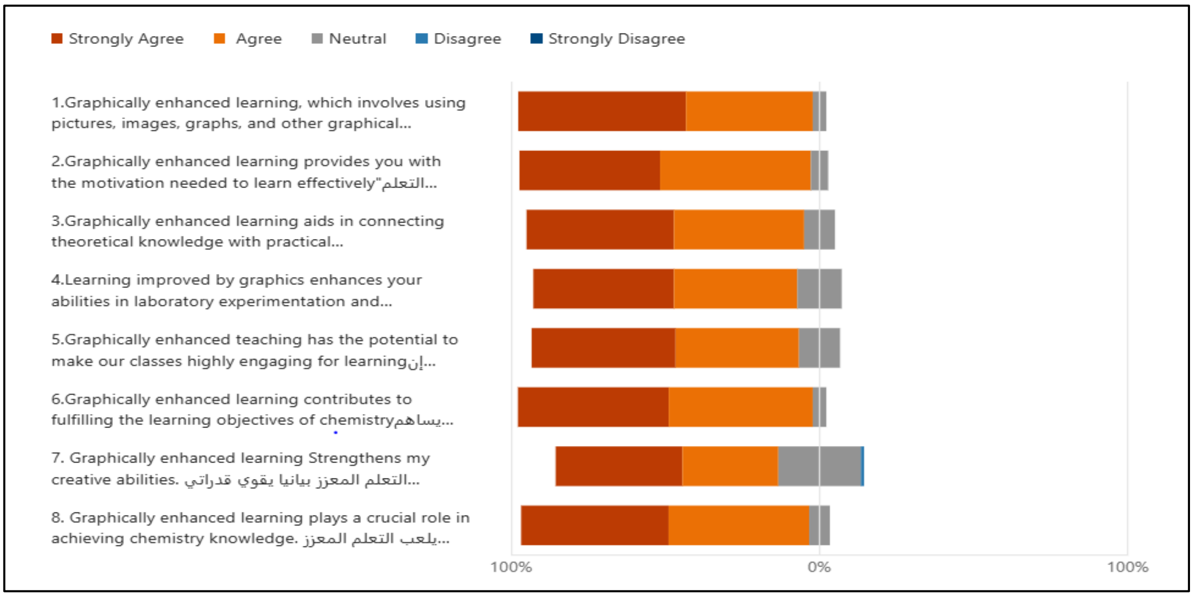

Figure 4. Percentage of responses to items of Scale 1.

4.7. Challenges of Implementing GET.

The average score of 3.09 reflects a moderate level of perceived challenges, with some students encountering significant obstacles, while others do not. A higher standard deviation (0.90) suggests greater variability in students' opinions of challenges. Figure 5 shows the percentage of responses to Scale 2 items.

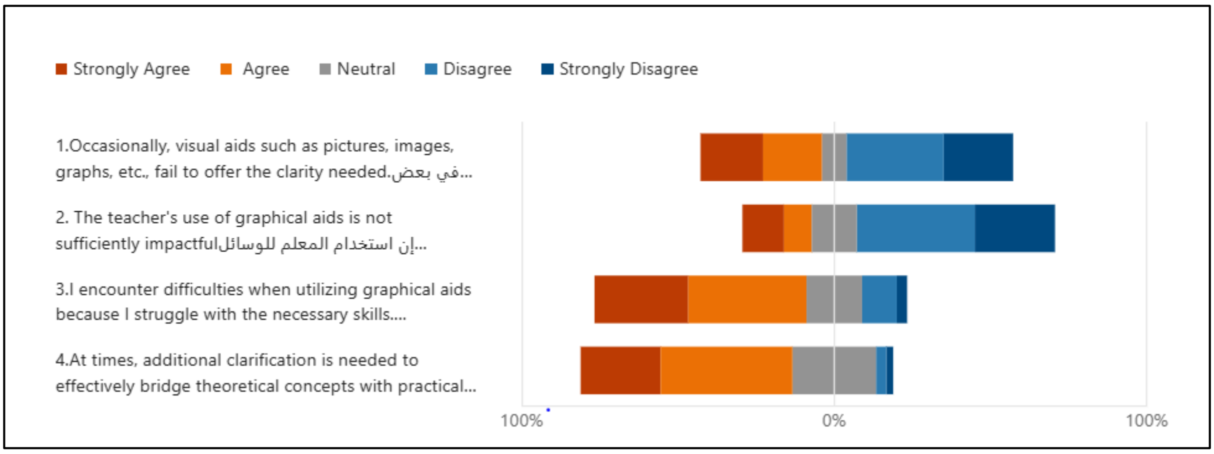

Figure 5. Percentage of responses to Scale 2 items.

Overall, both teachers and students viewed GET positively, particularly in terms of comprehension, engagement, and real-world application. However, challenges such as skills and resource limitations remain evident.

Research Question 2: How does teacher gender impact their views on the implementation of graphically enhanced chemistry teaching?

4.8. Perceived Effectiveness of GET.

A t-test revealed no statistically significant difference between male and female teachers' perceptions of the effectiveness of GET: t(69)=0.062t(69) = 0.062t(69)=0.062, p=.951p = .951p=.951.

4.9. Challenges and Barriers to Implementing GET.

The t-test showed that male teachers reported facing fewer challenges than female teachers, though the result was not statistically significant, t(69)=−1.709t(69) = -1.709t(69)=−1.709, p=.092p = .092p=.092. Notably, the effect size was moderate to substantial (Cohen’s d=0.902, d = 0.902, d=0.902), suggesting that gender differences in the perception of challenges require further investigation.

4.10. Factors Supporting the Effectiveness of GET.

No significant difference was found between male and female teachers in their views on the factors supporting GET, t(68)=0.439t(68) = 0.439t(68)=0.439, p=.662p = .662p=.662, with a small-to-medium effect size (Cohen's d=0.741d = 0.741d=0.741).

The statistical analysis suggests that gender has a limited impact on teachers' perceptions of the effectiveness of and support for GET. However, sex-related variations in perceived challenges were evident, with male teachers reporting fewer barriers.

Research Question 3: How do students' educational paths (General or Advanced) influence their views on the use of visual aids and graphical elements in Chemistry teaching?

4.11. Perceived Effectiveness of GET.

A statistically significant difference was found between students on the General and Advanced streams, with Advanced students perceiving greater benefits from GET (Mean M=4.54M = 4.54M=4.54, SD = 0.55) compared to General students (Mean M=4.20M = 4.20M=4.20, SD = 0.45), t(61.716)=−2.943t(61.716) = -2.943t(61.716)=−2.943, p=.005p = .005p=.005.

4.12. Challenges of Implementing GET.

No significant difference in perceived challenges was found between the two educational paths, t(42.087)=−0.300t(42.087) = -0.300t(42.087)=−0.300, p=.765p = .765p=.765.

These findings indicate that students in the advanced stream perceived greater benefits from GET than their peers in the general stream. However, both groups encountered similar challenges when using these methods.

4.13. Testing for Assumptions

Before performing t-tests, several diagnostic checks were conducted to ensure the validity of the analysis. The normality of the score distributions was verified using the Shapiro-Wilk test, and Levene’s test was used to confirm the homogeneity of variances between groups. The independence of the samples was ensured through the study design and the sample size for each group was adequate, with more than 30 observations per group.

4.14. Summary of Findings

The findings suggest that (1) both teachers and students perceive GET methods as beneficial for chemistry education, although challenges related to skill and resource limitations persist; (2) gender had minimal impact on teachers' perceptions of effectiveness and support for these methods, although male teachers reported facing fewer challenges than female teachers; and (3) advanced-stream students perceived greater benefits from GET than general-stream students, although both groups encountered similar levels of challenges.

Furthermore, the effect sizes and t-test results provide additional insights into these findings, which can inform future interventions aimed at maximizing the benefits of GET in chemistry classrooms.

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5. Discussion

5.1. Perceptions of Graphically Enhanced Chemistry Teaching

Research Question 1 explored how chemistry teachers and students perceived the advantages and challenges of GET. The results indicated a generally positive perception, with both groups recognizing the effectiveness of graphical tools in enhancing understanding and engagement. These findings align with multimedia learning theory, which suggests that integrating images and graphical tools can lead to deeper learning (Bobek & Tversky, 2016).

However, the challenges highlighted in this study emphasize the need for careful integration of these tools to ensure that they are aligned with the learning objectives. Improperly integrated graphical elements may distract or confuse students rather than aid in their learning. Thus, educators need proper training to maximize the impact of GET methods. Moreover, the study revealed that, while students generally benefit from these tools, there are universal challenges across different educational streams, such as technical difficulties and the need to develop the skills necessary to interpret graphical representations.

5.2. Impact of Teacher Participants' Gender

Research Question 2 examined whether teacher gender influenced perceptions of GET Statistical analysis revealed no significant differences in the perceptions of male and female teachers regarding the benefits or challenges of implementing these methods. This gender-neutral finding suggests that perceptions of the effectiveness of GET are shaped more by professional experience, familiarity with technology, and teaching philosophy than by gender.

The lack of significant gender-based differences underscores the shared recognition among male and female teachers regarding the potential of graphical tools for improving student outcomes. This finding supports the importance of focusing on professional development and training for all teachers, regardless of gender, to ensure that they are well equipped to effectively integrate graphical elements into their teaching practices.

5.3. Impact of Student Learning Path

Research Question 3 focused on how students' learning paths (General vs. Advanced) affected their views on graphically enhanced chemistry teaching. The analysis revealed a statistically significant difference between the two groups, with advanced students perceiving greater benefits from these methods. This suggests that students in the advanced stream, who typically engage with more complex and abstract chemistry concepts, are better able to appreciate the value of graphical tools in visualizing intricate topics.

The higher perceived benefits among the advanced students may also be due to their more developed spatial reasoning skills, which allow them to effectively interpret and apply graphical representations in learning. These findings suggest that curriculum designers should tailor graphical tools to meet the cognitive demands of more advanced courses and ensure that students at all levels are equipped with the necessary skills to effectively engage with these tools.

Interestingly, the challenges associated with GET were consistent across both General and Advanced students, indicating that certain obstacles, such as difficulty interpreting complex visual data, are universal. This highlights the need for comprehensive strategies to help students overcome these challenges regardless of their academic level.

6. Conclusion

This study investigated the perceptions of chemistry teachers and students regarding GET methods and analyzed the ways in which gender and learning paths affected these perceptions. The results suggest that both teachers and students generally perceived these methods as beneficial, with advanced students reporting greater benefits than their mainstream peers.

The study also found that gender did not significantly influence teachers' perceptions of the benefits and challenges of graphical tools. Both male and female teachers recognized the potential of these tools in improving student outcomes, highlighting the importance of professional development and training for all teachers.

Although the results are promising, the challenges associated with GET, such as interpreting complex visual data, must be addressed to fully integrate these methods into chemistry education. This study underscores the importance of aligning graphical tools with learning objectives and ensuring that students and teachers have the necessary skills to use these tools effectively.

7. Suggestion

Recommendations

To maximize the benefits of GET and address the challenges identified in this study, the following recommendations are proposed.

- Tailor Graphical Tools to Academic Levels: Curriculum designers should adapt graphical tools to meet the cognitive demands of different academic levels, particularly for students in the advanced stream, who benefit more from these tools.

- Provide Targeted Teacher Training: Teachers should receive professional development by integrating graphical tools effectively into their teaching strategies and addressing challenges, such as interpreting visual data.

- Enhance Student Support for Graphical Tools: Schools should implement support mechanisms such as workshops or tutorials to help students develop the skills required to engage with graphical tools.

- Explore Graphical Tools in Diverse Educational Settings: Future research should investigate the use of graphical tools in private schools and other educational contexts to provide a more comprehensive understanding of their impact.

- Align Graphical Enhancements with Learning Objectives: Graphical tools should be carefully integrated into the curriculum in a manner that aligns with specific learning objectives, to ensure that they are both engaging and effective.

7.1. Limitations and Future Considerations

These recommendations aim to enhance the use of GET methods in chemistry education and ensure that students across different academic levels benefit from these tools.

Although this study offers valuable insights, it has several limitations. First, the sample was drawn exclusively from public schools in the UAE, which limits the generalizability of the findings to private schools and other educational contexts. Additionally, reliance on self-reported data introduces potential for bias, such as social desirability or recall bias. Future studies should consider using observational or objective measures to validate self-reported data.

The scales used to measure perceptions of GET were developed specifically for this study. Although these scales demonstrated good reliability, future research could benefit from refining or developing more sensitive scales using graphical tools to capture the nuances of student and teacher experiences.

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Finally, further research is required to explore the impacts of different types of graphical tools on learning outcomes across various educational levels. Experimental studies can provide robust evidence of the causal effects of GET methods.

Declarations

Author Contributions. Alya Mohammed Ebrahim Al Shehhi: Introduction,Literature review , Methodology and Data collection
Shaikha Ali Mohamed Al Zaabi: Methodology, Data analysis, Discussion and Conclusion
Hassan Tairab: Supervision and review.
All authors have read and approved the final version of the article.
Conflicts of Interest. The authors declare no conflict of interest.
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References

Ali, T. (2012). A case study of the common difficulties experienced by high school students in chemistry classrooms in Gilgit-Baltistan (Pakistan). SAGE Open, 1–12. https://doi.org/10.1177/2158244012447299

Aubrecht, K. B., Dori, Y. J., Holme, T. A., Lavi, R., Matlin, S. A., Orgill, M. K., & Skaza-Acosta, H. (2019). Graphical tools for conceptualizing systems thinking in chemistry education. Journal of Chemical Education, 96(12), 2888–2900. https://doi.org/10.1021/acs.jchemed.9b00314

Abazar, F. A. (2021). The impact of Explore-Instruct teaching approach on university students' scientific reasoning at The United Arab Emirates (Doctoral dissertation, The British University in Dubai (BUiD)). https://bspace.buid.ac.ae/bitstream/handle/1234/1973/2014121016.pdf?sequence=3&isAllowed=n

Blanton, W. E., & Tuinman, J. J. (1973). Ausubel's theory of meaningful verbal learning: Implications for reading research. Literacy Research and Instruction, 12(3), 202–211.

Bobek, E., & Tversly, B. (2016). Creating visual explanations improves learning. Cognitive Research: Principles and Implications, 1(27). https://doi.org/10.1186/s41235-016-0031-6

Byusa, E., Kampire, E., & Mwesigye, A. R. (2022). Game-based learning approach on students' motivation and understanding of chemistry concepts: A systematic review of the literature. Heliyon, 8(5). https://doi.org/10.1016/j.heliyon.2022.e09724

Chan, P., Van Gerven, T., Dubois, J. L., & Bernaerts, K. (2021). Virtual chemical laboratories: A systematic literature review of research, technologies and instructional design. Computers and Education Open, 2, 100053. https://doi.org/10.1016/j.caeo.2021.100053

Edelsztein, V. C., Olga, I. T., & Galagovsky, L. (2020). Chemical senses: A context-based approach to chemistry teaching for lower secondary school students. Chemistry Teacher International, 1–14. https://doi.org/10.1515/cti-2019-0003

Eranpalo, T., Jorgenson, C., & Woolsey, M. L. (2016). The Abu Dhabi school model: Effective delivery of the curriculum. International Journal of Humanities and Social Science, 8, 1694-2620.

Emirates Schools Establishment. (n.d.). ESE overview. Retrieved September 2, 2024, from https://www.ese.gov.ae/En/aboutese/Pages/ESE-Overview.aspx

Holme, T. (2020). Using the chemistry of pharmaceuticals to introduce sustainable chemistry and systems thinking in general chemistry. Sustainable Chemistry and Pharmacy, 16, 100234. https://doi.org/10.1016/j.scp.2020.100234

Idika, M. I. (2021). Effect of visualized case-based learning strategy on students' academic performance in chemistry in Ibadan Metropolis, Nigeria. African Journal of Teacher Education, 10(1), 106–126. https://doi.org/10.21083/ajote.v10i1.6281

Indriyanti, N. Y., Saputro, S., & Sungkar, R. L. (2020). Problem-solving and problem-posing learning model enriched with multiple representation in tetrahedral chemistry to enhance students' conceptual understanding. Edusains, 12(1), 123–134. https://doi.org/10.15408/es.v12i1.13282

Kirby, J. R., Moore, P. J., & Schofield, N. J. (1988). Verbal and visual learning styles. Contemporary Educational Psychology, 13(2), 169–184.

Lee, C. B., Hanham, J., Kannangara, K., & Qi, J. (2021). Exploring user experience of digital pen and tablet technology for learning chemistry: Applying an activity theory lens. Heliyon, 7(1). https://doi.org/10.1016/j.heliyon.2021.e06319

Monnot, M., Laborie, S., Hébrard, G., & Dietrich, N. (2020). New approaches to adapt escape game activities to a large audience in chemical engineering: Numeric supports and students' participation. Education for Chemical Engineers, 32, 50–58. https://doi.org/10.1016/j.ece.2020.03.003

Paivio, A., & Clark, J. M. (2006). Dual coding theory and education. Pathways to Literacy Achievement for High Poverty Children, 1, 149–210.

Permatasari, M. B., Sri Rahayu, S., & Dasna, I. W. (2022). Chemistry learning using multiple representations: A systematic literature review. Journal of Science Learning, 5(2), 334–342. https://doi.org/10.17509/jsl.v5i2.42656

Rahmawati, Y., Ridwan, A., Hadinugrahaningsih, T., & Soeprijanto. (2019). Developing critical and creative thinking skills through STEAM integration in chemistry learning. Journal of Physics: Conference Series, 1156(1), 012033. https://doi.org/10.1088/1742-6596/1156/1/012033

Stammes, H., Henze, I., Barendsen, E., & de Vries, M. (2020). Bringing design practices to chemistry classrooms: Studying teachers' pedagogical ideas in the context of a professional learning community. International Journal of Science Education, 42(4), 526–546. https://doi.org/10.1080/09500693.2020.1717015

Stojanovska, M., Mijić, I., & Petruševski, V. M. (2020). Challenges and recommendations for improving chemistry education and teaching in the Republic of North Macedonia. CEPS Journal, 10(1), 145–166. https://doi.org/10.26529/cepsj.732

Stull, A. T., Fiorella, L., Gainer, M. J., & Mayer, R. E. (2018). Using transparent whiteboards to boost learning from online STEM lectures. Computers & Education, 120, 146–159. https://doi.org/10.1016/j.compedu.2018.01.002

Teplá, M., Teplý, P., & Šmejkal, P. (2022). Influence of 3D models and animations on students in natural subjects. International Journal of STEM Education, 9(65), 1–20. https://doi.org/10.1186/s40594-022-00382-8

Tairab, H., Al Arabi, K., Rabbani, L., & Hamad, S. (2020). Examining grade 11 science students' difficulties in learning about vector operations. Physics Education, 55(5), 055029. https://doi.org/10.1088/1361-6552/ab9fe7

Ulva, Y. I., Mahardika, I. K., & Nuriman. (2021). Graphic representation ability in learning chemistry through multi-presentation-based chemistry modules. Journal of Physics: Conference Series, 1832, 012044. https://doi.org/10.1088/1742-6596/1832/1/012044