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Improving Learning Results in Hydrocarbon Chemistry with Mind Mapping and Classical Music Accompaniment

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ABSTRACT

Purpose of the study: The purpose of this research is to evaluate the effect of using mind mapping learning accompanied by classical music on chemistry learning outcomes on hydrocarbon compound material in class X students at Public High School2 North Bengkulu.

Methodology: This research uses an experimental method with a t-test research design, where class X-3 is the control group that follows conventional learning, and class. Data collection instruments consist of pre-test and post-test questions. The analysis used data about learning outcomes using analysis descriptive and inferential.

Main Findings: The results of descriptive analysis show that the experimental class that used mind mapping accompanied by classical music had higher learning outcomes compared to the control class that followed conventional learning. The results of inferential analysis using the homogeneity test and normality test stated that the research hypothesis was accepted, indicating that there were significant differences in student learning outcomes between the two groups. The use of mind mapping learning accompanied by classical music can significantly improve student learning outcomes in hydrocarbon compound material compared to conventional learning.

Novelty/Originality of this study: The novelty of this research is to determine the effectiveness of applying themind mapping learning model accompanied by classical music to improve chemistry learning outcomes on hydrocarbon compound material.

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1. INTRODUCTION

Chemistry is a science that examines materials, natural phenomena, and the mechanisms that occur in them [1]. In simpler terms, chemistry is closely related to everyday life. Everything we experience, do, and the reasons why it happens and how it happens, is related to chemistry [2]–[4] Conveying chemistry concepts should start from the students' own lives. From the time he wakes up in the morning, to activities, to school, until he goes back to sleep at night everything is related to chemistry in particular and science in general, from this, mind mapping is a learning model that is suitable for delivering chemistry lessons, because mind mapping is one way of recording the lesson material make it easier for students to learn [5]–[7]. The way to learn is easier, starting from the center, students then move (their views) to the sides (left-right, up-down) as needed [8]–[10]. This makes remembering easier, because it matches the way the brain works [11]–[13].

Especially if when making a mind map students use different colors for each main idea. Apart from mind mapping, it looks beautiful, it also makes learning more exciting [14]–[16]. This attraction and passion can prolong students' concentration power, as well as awaken students' best ability to learn. As a result, learning outcomes become better.In general, students make traditional notes in the form of long linear writing that covers the entire content of the lesson material, so the notes look very monotonous and boring. Monotonous notes will omit important main topics from the course material [17], [18]. Therefore, the application of this mind mapping learning model is used in research by researchers on the subject of hydrocarbon compounds, because this subject is material that is mostly memorized material and chemical concepts that require strong memory [19]–[21]. So that the main important topics of the subject matter can be understood easily.

In an effort to remove barriers to learning, which means making the learning process more effective and speeding up, this can be done for example: through the use of music (to eliminate boredom while strengthening concentration through alpha conditions),visual equipment (to help students with strong visual abilities), appropriate materials. and the presentation is adapted to how the brain works, and active involvement (intellectually, mentally and emotionally). Siegel said that classical music produces calming alpha waves that can stimulate the limbic system, a network of brain neurons. Music Provides Stimulation to Cognitive Aspects (Mathematics) [22].The novelty of this research lies in the combination of using a mind mapping learning model with classical music accompaniment to improve chemistry learning outcomes on the topic of hydrocarbon compounds. This approach combines information visualization techniques that have been proven effective with elements of classical music which are believed to increase student focus and relaxation [23]. While these two methods have been applied separately in various educational contexts, this study is the first to examine the synergistic impact of both simultaneously in the context of chemistry learning. This opens up opportunities for innovative learning approaches that not only facilitate understanding of complex material but also create a more enjoyable and conducive learning environment.

This research is in line with research conducted by Anggraini & Hartono [24], who said that playing classical music is not only useful for students, teachers also benefit. By playing music, teachers can save energy to provide instructions to students during learning. This provides empirical evidence that creative and multisensory learning methods can facilitate better understanding of concepts and increase information retention. In addition, this impression can encourage teachers to adopt similar approaches in their teaching, creating a more interactive and enjoyable learning environment for students, as well as stimulating their interest and motivation to learn in the field of science [25].In this context, teacher success is student success, and student success means teacher success. In learning, it divides its constituent elements into two categories, consisting of context and content. Context is in the form of preparing conditions for implementing quality learning, while content is the presentation of lesson material.Based on this description, the author wants to solve the problem with the Quantum Teaching learning model, namely the "Mind Mapping" learning model because this learning model can be applied in high schools. Which will help students remember and process the information they receive. Finally, the researcher raised the title in conducting the research "Improving Learning Results in Hydrocarbon Chemistry with Mind Mapping and Classical Music Accompaniment".

2. RESEARCH METHOD

2.1. Type of Research

This research uses an experimental method with a t-test design, where class X-3 acts as a control group that follows conventional learning. This method allows researchers to compare the effectiveness of conventional learning with other learning methods applied to the experimental group, so that differences in learning outcomes between the two groups can be identified. Thus, this research can provide empirical evidence regarding the advantages or disadvantages of each learning method tested. The object of this research is class X students of Public High School2 North Bengkulu, which consists of an experimental class and a control class. In the experimental class the researchers applied the mind mapping learning model, while in the control class without applying mind mapping to the hydrocarbon compound material. Meanwhile, the subjects of this research are researchers who apply the mind mapping learning model accompanied by classical music.

2.2. Population and Sample

The population in this study were all class X students at Public High School 2 North Bengkulu which consisted of 5 classes. Two classes of samples were taken from the existing population, sampling was carried out by testing the homogeneity of all populations using the variance test formula. Then take 2 classes from the entire population that have been tested for homogeneity and the values are homogeneous. Then the two classes were randomly assigned one class as the experimental class and one class as the control class. The homogeneity test value used is the initial test value on the subject of redox reactions.

2.3. Data Collection Technique

The data collection technique in this research uses two types of techniques, namely documentation and tests. To obtain good questions as a tool for collecting students' chemistry learning achievements, trials were held on other students who were not involved in the learning process by giving embedded tests.The questions that were tested were then analyzed to determine their validity, differentiating power, level of difficulty and reliability.

2.4. Data Analysis Technique

Data analysis techniques in this research include initial data analysis and final data analysis. Where the initial data analysis uses a homogeneity test, and the final data analysis uses hypothesis testing.

2.5. Research Procedure

This research procedure begins by distributing questionnaires to a sample of students who have been determined randomly or through systematic selection [26], [27]. The following image illustrates how this research procedure was carried out:

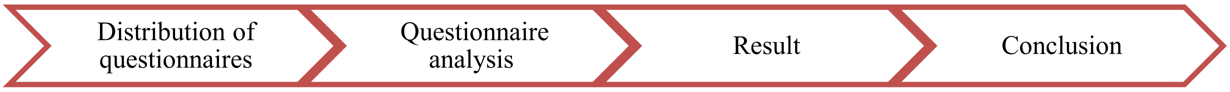

Figure 1. Research Procedure

3. RESULTS AND DISCUSSION

Initial data is taken from the homogeneity test value which is the value in the previous discussion, namely redox reactions. In determining the experimental class and control class, the researcher was immediately given 2 classes, namely classes X3 and meanwhile, for class According to the chemistry teacher in classes X3 and X5, they have the same abilities and this is confirmed by the initial data analysis which is summarized in the initial data analysis table for the two sample groups below.

Table 1. Initial Data Analysis Results

Class	N	ΣX	$\bar{X}$	F count	F table	S gab	t count	t table(0.975)
Experiment	38	2255	59.34	1.03	2.63	8.6662	1,005	1.98
Control	40	2295	57.37					

From the table above it can be seen that the value of Fcount = 1.03 and the value of Ftable = 2.63 and it is found that Fcount<Ftable. This means that the two sample groups have the same variance (homogeneous). Next, a two-party test was carried out to test the average similarity and the tcount value was obtained between -tcount and ttable ($-1.98 < 1.005 < 1.98$). So it can be concluded that the basic abilities of the two groups are the same.

The final data of this research were obtained from the difference in pre-test and post-test scores in the two sample groups (experimental class and control class). Data on pre-test and post-test scoresfrom the experimental class and control class are summarized in the following table:

Table 2. Hypothesis Test Data Analysis Results

Class	N	ΣX	$\bar{X}$	Sgab	tcount	ttable(0.95)	Kp
Experiment	38	1310	34.47	11.38	3.47	1.65	14%
Control	38	970	25.52				

The final data analysis was carried out using a 1 party test (1-α) to see the comparison between the experimental class and control class scores. Based on the table above, it can be seen that the value of tcount = 3.47 and ttable = 1.65 so that tcount>ttable, then the hypothesis can be accepted with a degree of influence of 14%.

The data used for the homogeneity test in this research is data taken from the results of the homogeneity test which includes redox reaction material. The results of the homogeneity test processing show that the basic abilities of the two classes are homogeneous with a value of Fcount = 1.03 and a value of Ftable = 2.63 and it is found that Fcount<Ftable. This shows that the two sample groups have the same variance (homogeneous). Then a two-tailed test (1-½ α) was carried out to test the similarity of the averages with $\alpha = 0.05$. From the analysis results, it was found that the tcount value was between–ttable and ttable ($-1.98 < 1.005 < 1.98$). So it is found that both classes have the same basic abilities (homogeneous). Before determining the experimental class and control class, I will first provide an explanation regarding this matter, that based on the explanation of the chemistry study teacher at Public High School2 North Bengkulu, there are 2 classes that are used as model classes or pilot classes for level X out of the 5 existing X classes at Public High School2 North Bengkulu. With that, I was only given the trust by the chemistry teacher to carry out a homogeneity test in class X, namely classes X3 and I will teach it has been taught or is currently running in that class. Then the determination of the experimental class and control class was carried out by drawing lots, and class X5 was obtained as the experimental class and class X3 as the control class. Then the experimental class was treated with the application of the mind mapping learning model, while the control class was without the application of mind mapping.

Before conducting this research, researchers first need to know whether the test questions used as instruments are appropriate or not. Sothe questions used for the pre-test and post-test must be tested first and then analyzed. This is to look at the desired criteria for validity, reliability, level of difficulty and differentiating power of the questions so that they are suitable for use as instruments in this research. The number of questions tested was 20 questions in the form of objective questions and the testing was carried out in class XI Science2 with a total of 30 students. In validity testing, researchers use content validity, where the essence of content validity is that a question is said to be valid if the question meets something that is measured (indicator). Based on the results of the analysis, it was found that the 20 questions tested met or matched the indicators, so that all questions or 100% of the questions were declared valid and 0% were declared invalid.

Based on the results of the question reliability analysis, the test reliability was found to be 0.56 with very high criteria. Based on the results of the trial analysis of the difficulty level of questions on the subject of hydrocarbon compounds, it is known that the number of questions is 0% with difficult criteria, 100% with medium criteria, 0% with easy criteria, and 0% with very easy criteria. Based on the results of the analysis of the discriminating power test, it is known that the number of questions is 20% with poor discriminating power criteria, 45% with good discriminating power criteria, 35% with very good discriminating power criteria.

Based on the results of the analysis of all the questions tested above, 16 questions were obtained that met the criteria, while researchers needed 20 questions that met the criteria to be used as instruments. This is because 4 of the 20 questions tested were not suitable for use as test instruments, because even though all the questions met the validity criteria, of these 4 questions there were 4 questions with poor discriminating power criteria. So these 4 questions cannot be used as test instruments. Therefore, the researcher created 4 new questions and had the same weight as the questions that had good validity and differentiating power so that they could be used as instruments in this research.

Data processing for hypothesis testing shows that tcount>ttable, namely tcount = 3.47 and ttable = 1.65, thus the hypothesis can be accepted with a degree of influence of 14%.In the control class average calculation $\overline{X}$, the number of X3 is divided by a sample of 38 students, even though the total sample size in the control class is 40, the reason is because there were two students who did not take the pre-test, only took the post-test, so the students were not counted in the sample study. The increase in student learning outcomes in the experimental class was due to the learning process using mind maps involving a lot of student activity, student independence, student aesthetics and student imagination, and also included the provision of sung classical music [28]. To students during the teaching and learning process to ensure a balance between the left brain used by students to think and the right brain used by students to receive aesthetics in the form of classical music or instrumental music which has high aesthetic value [29]. The transfer of sound waves which causes students' brains to relax, not tense, learning is more relaxed or does not force the brain to think hard which causes students to quickly become stressed and bored with the lessons taught by researchers, especially according to chemistry lessons [30]. is a lesson that gets boring quickly and makes the brain dizzy quickly.This can happen not only in chemistry lessons, but in other lessons. If the delivery of learning material is monotonous and does not create a learning atmosphere that creates students' interest in the subject matter taught by a teacher.

During the learning process by applying mind mapping, students will learn while imagining. Because the application of mind mapping requires students to fantasize about the values of art. In this case, students are given the freedom to draw whatever they want, because quite a few students really like drawing, although there are some people who may not like or dislike drawing, but we rarely encounter this because basically all humans likes art, whether in the form of painting, music and other arts.Mind mapping learning strategies in experimental classes can influence student learning achievement [31]. This is because in the experimental class the students are active in their imagination and this is balanced with the input of classical music which soothes the soul and creates a peaceful atmosphere in learning. However, this learning is also not free from weaknesses such as students' lack of imagination [32]. However, the mind mapping learning strategy has been able to influence the learning process so that it can improve student learning achievement on the subject of hydrocarbon compounds in class X at Public High School2 North Bengkulu.

The limitation of this research is that the sample limited to one school may not reflect the diversity of the student population in general, so the results may not be generalizable to a wider context. Additionally, control variables such as students' musical background and individual learning preferences may influence the results, but cannot be completely controlled. Then, the limited duration of the study may not be enough to see the long-term impact of using this learning model.

4. CONCLUSION

Based on the results of the analysis that has been carried out on students' chemistry learning outcomes on the main material of hydrocarbon compounds in class: The value of students' chemistry learning outcomes after conventional learning without using mind mapping accompanied by classical music and the value of using mind mapping accompanied by classical music is different, namely the higher the value of learning outcomes using mind mapping accompanied by classical music than conventionally. In this way, there is an increase in chemistry learning outcomes through mind mapping learning accompanied by classical music.There is a significant difference between students' chemistry learning outcomes through learning using mind mapping accompanied by classical music compared to students' chemistry learning outcomes conventionally.

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AUTHOR CONTRIBUTIONS

Conceptualization, S.; Methodology, S.; Software, S.; Validation, S.; Formal Analysis, S.; Investigation, S.; Resources, S.; Data Curation, S.; Writing – Original Draft Preparation, S.; Writing – Review & Editing, S.; Visualization, S.; Supervision, S.; Project Administration, S.; Funding Acquisition, S.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

REFERENCES

[1] H. Susanty, "Problematika pembelajaran kimia peserta didik pada pemahaman konsep dan penyelesaian soal soal hitungan," *Al Qalam J. Ilm. Keagamaan dan Kemasyarakatan*, vol. 16, no. 6, pp. 1929–1944, 2022.
[2] A. Sanova, A. Afrida, A. Bakar, and H. R. Yuniarccih, "Pendekatan etnosains melalui model problem based learning terhadap kemampuan literasi kimia materi larutan penyangga," *J. Zarah*, vol. 9, no. 2, pp. 105–110, 2021.
[3] S. Triwahyudi, "Pengembangan perangkat pembelajaran berbasis TPACK pada materi kimia SMA," *Chempublish J.*, vol. 6, no. 1, pp. 46–53, 2021.
[4] N. P. J. Artini and I. K. W. B. Wijaya, "Strategi pengembangan literasi kimia bagi siswa SMP," *J. Ilm. Pendidik. Citra Bakti*, vol. 7, no. 2, pp. 100–108, 2020.
[5] B. Revita, "Upaya meningkatkan hasil belajar siswa dalam mata pelajaran kimia melalui model pembelajaran mind mapping pada siswa kelas xi ipa 1 man 2 kota padang," *J. Pendidik. dan Konseling*, vol. 5, no. 2, pp. 4073–4080, 2023.
[6] M. Martini, "Melalui model pembelajaran mind mapping dapat meningkatkan hasil belajar siswa kelas x-tja 1 materi ikatan kimia mata pelajaran kimia di smk negeri 5 telkom banda aceh tahun pelajaran 2019/2020," *J. Serambi Akad.*, vol. 11, no. 1, pp. 85–99, 2023.
[7] M. Ramdhani and H. Habiddin, "Reduksi miskonsepsi siswa pada materi sifat asam basa larutan garam dengan pembelajaran learning cycle-5e dan mind-mapping," *Indones. J. Educ. Sci.*, vol. 6, no. 1, pp. 1–14, 2023.
[8] F. Aenulyaqin, L. I. Azizah, M. Sa'adah, and S. Mulyanti, "Analisis pola pembelajaran alkana dan sikloalkana pada jenjang sma," in *Prosiding Seminar Nasional Orientasi Pendidik dan Peneliti Sains Indonesia*, 2023, vol. 1, pp. 80–87.
[9] F. Helmastuti, D. N. Asri, and Q. K. A. Sari, "Efektivitas layanan bimbingan klasikal menggunakan teknik mind mapping untuk mengeksplorasi bakat dan kemampuan siswa kelas xi kimia analisa 3 di smk negeri 3 madiun," in *Seminar Nasional Sosial, Sains, Pendidikan, Humaniora (SENASSDRA)*, 2023, vol. 2, no. 1, pp. 97–104.
[10] A. Astalini *et al.*, "Identification of student character values in class x particle dynamics materials," *JIPF (Jurnal Ilmu Pendidik. Fis.*, vol. 8, no. 3, pp. 380–388, 2023.
[11] D. M. Roudloh, D. H. Laili, E. A. L. Zahro, and S. Mulyanti, "Review literatur perangkat pembelajaran kimia pada materi hidrokarbon," in *Prosiding Seminar Nasional Orientasi Pendidik dan Peneliti Sains Indonesia*, 2023, vol. 1, pp. 123–130.
[12] I. A. Ibrahim, J. Jusniar, and B. R. Diana, "Penerapan model discovery learning (dl) berbantukan mind mapping sebagai media belajar untuk meningkatkan hasil belajar peserta didik," *J. Pemikir. DAN Pengemb. PEMBELAJARAN*, vol. 5, no. 3, pp. 1035–1042, 2023.
[13] J. P. Casquilho, F. Sinaga, N. Septiani, S. W. Oktavia, N. N. Qoidah, and E. F. S. Rini, "Pengaruh kemampuan berpikir kritis terhadap hasil belajar ipa siswa," *EduFisika J. Pendidik. Fis.*, vol. 8, no. 2, 2023.
[14] M. Aizinsh, S. W. Oktavia, R. Firmansyah, and R. Ruttinawati, "Exploration of the character of cooperation in physics," *EduFisika J. Pendidik. Fis.*, vol. 8, no. 2, 2023.

[15] S. W. Oktavia, H. Mansyur, and M. Hidayat, “Investigasi keterampilan mengajar guru fisika sman 9 kerinci,” *Relativ. J. Ris. Inov. Pembelajaran Fis.*, vol. 6, no. 1, pp. 24–30, 2023.

[16] F. P. Sinaga, J. Jurhana, Y. Yusrita, and M. H. M. Hidayat, “Analisis penggunaan metode mengajar (metode demonstrasi, metode eksperimen, metode inquiry, dan metode discovery di sma negeri 11 kota jambi),” *Relativ. J. Ris. Inov. Pembelajaran Fis.*, vol. 5, no. 2, pp. 103–110, 2023.

[17] Astalini, Darmaji, D. A. Kurniawan, F. P. Sinaga, M. Z. Azzahra, and E. Triani, “Identification the 2013 curriculum teacher ' s book to determine the character values of class x students on circular motion material,” *J. Pendidik. Sains Indones.*, vol. 11, no. 3, pp. 545–558, 2023, doi: https://doi.org/10.24815/jpsi.v11i3.28567.

[18] R. Bellová, D. Melicherčíková, and P. Tomčík, “Possible reasons for low scientific literacy of Slovak students in some natural science subjects,” *Res. Sci. Technol. Educ.*, pp. 1–18, 2017, doi: 10.1080/02635143.2017.1367656.

[19] N. M. H. Nik Hassan, O. Talib, and H. F. Lokman, “Class map: Improving students' skills of organic synthesis in learning organic chemistry for pre-university students,” *Malaysian J. Soc. Sci. Humanit.*, vol. 7, no. 1, pp. 270–284, 2022, doi: 10.47405/mjssh.v7i1.1231.

[20] N. M. Rosa and A. Pujiati, “Pengaruh model pembelajaran berbasis masalah terhadap kemampuan berpikir kritis dan kemampuan berpikir kreatif,” *Form. J. Ilm. Pendidik. MIPA*, vol. 6, no. 3, pp. 175–183, 2017, doi: 10.30998/formatif.v6i3.990.

[21] A. Sibomana, C. Karegeya, and J. Sentongo, “Students' conceptual understanding of organic chemistry and classroom implications in the rwandan perspectives: a literature review,” *African J. Educ. Stud. Math. Sci.*, vol. 16, no. 2, pp. 13–32, 2020, doi: 10.4314/ajesms.v16i2.2.

[22] A. Hamid, “Keefektifan pembelajaran ber-background musik instrumental klasik terhadap aspek kognitif dan afektif siswa,” *QUANTUM, J. Inov. Pendidik. Sains*, vol. 5, no. 2, pp. 103–111, 2014.

[23] K. A. Rahmi, G. Rahmawati, B. P. Hati, S. Bulut, T. Rahmi, and U. Febriani, “Efektivitas penggunaan musik klasik dan warna secara bersamaan terhadap short term memory,” *J. Psikol. Terap.*, vol. 6, no. 1, p. 1, 2023, doi: 10.29103/jpt.v6i1.11828.

[24] M. H. Anggraini, Ade Rizki., Hartono, “Pendapat siswa mengenai pembelajaran kimia yang diiringi musik klasik pada siswa kelas xi ipa sman 5 palembang,” *J. Penelit. Pendidik. Kim. Kaji. Has. Penelit. Pendidik. Kim.*, vol. 2, no. 2, pp. 128–133, 2017.

[25] U. Khasanah, S. Nurhayati, and W. Sunarto, “Pengaruh model brain based learning dengan tugas membuat mind mapping terhadap hasil belajar kimia siswa sma,” *Chem. Educ.*, vol. 7, no. 1, pp. 17–23, 2018.

[26] S. Zubaidah, N. M. Fuad, S. Mahanal, and E. Suarsini, “Improving creative thinking skills of students through Differentiated Science Inquiry integrated with mind map,” *J. Turkish Sci. Educ.*, vol. 14, no. 4, pp. 77–91, 2017, doi: 10.12973/tused.10214a.

[27] R. Purwanti, Hobri, and A. Fatahillah, “Analisis kemampuan berpikir kritis siswa dalam menyelesaikan persamaan kuadrat pada pembelajaran model creative problem solving,” *KadikmA*, vol. 7, no. 1, pp. 84–93, 2016.

[28] G. Coppola *et al.*, “Mozart's music in children with drug-refractory epileptic encephalopathies,” *Epilepsy Behav.*, vol. 50, pp. 18–22, 2015, doi: 10.1016/j.yebeh.2015.05.038.

[29] J. S. Rahman, T. Gedeon, S. Caldwell, R. Jones, and Z. Jin, “Towards effective music therapy for mental health care using machine learning tools: human affective reasoning and music genres,” *J. Artif. Intell. Soft Comput. Res.*, vol. 11, no. 1, pp. 5–20, 2021, doi: 10.2478/jaiscr-2021-0001.

[30] L. Harmat, J. Takács, and R. Bódizs, “Music improves sleep quality in students,” *J. Adv. Nurs.*, vol. 62, no. 3, pp. 327–335, 2008, doi: 10.1111/j.1365-2648.2008.04602.x.

[31] X. Zheng, T. E. Johnson, and C. Zhou, “A pilot study examining the impact of collaborative mind mapping strategy in a flipped classroom: learning achievement, self-efficacy, motivation, and students' acceptance,” *Educ. Technol. Res. Dev.*, vol. 68, no. 6, pp. 3527–3545, 2020, doi: 10.1007/s11423-020-09868-0.

[32] M. H. de Menendez, C. E. Díaz, and R. Morales-Menendez, “Technologies for the future of learning: state of the art,” *Int. J. Interact. Des. Manuf.*, vol. 14, no. 2, pp. 683–695, 2020, doi: 10.1007/s12008-019-00640-0.