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Systematic Literature Review: A Fun Organic Chemistry Learning Experience with Educational Games

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Abstract: This article examines organic chemistry educational games developed between 2017-2023. The purpose of this study is to find out the types of educational games that are most developed, organic chemistry materials that have been developed in the form of educational games, and the positive impact of educational games in studying organic chemistry. The method used in this study is a systematic literature review. The systematic literature review is carried out in three stages, namely the planning stage, the implementation stage, and the reporting stage. Based on the results of the study, 38 articles were obtained by the criteria and further analysis was carried out. The results of the analysis show that organic chemistry educational games are developed with various types of games both in digital and non-digital forms. The most developed organic chemistry educational games are strategy video games and card games. The most developed material in the form of educational games is the molecular structure of organic compounds which is shown to deepen students' understanding in organic chemistry courses.

Keywords: Educational games; Organic chemistry; Systematic literature review

Introduction

Chemistry is one of the most important branches of science because it studies various phenomena that occur in everyday life (Kolomuç &; Tekin, 2011). However, there are several challenges in studying chemistry in the classroom (Byusa et al., 2022). This challenge occurs because of the characteristics of chemistry, which include its abstract nature and the amount of material that needs to be studied (Marthafera et al., 2018; Wu et al., 2018) so that often students lose interest in studying chemistry.

In various branches of chemistry studied in lectures, organic chemistry is one of the branches of chemistry that is considered difficult by most students. Some research was conducted to know the presentation of student failure in studying organic chemistry. the researchers found that around 40-60% of students failed to study organic chemistry (Da Silva Júnior, Santos De Lima, et al., 2020). Another study found that 73.6% of students find it difficult to study organic chemistry (Rahmawati & Irawati, 2023).

The high presentation of failure is due to the large number of reactions that need to be learned (Senol, 2021), the need for ingenuity and higher problem-solving skills (Da Silva Júnior, Santos De Lima, et al., 2020), and learning in class that tends to be monotonous makes students easily bored (Jodlowski et al., 2018; Jodlowski et al., 2018; Jodlowski et al., 2018).

Therefore, a solution is needed so that learning organic chemistry is easier to understand, more attractive to students, and not monotonous. One alternative media that can be used is to use games. The game was chosen based on the result of research conducted on 109 students, it was found that 91.8% of video game players were in the general range of 18-21 years, and the intensity of students playing games and

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the largest percentage of students playing games for 1-2 hours a day and 2-4 hours a day. Based on this, the application of video games in organic chemistry learning is one of the promising opportunities (Palupi et al., 2017).

Currently, games combined with chemistry learning have been widely applied in various chemical materials with various types of games such as card games (Kavak et al., 2021; Triboni &; Weber, 2018), board games (Eastwood, 2013; Zhang et al., 2021), and applications (Shoesmith et al., 2020; Winter et al., 2016). Therefore, this article will discuss systematic literature reviews of various forms and types of educational games that have been developed for organic chemistry and what organic chemistry concepts have been developed in the form of educational games to provide a more enjoyable learning experience for students.

Based on the description above, researchers are interested in conducting a systematic literature review with the following research questions: (1) What types of educational games were most developed to teach organic chemistry in the 2017-2023 period? (2) What organic chemistry concept is most developed in the form of educational games in both digital and non-digital forms? (3) What is the positive impact of each educational game that has been developed in studying organic chemistry?

Method

A literature review is one of those scientific investigations that must be valid, reliable, and repeatable. Literature review can take two forms, namely a literature review that is used as a background in a study and a literature review that stands alone as a work of literature (Xiao &; Watson, 2019). Literature reviews that stand alone and are carried out with systematic and strict standards are called systematic literature reviews (SLR) (Okoli &; Schabram, 2010). A review is said to be systematic if the research questions are formulated, identify relevant studies, assess their quality, and summarize the evidence with an explicit methodology (Khan et al., 2003). There are three stages carried out in this SLR research, namely the planning stage, the conducting stage, and the reporting stage.

Planning stage

At this stage, researchers determine the theme of the research to be carried out, namely about educational games in organic chemistry courses. After that, the researcher determines the criteria for the article to be used in the SLR. The criteria for articles used are shown in Table 1.

Table 1. Article Criteria used in SLR

Criteria	Description
Included	The article that will be used discusses the game on organic chemistry
	The articles used are articles that have been published in the 2017-2023
	The articles used are articles published in journals indexed by Scopus
	Articles with participants are undergraduate students
	Articles accessible
Excluded	Literature review, nomenclature, and proceedings articles are not included
	Articles not about games on organic chemistry are not included
	Articles not indexed by Scopus are not included
	Articles with high school student participants are not included
	Article inaccessible

Conducting stage

At this stage, the collection of articles from various database sources by the criteria that have been developed. Articles are taken from various Scopus database sources, such as Google Scholar, and Publish or Perish. The articles taken are articles published for the last 6 years with a period of 2017-2023. The keywords used in the article search are game education, game-based learning, organic, and chemistry. Search results with Google Scholar and Publish or Perish obtained 77 related articles. The 77 articles were further analyzed and grouped into included and excluded groups according to predetermined criteria. From the grouping results, 38 articles were included and 39 articles were excluded. The flow used at the implementation stage can be seen in Figure 1.

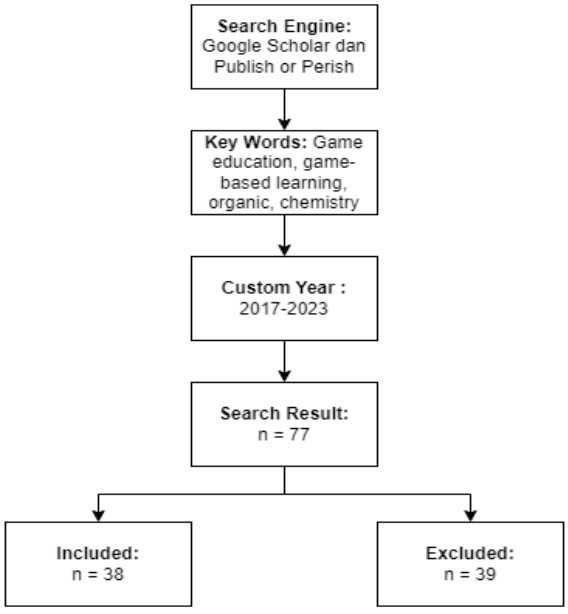

Figure 1. SLR conducting stage flow

Table 2. Articles used in SLR

Article Title	Writer	Year	Code	Source
CHEMCompete: An Organic Chemistry Card Game to Differentiate between Substitution and Elimination	Kristin Gogal, William Heuett, and Deana Jaber	2017	ND	(Gogal et al., 2017)
Teaching Classes of Organic Compounds with a Sticky Note on Forehead Game	Kevin P. O'Halloran	2017	ND	(O'halloran, 2017)
Incorporation of Brainteaser Game in Basic Organic Chemistry Course to Enhance Students' Attitude and Academic Achievement	Jeongho Cha, Su-Yin Kan, Nurul Huda Wahab, Ahmad Nazif Aziz, and Poh Wai Cha	2017	ND	(Cha et al., 2017)
MOL: Developing a European-style board Game to Teach Organic Chemistry	Eduardo Triboni and Gabriel Weber	2018	ND	(Triboni & Weber, 2018)
"Spot the Differences" Game: An Interactive Method That Engage Students in Organic Chemistry Learning	Jeongho Cha, Su-Yin Kan, Poh Wai Chia	2018	ND	(Cha et al., 2018)
Chirality-2: Development of a Multilevel Mobile Gaming App to Support the Teaching of Introductory Undergraduate-Level Organic Chemistry	Oliver A. H. Jones, Maria Spichkova, and J. S. Spencer	2018	D	(Jones et al., 2018)
Interactive Computer Game That Engages Students in Reviewing Organic Compound Nomenclature	JoséNunes da Silva Júnior, Davi Janoˆ Nobre, Roˆmulo Silva do Nascimento,Giancarlo Schaffer Torres, Jr., Antonio José Melo Leite, Jr., André Jalles Monteiro, Francisco Serra Oliveira Alexandre, Maria Teresa Rodríguez, and Maria Joseja Rojo	2018	D	(Da Silva Júnior et al., 2018)
Applying a Quiz-Show Style Game to Facilitate Effective Chemistry Lexical Communication	Sam Boon Kiat Koh and Fun Man Fung	2018	D	(Koh & Fung, 2018)
CHEMCompete-II: An Organic Chemistry Card Game to Differentiate between Substitution and Elimination Reactions of Alcohols	Maria Camarca, William Heuett, and Deana Jaber	2019	ND	(Camarca et al., 2019)
Stereochemistry Game: Creating and Playing a Fun Board Game to Engage Students in Reviewing Stereochemistry Concepts	José Nunes da Silva Júnior, Andiel Esdras de Andrade Uchoa, Mary Anne Sousa Lima, and André Jalles Monteiro	2019	ND	(Da Silva Júnior et al., 2019)
Game-Based Application for Helping Students Review Chemical Nomenclature in a Fun Way	Mary Anne Sousa Lima, Álvaro Carvalho Monteiro, Antonio José Melo Leite Junior, Izac Sidarta de Andrade Matos, Francisco Serra Oliveira Alexandre, Davi Janoˆ Nobre, André Jalles Monteiro, and José Nunes da Silva Júnior	2019	D	(Sousa Lima et al., 2019)
Puzzle to Build Organic Molecules with Sticky Notes	Kevin P. O'Halloran	2019	ND	(O'Halloran, 2019)
Organic Chemistry I Cassino: A Card Game for Learning Functional Group Transformations for First Semester Students	Petter T. Bell, Bernat A. Martinez-Ortega, and Ashlee Birkenfeld	2020	ND	(Bell et al., 2020)
Gamification of ChemDraw during the COVID-19 Pandemic: Investigating How a Serious, Educational-Game Tournament (Molecule Madness) Impacts Student Wellness and Organic Chemistry Skills while Distance Learning	Matthew T. Fontana	2020	D	(Fontana, 2020)
Go Fischer: An Introductory Organic Chemistry Card Game	Georgia L. Battersby, Corey Beeley, Andielle A. Baguley, Harrison D. Barker, Harvey D. Broad, Niamh C. Carey, Edward S. Chambers, Daria Chodaczek,	2020	ND	(Battersby et al., 2020)

Article Title	Writer	Year	Code	Source
	Richard A. R. Blackburn, and Dylan P. Williams			
Interactions 500: Design, Implementation, and Evaluation of a Hybrid Board Game for Aiding Students in the Review of Intermolecular Forces During the COVID-19 Pandemic	José Nunes da Silva Júnior, José Mariano de Sousa Oliveira, Jean-Yves Winum, Antonio José Melo Leite Junior, Francisco Serra Oliveira Alexandre, David Macedo do Nascimento, Ulisses Silva de Sousa, Antônia Torres Ávila Pimenta, and André Jalles Monteiro	2020	D	(Da Silva Júnior, De Sousa Oliveira, et al., 2020)
Organic Fanatic: A Quiz-Based Mobile Application Game to Support Learning the Structure and Reactivity of Organic Compounds	Jake Shoesmith, Jonathan D. Hook, Andrew F. Parsons, and Glenn A. Hurst	2020	D	(Shoesmith et al., 2020)
Reactions: An Innovative and Fun Hybrid Game to Engage the Students Reviewing Organic Reactions in the Classroom	José Nunes da Silva Junior, Mary Anne Sousa Lima, Ulisses Silva de Sousa, David Macedo do Nascimento, Antonio José Melo Leite Junior, Kimberly Benedetti Vega, Beatrice Roy, and Jean-Yves Winum	2020	D	(Da Silva Júnior, Sousa Lima, et al., 2020)
A Hybrid Board Game to Engage Students in Reviewing Organic Acids and Bases Concepts	José Nunes da Silva Junior, Davila Zampieri, Marcos Carlos de Mattos, Bruna Ribeiro Duque, Antonio José Melo Leite Junior, Ulisses Silva de Sousa, David Macedo do Nascimento, Mary Anne Sousa Lima, and André Jalles Monteiro	2020	D	(Da Silva Júnior, Zampieri, et al., 2020)
Time Bomb Game: Design, Implementation, and Evaluation of a Fun and Challenging Game Reviewing the Structural Theory of Organic Compounds	José Nunes da Silva Junior, Paulo Roberto Santos de Lima, Mary Anne Sousa Lima, Álvaro Carvalho Monteiro, Ulisses Silva de Sousa, Antonio José Melo Leite Junior, Kimberly Benedetti Vega, Francisco Serra Oliveira Alexandre, and André Jalles Monteiro	2020	D	(Da Silva Júnior, Santos De Lima, et al., 2020)
Choose Your Own "Labventure": A Click-Through Story Approach to Online Laboratories during a Global Pandemic	John G. D'Angelo	2020	D	(D'Angelo, 2020)
Intermolecular Forces Game: Using a Card Game to Engage Students in Reviewing Intermolecular Forces and Their Relationship to Boiling Points	Luke Nambi Mohanam and Amanda J. Holton	2020	ND	(Mohanam & Holton, 2020)
C=ocarbohidratos: Efecto Del Juego Sobre El Aprendizaje	Sulma Paola Vera-Monroy, Alexander Mejía-Camacho, and María Cristina Gamboa Mora	2020	ND	(Vera-Monroy et al., 2020)
Online Chemistry Crossword Puzzles prior to and during COVID-19: Light-Hearted Revision Aids That Work	Russell J. Pearson	2020	D	(Pearson, 2020)
1H NMR Spectrum: A Team-Based Tabletop Game for Molecular Structure Elucidation	Zachary Thammavongsy, Michael A. Morris, and Renée D. Link	2020	D	(Thammavongsy et al., 2020)
CheMakers: Playing a Collaborative Board Game to Understand Organic Chemistry	Zilong Zhang, Phillmont Muktar, Christoper Ivan Wijaya Ong, Yulin Lam, and Fun Man Fung	2021	ND	(Zhang et al., 2021)
Organosliding Game: Organic Compounds Maker	Nusret Kavak, Havva Yamak, and Hatice Togru	2021	ND	(Kavak et al., 2021)
ChemistDice: A Game for Organic Functional Groups	Senol Sen	2021	ND	(Senol, 2021)

Article Title	Writer	Year	Code	Source
Make or Take: An Active Learning Game of Organic Synthesis	Claire S. Therriault and Eric J. Kantorowski	2021	D	(Therriault & Kantorowski, 2021)
HSG400 – Design, implementation, and evaluation of a hybrid boardgame for aiding chemistry and chemical engineering students in the review of stereochemistry during and after the COVID-19 pandemic	José Nunes da Silva Júnior, Antonio José Melo Leite Junior, Jean-Yves Winum, Andrea Basso, Ulisses Silva de Sousa, David Macedo do Nascimento, and Samuel Moura Alves	2021	D	(da Silva et al., 2021)
Design, implementation, and evaluation of a game-based application for aiding chemical engineering and chemistry students to review the organic reactions	José Nunes da Silva Júnior, Mary Anne Sousa Lima, Antonia Torres Ávila Pimenta, Fátima Miranda Nunes, Álvaro Carvalho Monteiro, Ulisses Silva de Sousa, Antonio José Melo Leite Júnior, Dávila Zampieri, Francisco Serra Oliveira Alexandre, Ulisses Silva de Sousa, Natalia Lorena Pacioni, and Jean-Yves Winum	2021	D	(da Silva Júnior et al., 2021)
The Development, Use, and Evaluation of Digital Games and Quizzes in an Introductory Course on Organic Chemistry for Preservice Chemistry Teacher	Jolanda Hermanss and David Keller	2022	D	(Hermanns & Keller, 2022)
A Virtual Game-Based Tournament to Engage Students in Reviewing Organic Acids and Bases Concepts	José Nunes da Silva Júnior, Dávila Zampieri, Antonio José Melo Leite Junior, Francisco Serra Oliveira Alexandre, Jean-Yves Winum, Andrea Basso, André Jalles Monteiro, and Lucas Lima da Silva	2022	D	(Da Silva Júnior et al., 2021)
Hybridization Gamified: A Mobile App for Learning About Hybridization	Steven J. Petritis, Katherine M. Byrd, and Will Schneller	2022	D	(Petritis et al., 2022)
Advancing Global Chemical Education Through Interactive Teaching Tools	Fransesca M. Ippoliti, Jason V. Chari, and Neild K. Garg	2022	D	(Ippoliti et al., 2022)
Inter-Twine-d: Combining Organic Chemistry Laboratory and Choose-Your-Own-Adventure Games	Shannon J. Saluga, Hannah Peacock, Andiel D. Seith, Casadora C. A. Boone, Yasamin Fazeli, Rebecca Mai Huynh, Jinyu Luo, Zane Naghi, and Renee D. Link	2022	D	(Saluga et al., 2022)
GALIO Gaming: aprendizaje lúdico de Química Inorgánica y Orgánica Parte 1: desarrollo de un proyecto lúdico-didáctico en la Facultad de Química de la UNAM	Antonio Reina, Chloé Lhardy, Héctor García-Ortega, Jesús Gracia-Mora, Armando Marín-Becerra, and Miguel Reina	2023	ND	(Reina et al., 2023)
Development and Implementation of an Online Narrative Game to Aid Studying and Review in an Online General Chemistry Course	Maria Samy William Yacoub and Amanda J. Holton	2023	D	(Yacoub & Holton, 2023)

Reporting stage

At this stage, reporting on SLR results is carried out following previously developed research questions. At this stage, articles that fall into the included category are coded D (Digital) and ND (Non-Digital). The articles used in this SLR are shown in Table 2

Result and Discussion

Q1. What type of educational game were most developed to teach organic chemistry from 2017-2023?

Games can be defined as a self-chosen activity without any element of coercion and pressure by a sense of responsibility. The purpose of the game lies in the game itself (Khobir, 2009). Games used for learning require a careful balance between material and game needs (Plass et al., 2010). Some other terms used in games intended for learning are serious games, educational games, or simulation games (Jääskä &; Aaltonen, 2022). In this study, the term educational games or educational games was used.

The educational games analyzed in this study are divided into digital educational games and non-digital

educational games. The underlying differences between digital games and non-digital games are their distribution, storage, accessibility, and physical form. Digital games do not have a physical form that can be touched so in distribution digital games are distributed electronically and the necessary data is stored in digital storage such as hard drives and SSDs. In an internet connection, digital games require a stable internet connection, but in its development, digital games can be developed to be played without requiring an internet connection. Therefore, digital games can be accessed anytime and anywhere without carrying the physical game. Non-digital games have a physical form that can be touched so that if the physical game is lost or damaged, it needs to be replaced to still be able to play the game. Non-digital games do not require an internet connection to play.

Non-digital games are divided into several groups, namely card games, board games, puzzles, gambling, tile/tabletop games, and physical / sports (Mortenson et al., 2017). Digital games are divided into several groups, namely simulation games (SGs), strategy video games (SVGs), action video games (AVGs), and fantasy games (FGs) (Choi et al., 2020).

Strategy video games (SVGs) are divided into real-time strategy (RTS) and Turn-Based Strategy (TBS). The difference between RTS and BTS is in the player's thought process. RTS requires players to determine the results of relevant thought processes and determine their strategies, while BTS's thought processes are directed by the game system. Furthermore, Action video games (AVGs) are divided into first-person shooters (FPS) and third-person games (TPGs). The difference between FPS and TPGs is based on the player's perspective. FPS is played based on the player's perspective while TPGs are played based on experience that depends on the time and space settings in the game environment. Role-playing games (RPG) and Massive-Multi Player Online RPGs (MMORPGs) are games in the form of fantasy games where social and participatory aspects are emphasized and the game itself becomes a social arena (Choi et al., 2020).

Educational games on organic chemistry that have been analyzed in the range of 2017-2023 are grouped into digital and non-digital games. The results of grouping organic chemistry educational games are presented in Table 3.

Table 3. Results of grouping digital and non-digital organic chemistry educational games

Category	N	Percentage (%)
Digital	22	57.9
Non-Digital	16	42.1
Total	38	100

Based on Table 3. It is known that in the 2017-2023 period with the article criteria mentioned in Table 1, it was found that 57,9% of organic chemistry educational games developed were digital games and 42,1% were non-digital games. The types of educational games that are spread in digital and non-digital forms are shown in Table 4.

Table 4. Results of grouping types of organic chemistry educational games

Category		Game Type	N	Percentage (%)
Digital	SVGs	SGs	4	11
		RTS	5	13
		TBS	11	29
	FGs	RPG	1	3
		MMORPG	1	3
Non-Digital		Card Game	10	26
		Board Game	4	11
		Puzzle	2	5
		Total	38	100

Based on table 4. It is known that in the 2017-2023 range with the article criteria listed in Table 1, it was found that in organic chemistry digital educational games, the most developed type of game is Strategy Video Games with the Turn-Based Strategy (SVGs-TBS) subcategory. This is because technology is growing and it is easier to access video games. Digital games are also shown to build knowledge and help students review the material learned in class so that in the process of playing and learning, students' thinking processes will be directed by games. However, not all digital organic chemistry educational games developed are shown to review material or build knowledge. Some types of games developed are tailored to the needs of organic chemistry to be taught. Digital games developed for competition purposes are found with SVGs-RTS and RGP / MMORPG types, where students can make decisions based on their strategies. The digital games developed to provide an overview and simulation such as spectrum creation or virtual laboratories are found with the type of SGs.

In non-digital organic chemistry educational games, the most developed type of game is a card game. Card games have the advantage of being relatively small and lightweight so they are easy to carry anywhere. In addition, the components on the game card are not as complex as board games and have a realistic flexible time. However, it is possible that board games and puzzles are not suitable for organic chemistry, because both types of games can also be found in the form of board games (11%) and puzzles (5%). You also do not rule out the possibility that organic chemistry can be packaged in other types of educational games.

Q2. What organic chemistry concepts were most developed in the form of educational games in both digital and non-digital forms?

Table 5. Grouping of the concepts of organic chemistry developed in the form of games

Organic Chemistry Concepts	
Basic Organic Chemistry	Introduction of organic chemistry
	Symmetry
	Structure of organic compounds
	Chirality
	Stereochemistry
	Binding configuration
Molecular structure	Intermolecular force
	Reactivity of organic compounds
	Structural theory of organic compounds
	Heteroatom
	Hybridization
	Substitution reaction
	Elimination Reaction
	Reaction mechanism
Organic chemical reactions	Nucleophilic
	Electrophilic
	Steric effect
	Acid-Base
	Functional groups
	Nomenclature
Functional compounds	Functional group transformation
	Alkenes
Synthetic organic	Synthesis of organic compounds
	Organic chemistry laboratory
	Organic chemical separation technique
	FT-IR
Analysis of spectroscopy	Melting point identification
	Boiling point identification
	Liquid-liquid extraction
	Recrystallization
	NMR spectrum
Biosynthesis	Organic chemistry and medicine

Organic chemistry can be defined as one of the branches of chemistry that studies the structure, properties, composition, reactions, and synthesis of organic compounds (Legiso, 2021). As a branch of science, organic chemistry has a wide variety of topics and discussions. Fessenden & Fessenden (1982a, 1982b) in their book describes several concepts in organic chemistry, namely a review of atoms and molecules; the role of orbitals in covalent bonds; isomeric structures; stereochemistry; alkyl halide substitution and elimination reactions; free radical reactions in organometallic compounds; hydrocarbon compounds and their derivatives; alcohol-derived compounds; infrared spectroscopy, NMR, UV, mass spectroscopy; heterocyclic and polycyclic aromatic compounds; enolate and carbanion; pericyclic reactions; and macromolecules. Rangkuti (2023) in her writing summarizes the topics of organic chemistry presented by (Fessenden &; Fessenden, 1982a, 1982b) into six major groups, namely molecular structure, organic chemical reactions, functional compounds, organic synthesis, spectroscopic analysis, and biosynthesis.

The educational games organic chemistry analyzed in the range 2017-2023 according to the criteria in Table 1. Then it is grouped according to the concepts that are developed into educational games of organic chemistry. This grouping is shown in Table 5. Based on Table 5 it is known that in the 2017-2023 period, the most developed organic chemistry was in the molecular structure group, with several concepts such as symmetry, organic chemical structure, chirality, stereochemistry, etc. Games developed in both digital and non-digital forms vary in terms of chemical materials. Given the many concepts of organic chemistry that have not been developed in the form of games, the opportunity to develop educational games on organic chemistry is still very likely both in digital and non-digital forms.

Q3. What is the positive impact that each educational game that has been developed in studying organic chemistry has had?

As mentioned by Plass et al. (2010) that games used for learning purposes either as a medium to build knowledge or strengthen student knowledge must have a balance between material and games. Table 6. Shows the equilibrium between organic chemistry and the goals to be achieved using the game used.

Based on Table 6. In the 2017-2023 period, organic chemistry educational games were developed with various goals, such as to improve student academic performance, increase student interest and motivation, and also deepen student understanding. In addition, games are also developed to be developed to evaluate student understanding. Organic chemistry educational games are also developed to improve some skills that are important in the 21st century such as critical thinking skills, communication skills, analytical skills, student creativity, spectrum interpretation skills, and improving spatial visual intelligence. And problem-solving skills. Students agree that using organic chemistry educational games can increase their confidence in studying organic chemistry.

Table 6. The purpose of using organic chemistry educational games in the 2017-2023 range

Impact	Source
Evaluate student understanding	(Battersby et al., 2020; Da Silva Júnior et al., 2018, 2019; Da Silva Júnior, De Sousa Oliveira, et al., 2020; Da Silva Júnior, Sousa Lima, et al., 2020; Gogal et al., 2017; Pearson, 2020; Sousa Lima et al., 2019)
Increase student interest and motivation	(Bell et al., 2020; Cha et al., 2017, 2018; Da Silva Júnior, De Sousa Oliveira, et al., 2020; O'halloran, 2017; Shoesmith et al., 2020; Triboni & Weber, 2018; Vera-Monroy et al., 2020)(Zhang et al., 2021)
Improve academic performance	(Bell et al., 2020; Cha et al., 2017; Da Silva Júnior et al., 2018; Mohanam & Holton, 2020; Shoesmith et al., 2020; Sousa Lima et al., 2019; Vera-Monroy et al., 2020)
Improve critical thinking skills	(Mohanam & Holton, 2020; Triboni & Weber, 2018)
Deepen students' knowledge	(Camarca et al., 2019; Cha et al., 2018; D'Angelo, 2020; Da Silva Júnior, Santos De Lima, et al., 2020; Da Silva Júnior, Zampieri, et al., 2020; Fontana, 2020; Gogal et al., 2017; Jones et al., 2018; Kavak et al., 2021; O'Halloran, 2019; O'halloran, 2017; Senol, 2021; Thammavongsy et al., 2020; Vera-Monroy et al., 2020)
Improve analytical skills	(Cha et al., 2018)
Improve communication skills	(Da Silva Júnior, Zampieri, et al., 2020; Fontana, 2020; Kavak et al., 2021; Koh & Fung, 2018; Mohanam & Holton, 2020; Thammavongsy et al., 2020; Vera-Monroy et al., 2020; Zhang et al., 2021)
Improve problem-solving skills	(Da Silva Júnior et al., 2019; Da Silva Júnior, De Sousa Oliveira, et al., 2020)
Increase students' confidence	(Fontana, 2020)
Improve spectrum interpretation skills	(Thammavongsy et al., 2020)
Develop creativity	(Kavak et al., 2021)
Improve spatial visual intelligence	(Kavak et al., 2021)

Conclusion

Based on the systematic literature review that has been reported, in the 2017-2023 period, various organic chemistry educational games have been developed with various types of games both in digital and non-digital forms. Games developed have proven to have a positive impact in improving students' academic performance and improving some of the skills needed in the 21st century.

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Author Contributions

Conceptualization, Clarysa Satari, Wiji, Tuszie Widhiyanti, and Sri Mulyani; Data curation, Clarysa Satari; Formal analysis, Clarysa Satari; Investigation, Clarysa Satari; Methodology, Clarysa Satari, Wiji, Tuszie Widhiyanti, and Sri Mulyani; Project administration, Clarysa Satari; Resources, Clarysa Satari, Wiji, Tuszie Widhiyanti, and Sri Mulyani; Visualization, Clarysa Satari; Writing-original draft, Clarysa Satari; Writing-review & editing, Clarysa Satari, Wiji, Tuszie Widhiyanti, and Sri Mulyani.

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Conflict of Interest

The authors declare no conflict of interest in this research.

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