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MULTIMAODAL LEARNING IN THE CONTEXT OF INTEGRATION ENGINEERING GRAPHICS WITH ART EDUCATION

Abstract

Through multimodal learning, this literature review investigates how engineering graphics is integrated with art education and drawbacks of straddling disciplinary boundaries. How such multidisciplinary learning might advantage people in messy real-life situations. At the heart of the review is synthesis on Key studies: Education that engages multiple senses as well as perspectives-multimodal learning. By doing so, creativity may be unleashed to flourish, problem-solving skills honed, and pupils drawn deeper into their subjects than would otherwise be the case. In this way also student performance will thrive. Of course, these conclusions may already have implications for educational design by suggesting new paths. The findings underline the relevance of establishing techniques used by artists in drawing and sculpture to engineering, confuting any suggestion that creative work is mere window-dressing. They hold out greater certainty than is often imagined that broad-based really does work. Although the review shows some important findings, it also points to many areas requiring further research. For example, there is a need to look at long-term impact studies; another is research about different student groups and practical problems faced by teachers in various places. Tentative suggestions for future research include making measures that will assess an interdisciplinary education's full array of skills, studying new teaching techniques using state-of-the-art technology and investigating ways to improve teacher training. The review concludes that, while still under development, the integration of engineering and art through multimodal learning has promising prospects for enriching education and preparing students better for life in today's world.

Key words: multimodal learning, engineering graphics, art education, interdisciplinary, creativity.

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ИНЖЕНЕРЛІК ГРАФИКАНЫҢ КӨРКЕМДІК БІЛІММЕН ИНТЕГРАЦИЯЛАНУЫ ЖАҒДАЙЫНДАҒЫ МУЛЬТИМОДАЛЬДЫ ОҚЫТУ

Аңдатпа

Мультимодальды оқыту арқылы бұл әдебиеттік шолу инженерлік графиканың көркемдік біліммен қалай интеграцияланғанын және тәртіптік шекараларды шектеудің кемшіліктерін

зерттейді. Мұндай көпсалалы оқыту нақты өмірдегі қиын жағдайларға тап болған адамдарға қалай пайда әкелуі мүмкіндігі берілген мақалада қаралады. Шолудың негізінде негізгі зерттеулердің синтезі жатыр: көптеген сезімдерді, сондай-ақ перспективаларды қамтитын білім беру - мультимодальды оқыту. Осылайша, шығармашылықтың өркендеуі, проблемаларды шешу дағдыларын шыңдау және студенттердің өз пәндеріне басқаша қарағанда тереңірек енуі мүмкін. Осылайша, студенттердің үлгерімі де жақсарады. Әрине, бұл тұжырымдар жаңа жолдарды ұсына отырып, білім беру дизайнына әсер етуі мүмкін. Нәтижелер суретшілердің сурет салуда және мүсіндеуде қолданатын әдістерін әзірлеудің инженерияға қатыстылығын көрсетеді, бұл шығармашылық жұмыс жай ғана безендіру деген кез келген болжамды шатастырады. Олар көбінесе кең негізде шынымен жұмыс істейді деп ойлағаннан да үлкен сенімділікке ие. Шолу кейбір маңызды нәтижелерді көрсеткенімен, сонымен қатар қосымша зерттеулерді қажет ететін көптеген салаларды көрсетеді. Мысалы, ұзақ мерзімді әсер ету зерттеулерін қарастыру қажет; екіншісі – әртүрлі студенттер топтары туралы зерттеулер және әртүрлі жерлерде мұғалімдердің алдында тұрған практикалық мәселелер. Болашақ зерттеулерге арналған алдын ала ұсыныстарға пәнаралық білім беру дағдыларының толық спектрін бағалауға мүмкіндік беретін шараларды әзірлеу, заманауи технологияларды пайдалана отырып оқытудың жаңа әдістерін зерттеу және мұғалімдердің біліктілігін арттыру жолдарын зерттеу кіреді. Шолу қорытындысы бойынша, әлі де әзірлену үстінде, мультимодальды оқыту арқылы инженерия мен өнерді біріктіру білім беруді байыту және студенттерді қазіргі әлемде өмір сүруге жақсырақ дайындау үшін перспективаларға ие.

Түйін сөздер: мультимодальді оқыту, инженерлік графика, көркемдік білім, пәнаралық байланыс, шығармашылық.

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МУЛЬТИМОДАЛЬНОЕ ОБУЧЕНИЕ В КОНТЕКСТЕ ИНТЕГРАЦИИ ИНЖЕНЕРНОЙ ГРАФИКИ И ХУДОЖЕСТВЕННОГО ОБРАЗОВАНИЯ

Аннотация

В данном обзоре литературы рассматриваются вопросы интеграции инженерной графики и художественного образования, а также выявляются недостатки для преодоления междисциплинарных границ. Объясняется также возможность такого обучения для выхода из сложной жизненной ситуации разных групп людей. В основе литературного обзора положены ключевые исследования, посвященные подобному роду обучению, учитывающие различные аспекты, а также перспективы развития. В мультимодальном обучении дается воля студентам в своих творческих выражениях, отточить навыки решения образовательных и жизненных проблем и дается возможность для глубокого погружения в процесс изучения предметов художественного цикла в контексте интеграции с инженерной графикой. В результате такой интеграции повышается интерес и успеваемость студентов по дисциплинам. Эти выводы дает основание полагать, что они эффективны для образовательного дизайна. Полученные в ходе обзора результаты лишь подчеркивает значимость использования студентами техники рисования в инженерном деле, напрочь отрицая все стереотипы о том, что творчество это просто абстрактно. Также, в обзоре приводятся уверенность в том, что полномасштабный подход к интеграции двух отраслей действительно работает. Помимо всех вышеперечисленных преимуществ в обзоре указываются некоторые области, требующие дальнейшего изучения, в

частности указывается на изучения долгосрочного воздействия такой интеграции с группами студентов, отличающихся различными уровнями восприятия. Предполагается разработка специальных мер, направленных на оценку сформированных навыков междисциплинарного образования, исследование самых современных технологий и поиск всевозможных путей совершенствования подготовки учителей. В заключение дается вывод о том, что такой подход в изучении предметов художественного цикла в контексте интеграции с инженерной графикой все еще находиться на стадии разработки, но уже сейчас подход имеет многообещающие перспективы в обогащении процесса образования и системной подготовки студентов к реалиям современного мира.

Ключевые слова: мультимодальное обучение, инженерная графика, художественное образование, междисциплинарная связь, творчество.

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Introduction. There is an increasing overlap between traditionally distinct fields such as engineering and the arts. That has aroused interest in multi-modal learning strategies that draw on both disciplines.Engineering graphics, often seen as a purely technical subject, has frequently been taught apart from the more creative realms of art. However, joint trends in education focus on merging learning from different disciplines to create a more rounded understanding of complex ideas. The significance of this topic lies in its potential to span the gulf between technical precision and artistic creation, giving students a richer and more flexible educational experience. Multi-modal learning, which supports multiple forms of representation and communication, is particularly well suited to integrate this, allowing students to take in content through various channels that are suited to different learning styles or ways of thinking.

The main purpose of this literature review is to survey the existing research on multimodal learning as related to the integration of graphic engineering and arts courses. This survey is to explore pros and cons, teaching strategies involved with interdisciplinary approaches. It will also evaluate how effective multimodal learning can improve students' understanding and skills in both engineering and art, and how this integration will prepare them for the challenges of today's labour market that requires an equal measure of creative talent and technical expertise.

This review will concentrate on the theories and practices of multimodal learning specifically in the context of integrating graphic engineering with art education. Is this intersection, the subject of this study, and it hopes to show how one can synthesize two fields into a fuller more interesting mode of study than is possible for either discipline separately", wrote the editor. Specifically, this review will focus on methods of teaching engineering graphics to incorporate artistic principles, thereby fostering a more penetrating comprehension of both disciplines. The kind of evidence discussed in this section is designed to help you understand what is being presented in the other sections of the text. Those types of analysis are vital, for as A. J. Ayer said: "There is no doubt that true science must be empirical in concept. Theoretical Pursuit—to its credit—rightly retains only those elements which are amenable to empirical test." It is hoped that reviewers of this report may bring such new material from their own research to the conference as will update and reorient the ground covered above.

1. How does the integration of engineering graphics with art education through multimodal learning affect student self-expression and problem-solving abilities?
2. What challenges do teachers face in attempting to carry out multimodal learning approaches that join engineering and art?
3. From the point of view of academic career prospects and prospects for life-long learning, what impact does the interdisciplinary mixture of engineering graphics and art education have on student does indeed prove itself worthy as "More than merely the comprehensive culmination of

knowledge, it reflects scholarly trends expanding gradually to Eastern countries. Which are in line with all recognized canons of research and development? By addressing these questions, the review aims to provide a concentrated survey of where research has got to today, and to signal future gaps for investigation.

This section looks at the key theoretical concepts on which multi-sense learning is based, as it is interwoven with engineering graphics. II. Empirical Data about the Combination of Engineering and Art Here, individual empirical studies are presented to illustrate multimodally conducted effects in these two merged disciplines. III. Problems of Carrying Out Multimodal Learning Here are detailed difficulties that pedagogists encounter when they try to implement curricular innovation.

4. Impact on creativity and problem-solving skills - This section will elaborate some of the specific educational results that may flow from multimodal integration. Enhanced creativity, for instance, after all, is a natural consequence of involving students in processes such as these.

5. Directions for Future Research and Practice - Finally, the paper will offer suggestions on where studies should go in relation to these two themes. Relying on previous discussions in this chapter, the aim is to indicate new areas that need investigation and to propose some practical steps for closing gaps in knowledge (e.g., research needs).

In the literature, a broad scan reveals a few main strands of inquiry. Some researchers have attempted to unify art and engineering in various styles, typically pointing up these two subjects' complementary natures. For example, the application of design and aesthetics techniques that are commonly taught in art education today to subjects such as technical graphics can produce stunning results; conversely, precision and technical correctness which engineering attaches great importance to may become obstacles in art. It is no surprise then that studies have found students who are trained in both fields become generally better at spatial thinking, creativity and solving problems. Thus, multimodal learning--the simultaneous use of different senses for studying (as when reading text out loud or watching pictures on a screen) compared to unimodal learning such as using only visual input to absorb information has been shown to increase the student's skill levels considerably. Also in this area, key thinking on developing such ways of learning has been provided by Cheng and Tsai (2015), who explored ways that visual thinking can be integrated into engineering education, Eisner (2002) who looked at interdisciplinary effects of mixing art forms up with different academic subjects. Viewed together, these works point in general to the conclusion that bringing art and design studies into engineering education through multimodal learning not only enriches the student's education, but they also end up with skills that are highly in demand all over our increasingly complex world

This paper will carry out a further exploration of these themes, consolidating current researchto produce a comprehensive overview of where knowledge now stands on this issue, and pinpointing areas calling out for further study.

Methods. To transform this novel into a comprehensive literature review, we use systematic techniques to confirm the choice of available sources, but only the high-quality ones that knit together multimodal learning and designed to affect art education in integration with engineering graphics: The criteria used when sources were chosen to seek the best, most recent research that is currently going on. Only works published in the last twenty years (2004-2024) have been taken into consideration: typically, such pieces have been about improvements and developments in all methods of learning about technology and education, but we want here to ground this review firmly within established research. The sources were plucked from the English publications, to maintain unified and easily accessible language for the most part in this field where most significant research is being published. Likewise, we sought sources that spoke directly to the intersection between engineering and art education, multimodal learning and cross-disciplinary teaching methods.

A variety of academic databases and digital libraries - well-known for their wide collection on education, the arts and engineering - were used in the literature search process. Primary among these were JSTOR, IEEE Xplore, Google Scholar and ERIC (the Education Resources Information Centre). Variation between "multimodal learning," "engineering graphics," "art education," "interdisciplinary education" and "integrative pedagogy," kept the search broad. In addition, we examined the reference lists of key articles to find other valuable studies which the original search might not have captured.

Once potential sources have been identified, each article is carefully reviewed for relevance and quality. Articles that brought empirical evidence, insightful theories or comprehensive reviews into the integration of engineering graphics and art education through multimodal learning were prioritized. This process ensured the broadest and most varied body of research flows through our literature review, providing an extensive account of the topic at hand and supporting review objectives with up-to-date, pertinent data.

Main body. Exploring Multimodal Learning in the Integration of Engineering. Graphics with Art Education. Familiar Ground or a New Divide? Exploring Multimodal Learning in the Integration of Engineering Graphics with Art Education By combining engineering graphics with art education and taking a multimodal learning method, students can find unique and compelling experiences that enhance their life experiences. Not only does the present review of literature in various domains provide a comprehensive exposition on this interdisciplinary junction, it also integrates those important aspects which are related to the topic today. By looking at the themes, methodologies and conclusions of successive studies, this section attempts to present a balanced view about what might be achieved through such creative teaching strategies.

Theoretical Foundations of Multimodal Learning. Theoretical Foundations of Multimodal Learning According to multisensory learning theory, learning is most effective whenit incorporates a variety of sensory channels - visual, auditory, tactile, and so forth. This approachis particularly relevant in the context of integrating engineering graphics with art education, where both technical precision and the expression of ideas are required. As Jewitt et al. (2016) put it, open learning allows for a more dynamic interaction within a richer context. In this context learners bring complex things to life in the way they feel most natural doing so, applying diverse (burning oil) to what you are examining.

Whereas this theoretical framework supports much early-day research, it also underscores the need for a move beyond traditional, single-modal teaching methods in favor of more comprehensive approaches. To support or challenge these theories, one must not only consider the theoretical foundations of multimodal learning but also could also observe what empirical evidence there may be. For example, studies by Cheng and Tsai (2019) have shown thatintegrating engineering graphics with art education the multimodal learning way significantly improves students' skill in spatial thinking and product designing. Such empirical evidence serves as a realistic foundation for understanding the merits in practical terms of this amalgamation of different domains, as well as complementing the preceding theoretical life views.

Studies by Kress (2010) and others have confirmed that multimodal learning not only increases the retention of material but also cultivates creativity and critical thinking. Additionally, in terms of engineering graphics and art education, this means that students can gain a better understanding of both the technical and aesthetic aspects of their work. For example, a combination of visual and spatial ways of learning, which are equally relevant in both engineering and art, can help students grasp complex concepts in geometry or design principles better (Mayer, 2009). This alignment of cognitive processes across disciplines is helpful to establish versatile skills that are needed in today's educational and industrial environment.

Interdisciplinary Approaches to Integrating Engineering Graphics and Art Education. The merging of the fields of engineering graphics and art education is more than just another pedagogical trend. Instead, it marks the departure towards interdisciplinary learning settings. This

merger can be observed in project-based learning, where students are encouraged to employ both technical and creative skills to solve a real-life issue. According to Yıldırım and Şimşek, "engineering and art integrated project-based learning environments provides opportunities to the students to sense the unity and interdisciplinarity between the two fields". As a result, not only do they learn more about each area, but also the transferable skills, such as collaboration and problem-solving, and creativity, also become the target of development.

Nonetheless, this is not the only positive implication of such an approach. Existing research indicates that students perform better when studying a particular subject using an interdisciplinary approach that connects it to another discipline, in particular, art. For instance, the study by Bequette and Bequette shows that where students were required to create an artistic representation of an engineering concept, they learned the materials much better than when studying the subject purely technically. It implies that the synthesis of the two disciplines into an educational approach could have a positive impact on their learning outcomes whenever such knowledge application takes place through an integrated, multimodal approach. In addition, such integration leads to the development of more inclusive learning settings where every student, regardless of learning style, can succeed.

The integration of engineering graphics and art education in learning can lead to a series of profound outcomes. For instance, the studies by Bequette and Bequette specify that it positively affects creativity as it allows using art principles to solve technical tasks in innovative ways. At the same time, students learn to perceive the issue from multiple perspectives, which positively influences their problem-solving abilities. The study by Harris and de Bruin shows that due to students' engagement in interdisciplinary projects and multimodal learning, more students are equipped with the skills necessary for the modern job market. This phenomenon is also associated with a positive increase in the overall interest in engineering as a subject, as students who previously may not have succeeded in a purely technical course are now successfully learning it in an interdisciplinary environment. The new learning approach is also more inclusive, as it is multimodal and differentiates the learning to the needs of every student. As a result, equity in education is promoted.

Pedagogical Strategies for Multimodal Integration. A successful integration of engineering graphics with art education is only possible through the application of pedagogical strategies that back up multimodal learning. One of such strategies is the application of digital tools that can enable students to learn how to visualize and manipulate engineering designs while also using various artistic approaches. According to Dousay and Weible, digital tools, such as CAD software, are particularly useful when used alongside art-based applications, as they help enhance student spatial reasoning and design skills. Furthermore, the tools in question help bridge the gap between the artistic and the technical. In the meantime, it also helps students see how engineering design can be influenced by an art-based one and vice versa. Another strategy is collaborative learning, in which students work in teams on interdisciplinary projects. This approach not only helps students develop communication and teamwork skills. It is also useful because it helps students tap into each other's strength in the field of engineering and that of art. According to Goldsmith and Bell, such an approach is particularly beneficial in the case of disciplines, in which, traditionally, it is difficult to have comprehensive knowledge of the discipline since it is composed of both technical and more humanistic elements. The approach is also multimodal, as it includes multiple perspectives and involves the integration of knowledge in more than one way.

One more strategy is focusing on real-world applications. For instance, in a study of Kolodner et al., students were asked to design an eco-friendly building. It was reported that such a task helps develop students' understanding of the nature of the discipline. Furthermore, it was stated that students who participated in the project were more aware of what it meant in practice to design an eco-friendly. Such strategies are particularly beneficial because history is one of the disciplines in relation to which multiple class projects involving both technical and humanistic elements are possible.

Challenges and Considerations in Multimodal Integration. Many challenges prevent the successful integration of engineering graphics with art education through multimodal learning. Although this type of learning has multiple advantages, many difficulties may persist due to failureto address these problems. Indeed, one of the most significant challenges that such an approach might face is the danger that separate disciplines might be seen as distinct even within interdisciplinary education. Others claim that developing projects and curricula that would truly reflect the combination of technical and artistic practices remains complicated. In other words, oneof the most serious challenges to integrating engineering graphics with art education using multimodal learning is the need to ensure that learners truly see these disciplines as connected fields, not as separate entities. The second challenge is that educators must possess expertise in multiple fields, and they must Know not only both art and engineering but how they could be taught within one program at once. This might be especially difficult in institutions where such initiatives are scarce or where educators are accustomed to firmly fixed disciplinary boundaries. Finally, assessment remains a significant problem as if one discipline is to be assessed using the methods of another one, and no existing approaches might yield sufficient results. Specifically, OlitsKy asserts that "high school-looking work is often accepted from student projects that reflect divergent haptic and aesthetic expectations, scientific and social content, design drawings and final products" but such projects become roadblocks in the path toward successful integration. Since this problem is not simple, only teaching educators research uncovers might stimulate positive change.

Overall, there is much work that must be done to implement multimodal learning in the context of interdisciplinary art education, and educators must address all problems to make students truly see engineering graphics and art as interconnected fields. This might be complicated by the need for appropriate assessment and the scarcity of research on the long-term effects of such programs, all suggesting that more research could benefit programs in this area.

Comparative Perspectives on Multimodal Integration. Comparative analysis of the approaches to integrating engineering graphics and art education illustrates a wide diversity of strategies and outcomes in different educational contexts. For example, research in higher education institutions is often related to the use of advanced digital tools and project-based learning, which is essential in preparing students for professional work in fields such as architecture and industrial design. Inversely, research in K-12 education is more often associated with developing students' fundamental skills and using simpler tools and activities suitable for younger students. Additionally, notable differences are prominent in implementing multimodal learning based on culture and type of educational institutions. In countries with well-developed traditions of integrating technical and art education, multimodal learning is facilitated by a better-trained context. For example, Scandinavian educational system culture often pays special attentionto the creative aspect of technical education and considers creativity and innovation important in the technical profession, which results in less significant cultural differences in integrating art and engineering. On the other hand, in countries where technical and art education is more isolated, some difficulties might occur in implementing an interdisciplinary approach, as going across the institution's traditions and routines requires special effort. However, despite these differences, the general trend observed in all Kinds of contexts is the growing Knowledge of integrating engineering graphics with art education, which resonates with the general tendency of modern education in recognizing the importance of multifaceted student-centered education. According to Fullan and Langworthy, such tendencies are typical for the modern world, which grows increasingly complex and demands new approaches.

Future Directions and Implications for Practice. Multimodal learning with the integration of engineering graphics and art education is an emerging field of inquiry. It is characterized by high potential, as well as future as the integration of seemingly unrelated fields into big ones seemto be an activity that will bring results. Furthermore, it is manifested that education will continue its shift towards non-formal and student-centered, as well as interdisciplinary paradigms. Thereby,new,

innovative approaches to teaching are required to meet the educational needs of many learners. Multimodal learning is manifested to combine technical and creative education of students, and thus more research is required to outline the best approaches for integrating these fields. Furthermore, the long-term impacts of the integration on students' academic and professional success should be studied to make additional methods of teaching art to engineering students, as well as engineering to art ones measuring effective.

One of the most effective and, at the same time, promising areas for research is the study of the integration of art and engineering through the lens of new technologies. Virtual reality and augmented reality are emerging technologies that have the potential to provide truly immersive learning experiences. Such experiences may be classified as multimodal learning that helps students deeply and conceptually understand complex concepts and find creative ways for solving real-world problems. Thus, further scientific developments are required to explore how art and engineering can be enriched using these technologies.

Another area for further study is the study of how multimodal learning can be adjusted to various student populations. Even though the review of the scientific literature revealed that multimodal learning is a valid approach to teaching to engage the students and enhance education and, at the same time, be inclusive, it should be adjusted to students who are not able to participatein them. Furthermore, it is necessary to adjust multimodal learning to gift students who can struggle with the project works that require deep understanding of either technical or artistic concepts.

One of the other important directions for future research is an investigation of assessment strategies corresponding to the needs and goals of multimodal and interdisciplinary learning. As previously discussed, traditional methods of assessment, such as tests or exams, often emphasize on rote memorization and isolated skills, not offering a comprehensive understanding of the integration of engineering and art forms. At the same time, nothing is known about the alternative methods of assessment, which might include portfolio assessments, peer reviews, or reflective practices, and support the evaluation of students' learning and development in a broad sense. The development and validation of these tools are vital for educators willing to apply multimodal learning in their practice.

Another major gap is related to the study of the role of teacher education and professional development in the process of implementation of the integration of the two disciplines. Accordingto Henderson and Mapp, one of the obstacles to implementing such approaches is a lack of teachers with the necessary skills and knowledge to provide interdisciplinary learning. Therefore, future studies need to explore effective models of professional development forteachers to prepare them to employ multimodal learning in their practice. This implies not only acquiring necessary content knowledge in engineering and art but also the knowledge on pedagogical strategies helpful in facilitating the integration of the two fields.

This research has implications not only in the current classroom discourse but also in the overall education system and related policies. While many institutions of education may already realize or slowly come to realize the imperative need for incorporating multimodal and interdisciplinary learning approaches into the curricula, it is essential to consider the related policies and systems. First, it may be necessary to revisit the preservice and in-service education of educators and ensure they are ready, both by knowledge and mentality, to approach multimodal learning integration. Other policies that need evaluation and changes include those related to the curriculum, especially in the K-12 and higher education levels. Flexibility and support for educators are important. Finally, policymakers should configure assessment frameworks that encourage the recognition of students' skills, developed through diverse and broad learning, in the current system currently obsessed with results of traditional academics and standard tests. The integration of engineering graphics within the broader and previously existing subset of art education is a welcomed change and one of the most promising and inspiring paradigms. Literature reviewed in the current paper provides important evidence for the need and ability of such

integration. Contacting engineering graphics with art education may be expected to provide a holistic and balanced learning avenue where the exactitude of engineering is coupled with creativity and free expression in art. Still, there are challenges to the integration of these two otherwise isolated disciplines. The multimodal learning process is easily affected by the rigidity of basic disciplines. Into the future, researchers need to consider more options that consider the disciplines as integrated. As the world becomes more complex and interconnected, engineers and artists need to achieve an appropriate problem-solving avenue, developing multi-competency.

This review aimed to provide an overview of the discussion on the integration of engineering graphics and art education through multimodal learning. Having synthesized the existing literature on the topic, the discovered key themes, challenges, and opportunities have been outlined. The results of this review suggest that, while considerable evidence already supports multimodality asa viable approach to learning in both areas, further research and development both in the method and its related concepts is needed. By responding to the challenges posed by the use of multimodal learning and going in new directions, educators create learning environments that not only increase the level of students' understanding of the fields of engineering and of art but also prepare learners for the modern world in motion.

Education's future lies in its potential to fuse technical proficiency with creative ingenuity, and multimodal learning via combining engineering graphics and art studies is a major part of how this can be achieved. By adopting the strategy of multimodal learning, educators ensure that students learn with skill sets that allow them to succeed in an increasingly complex and interdisciplinary world. The continued development and adoption of multimodal learning approaches, by both those who research the concept and those who apply it, will be essential for the future of education and will enable all students to succeed in their academic and professional aspirations.

Discussion. The current literature on the integration between engineering graphics and art education through multimodal learning is explicit and potential in the insights that the researchers have provided. However, literature is not without its gaps, which would rely on other studies to understand the interdisciplinary program better. These gaps determine the need for further research involving the integration of engineering graphics and art in the education system. A review of other literature reveals both strengths and weaknesses in them. For example, while Yıldırım and Şimşek provide excellent examples of how multimodal learning can improve student engagement, the homogeneity of the sample is one of its most significant downsides.

The same case applies to Bequette and Bequette's research, with the only differences being the topic of interest, approach, and the critical phenomenon. They explain that multimodal learning has the potential to enhance creativity but has an observational viewpoint to determine the long-term concerns. Consequently, it is evident that the field of multimodal learning and other areas of interdisciplinary education require more robust methodologies and research approaches.

One major gap that would inform future studies involves the absence of designing long-term outcomes for students in interdisciplinary programs for students. While it is evident that there are areas of short-term success, such as increased engagement and creativity, and improved problem-solving capabilities, there are no robust studies concerned with observing the necessary considerations for the output of the students in the long term. Consequently, such observations will provide information on the relevance of students studying integrated learning between art and graphics.

Another shortcoming relates to the lack of focus on diverse student populations and how they can gain from multimodal learning. A vast majority of the identified studies are based on relatively homogeneous educational settings that are typically well-resourced. This limits the generalization and applicability of the findings. Future research should center around understanding how multimodal learning and the combination of engineering and art can be adaptedto the needs of students with varying cultural, socioeconomic, and educational backgrounds.

Emphasizing the needs of students from different populations will enable the creation of more equitable and inclusive learning approaches. Another related aspect is that the previous literature has not comprehensively addressed the challenge of implementing integrated curricula. Although some studies indicated the benefits and challenges of combining engineering and art learning in schools, many did not explore the implementation challenges, including need for professional development, style of integration of two teaching paradigms, and alignment of the two approaches with dominant assessment methods. Future studies will benefit greatly from discussing these challenges so that educators are better equipped to implement multimodal learning.

The future research and development of multimodal learning are likely to follow several directions. First, one area that needs further development is the focus on the assessment in integrated engineering and art learning. Existing assessment methods do not cover the wide range of skills that students can develop at the intersection of art and engineering. Therefore, there is a need to design new methods that validate the learning process and the learning products. For this, future studies should consider the use of portfolios, peer review, and other reflective activities.

Research into the use of emerging technologies in multimodal learning environment can also be considered a potential direction for future research. Specifically, such technologies as virtual reality, augmented reality, and advanced digital fabrication tools can present the opportunity to better integrate engineering graphics with art education. Students can benefit from immersive experiences that can help them cross the narrow line between technical precision and creative spontaneousness. Further research in this field can bring valuable insights and enhance both areas of study. Additionally, future research can be focused on the professional development ofeducators working in fields that require teaching integrated curriculum. One of the key factors forsuccessful multimodal learning that was mentioned in the review is that there should be qualified educators who are interested and know how to teach across disciplines. Thus, future research can focus on identifying the most efficient forms of professional development of educators working in the engineering and art fields, such as collaborative workshops, co-teaching, and interdisciplinary planning sessions.

Finally, it seems crucial that further research should involve a comparative analysis of integrated learning across different educational contexts or different regions of the world. On the one hand, the research has shown that the effectiveness of multimodal learning is critically dependent upon the local context. On the other hand, there are still many educational universities and institutions across the world where this method of learning is not likely to be implemented dueto multiple factors. Thus, contrastive research of different educational contexts and different countries or regions can also ensure a more solid and well-grounded knowledge of the general patterns of the implementation of multimodal learning.

For obtaining a more complete insight of the influence of multimodal learning utilized for integrating engineering graphics with art education, it is vital to consider multiple educational contexts. It is evident that research based on analysis of non-Western educational settings would present alternative ways of integrating engineering and art education, affected by the dominant cultural and institutional contexts. For example, the research conducted by Saarnivaara and Sarja tends to provide a wide perspective of such an approach, considering peculiarities of Scandinavian educational settings. The authors conclude that these settings are focused on creativity and innovativeness in technical education. It is argued that an approach that is focused on integrating art and engineering education exists in practice because engineering education in these countries tends to utilize a wider perspective of the role of engineers and technical specialists. Integrating these perspectives enables us to provide more diverse results and a broader overview of the possibilities of such learning for making the educational process more inclusive.

In conclusion, it is possible to state that while integrating art with engineering graphics by means of multimodal learning is a viable option, the existing research is not extensive and leaves multiple questions unaddressed. At the same time, the approach also has multiple limitations that

must be addressed to ensure that it is viable on a large scale. The most essential among the identified issues is the absence of evidence on the most efficient ways of implementing multimodal learning to integrate art with engineering graphics. The absence of knowledge on this issue indicates several areas that can becomethe focus of future research and practical explorations. Such studies can help to explore the possibilities.

Conclusion. Summing up the information that has been presented, the literature review on the integrationof engineering graphics with art education through multimodal learning provided several insights.First, it should be stressed that the majority of the research examined creators the idea that the integration of previously separate concepts of engineering and art provides better learning experiences. In terms of creativity, problem-solving abilities, and engagement, the opportunity to benefit from multimodal learning appears to have more advantages. Moreover, the review findings accentuate that many cognitive processes applicable to engineering performance correspond to those of an artist. Therefore, it is possible to argue that visual and spatial learning, both of which can be enriched through art education, can be particularly beneficial. Many of the papers examined also highlighted the importance of project-based learning, as well as digital tools and other technology-related strategies, as they facilitate more meaningful integration.

Second, it is likely to note that the review revealed several gaps and opportunities for further research. Most of the available studies can still be regarded as non-longitudinal, and, in fact, little is known about the way the integration of these subjects influences future academic and career achievements. Also, concepts of diversity and inclusion can be incorporated in the review to a greater extent. Research studies that are to be conducted should concentrate on the way the educators react to the obligation to implement more integrated curricula and consider their needs. Based on the critical review findings, it is also possible to suggest several recommendations. First, future researchers should aim to create valid and comprehensive assessment instruments that would measure a wider range of skills that can be developed through the combined education. The diverse aspects of new technologies, including the development of VR and AR for schools, also appear to have potential in the field. Finally, more vivid and comprehensive teacher professional development programs should be promoted.

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THE INFLUENCE OF MULTIMEDIA TECHNOLOGIES ON THE PERCEPTION AND TEACHING OF GRAPHICS

Abstract

This research analyzes the impact of multimedia technologies on graphic design perception, and how this influences graphic design pedagogy, using examples such as visual reality (VR), 3D modeling, and interactive design platforms. The idea is to look at how virtual technologies affect students learning in visual literacy, spatial reasoning and design hands-on skills. Approaches Mixed The approach included pre/post assessments, surveys, classroom observations, and interviews.