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A Literature Review on Learning Innovations in Atomic Structure Materials

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Abstract

The issue lies in the difficulty students face in understanding abstract chemistry concepts, particularly atomic structure. Traditional teacher-centered approaches, with limited use of technology and innovation, lead to low student motivation, reduced interest in learning, and suboptimal comprehension of key concepts.This study aims to provide an overview of new learning strategies in the topic of atomic structure in chemistry learning. The research method used is *a study literature review* through *a website* using the google scholar database and the Publish or Perish application. This research technique uses qualitative analysis with a focus on data obtained from journals regarding learning innovations presented in the form of tables and narratives. The results of the study show that journal publications on chemistry learning innovations tend to increase, especially in 2019. The level of accreditation varies, with most indexed at sinta levels 3 and 4. The types of learning innovations found include learning media, learning models and learning methods. Innovation in learning media is the main focus, followed by learning models and methods. This review reveals that the most effective chemistry learning innovations involve learning media such as digital modules, interactive multimedia, and virtual laboratories, supported by problem-based and inquiry-based learning models, which enhance interactivity, clarity, efficiency, and student learning outcomes while promoting sustainability in chemistry education.

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1. INTRODUCTION

Education is a series of activities that aim to develop individuals positively. This includes changing behavior for the better and improving self-quality. According to Law No. 20 of 2003, education is a deliberate and planned effort to create a learning environment where students can actively develop their potential, such as spiritual strength, self-control, personality, intelligence, noble character, and skills necessary for the benefit of individuals, society, nation, and state (Sudarmin et al., 2013). The use of technology in education has a positive impact on the learning process (Syazali et al., 2019). This is because increasingly advanced technology requires educators to hone their skills in utilizing technology and learning media (Tafonao, 2018).

Concepts in chemistry are often abstract and microscopic, thus posing challenges for students to understand. Therefore, understanding the basics of chemistry has a great impact on further understanding of matter. One of the subjects that is the basis for learning chemistry is the structure of atoms. Concepts such as the identification of atomic and mass numbers, quantum numbers, and the configuration of electrons contained in atomic structures, are abstract concepts. Because of its abstract nature, it often makes it difficult for students to understand it.

Material on atomic structure is one of the key topics in chemistry learning in Senior High School (SMA).

Usually, students are more likely to rely on memorization rather than actively trying to understand the concept on its own. However, in order to gain a thorough understanding of chemical concepts, it is important for learners to have a solid foundation in the basic concepts that make up those concepts. Therefore, creating meaningful learning conditions is very important so that students can understand the concept of atomic structure well (Arifin, 2014).

However, the lack of students' interest in learning chemistry subjects is an issue that has the potential to affect their learning achievement. High interest in learning usually has an impact on better achievement, while low interest in learning can result in less satisfactory achievement. This situation causes a lack of motivation for students to participate in learning activities, especially because the learning approach is still teacher-centered. Therefore, it is recommended that chemistry learning be carried out by providing direct experience to students, both through the use of media available at school and through direct experience in the surrounding environment, such as in nature. The goal is to develop student competencies.

The use of inefficient learning tools and lack of involvement of students in the learning process can result in unsatisfactory understanding of the material, including in terms of atomic structure. An approach that can be adopted by educators is to make optimal use of learning tools in the teaching process. Educators today are required to adopt a creative approach in combining various learning models and media (Lutfi & Nugroho, 2019).

Innovation is the introduction of new ideas, goods, services, or methods that are more beneficial to humans. In general, innovation is closely related to human creativity and comes from the word *to innovate*, which means producing change or introducing something new. Specifically, innovation in education refers to changes or updates made in the context of education to solve existing problems. Innovation in education involves new ideas, goods, or methods that are considered new by individuals or groups (society). These can be new inventions or inventions that change existing ones, and are used to achieve educational goals or overcome challenges in the field of education (Syafaruddin et al, 2012).

In the context of this problem, this innovation includes the use of technology in various aspects of learning, including media, methods, models, and teaching materials in chemistry learning. The purpose of this research is to identify and analyze journal studies that discuss chemistry learning innovations with technology and to understand their impact on students.

2. METHOD

In this study, the approach used is study literature with the aim of providing an overview of learning innovations in chemistry learning, especially in atomic structure materials. The articles were collected through searches on the website using the Google Scholar database and the Publish or Perish application in the period 2019-2024. In the early stages of the search, as many as 1000 articles were found with the keyword "chemistry learning innovation". Furthermore, all articles were filtered using the keyword "atomic structure", so that 100 articles were selected. From an initial identification of 100 articles, a total of 24 articles were selected through a systematic screening process based on predefined inclusion and exclusion criteria. The selection was guided by title and abstract relevance to learning innovations in atomic structure materials, methodological rigor, availability of full-text access, and alignment with the research objectives. This process followed the PRISMA guidelines for systematic literature reviews.The next steps include data collection, data classification, and data analysis to draw conclusions that are then presented in this article.

This study uses qualitative analysis techniques with a focus on data found from journals related to chemistry learning innovations. The analysis is carried out by reading and evaluating the information contained in these journals, then presented through qualitative tables and narratives to provide a comprehensive overview of the trends, types of innovations, benefits, and characteristics of existing journal publications. The mode method, which involves presenting tables and narratives, is also used to explain the findings of *Reviews* literature carried out. The analysis technique used in evaluating these journals can be said that the analysis is carried out descriptively. This means that data from journals are reviewed, extracted, and categorized based on publication characteristics, types of innovations, and benefits.

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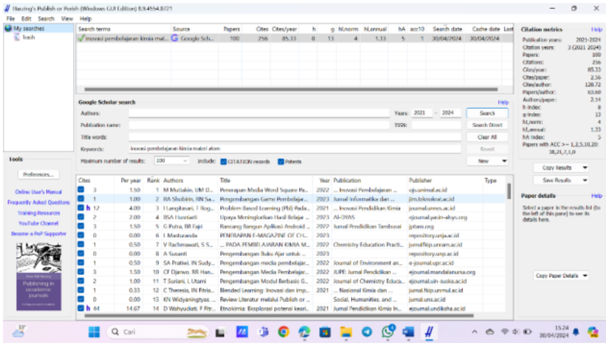

Figure 1. Data Collection Results

3. RESULT AND DISCUSSION

1. Characteristic

a. Number of publications per year

Based on the research, the number of publications per year from the journals reviewed is obtained as follows:

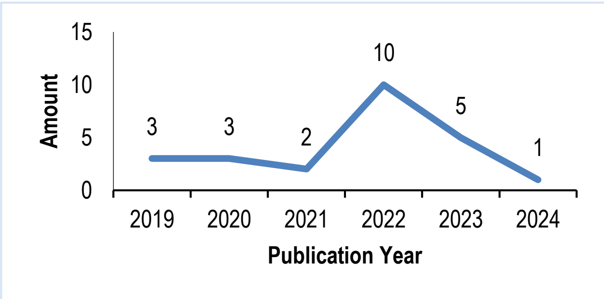

Figure 2. Graph of Number of Publications Per Year

This study was selected to be reviewed from 2019 to 2023 (as shown in the graph above). Most of the research is published in leading scientific education journals such as chemistry education and chemical sciences. The number of publications has increased significantly during 2022 while in 2023 publications have begun to decline and have experienced a significant decrease in 2023. The increase in this research is due to the pandemic factor. During the pandemic, learning was carried out online/*online* so that the Atomic Theory material experienced changes in the media used in the learning process. Thus, a lot of research has been done to obtain learning media that are suitable for use in Atomic Theory material. The decline in the graph occurred in 2024 because this research was conducted at the beginning of the year so not many studies have been published.

b. The amount that has been selected and analyzed

Based on Table 1, most of the reviewed articles were published in non-Sinta or unaccredited journals, followed by journals indexed in Sinta 4. This distribution indicates variations in the level of journal accreditation and may reflect differences in research scope, quality, and target readership. It also suggests that studies on learning innovations in atomic structure materials are still predominantly disseminated through local or national journals, highlighting the need to encourage broader publication in higher-tier accredited or international journals. Some of the research is included in the Sinta 3 index, likely because the research does not require large costs. In addition, there are also two research articles that are included in the Sinta 5 index, which may also be due to the diversion of costs to more demanding research processes.

Table 1. Journal Analysis

No	Journal Name	Index	Frequency
1.	Edukimia Journal	Sinta 4	1
2.	Competitive: Journal of Education	Sinta 4	1
3.	Redox Journal: Journal of Chemistry and Chemical Science Education	Sinta 5	1
4.	Chemistry Education Practice	Sinta 4	1
5.	MATRIX Journal	Sinta 4	1
6.	Al-DYAS: Journal of Innovation and Community Service	Sinta 6	1
7.	Journal of Education and Socio-Culture	Sinta 4	1
8.	Journal of Informatics and Engineering Software (JATIKA)	Sinta 4	1
9.	JIPI (Scientific Journal of Informatics Research and Learning)	Sinta 3	1
10.	JUPE: Mandala Education Journal	Sinta 6	1
11.	Tambusai Education Journal	Sinta 6	1
12.	Journal of Chemistry Learning	Sinta 3	1
13.	Journal of Chemistry Education, University of Riau	Sinta 4	1
14.	INNOVATIVE: Journal Of Social Science Research	Sinta 5	1

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No	Journal Name	Index	Frequency
15.	RELATIVITY: Journal of Physics Learning Innovation Research	Sinta 4	1
16.	Journal Of Chemistry Education and Integration	Sinta 2	2
17.	Journal of Chemistry Education	Sinta 2	1
18.	Jambura Journal of Educational Chemistry	Sinta 4	1
19.	Journal of Innovation in Chemistry Education	Sinta 3	1
20.	Chimica Didactia Acta	Sinta 4	1
21.	Journal of Mathematics and Science Education	Sinta 3	1
22.	UNESA Journal of Chemical Education	Sinta 4	2
	Total		**24**

2. Topics discussed in the researcher

Based on Table 2, the majority of research focuses on the use of learning media to overcome difficulties in studying the atomic theory subchapter. The research that has been carried out aims to produce optimal learning outcomes, increase students' understanding of concepts, and foster students' interest and motivation in learning atomic theory. Several other studies reviewed the learning models applied by educators in the classroom, with the aim of finding the most effective model for atomic theory, so that learners can understand the material well. In addition to helping students understand the material, the research that has been carried out also aims to improve the quality of learning outcomes.

Table 2. Research Type Analysis

Type of Research	Specific Approach	Bound Variables	Reference
Learning Media	Media Word Square	Student Learning Outcomes	Muttakin et al., 2022
	Video Stop Motion	Concept of Understanding	Arfah & Fatisa, 2020
	AR-based Android apps	Learning Interest	Putra & Fajri, 2022
	Game Slash Man	Learning Interests and Success	Lutfi & Nugroho, 2019
	Props "Chemical Carpet"	Learning Outcomes	Ruslan, Mutmainnah, 2019
	Virtual Reality Applications	Learning Motivation	Novianty et al., 2020
	E-Modul Kimia	Learning Outcomes	Mufida et al., 2022
	Sparkol Videoscribe	Learning Outcomes	Nadia et al., 2022
	Media Word Square	Learning Outcomes	Muttakin et al., 2022
	Media Digital Flipbook	Learning Outcomes	Djarwo & Handasah, 2022
	Simple Learning Media	Innovation	Irfandi & Yuhelman, 2023
	Interruptive Multiedia	Chemistry Learning	Rachmawati & Sukarmin, 2022
	PBL-based LKPD	Learning Needs	Nofriyanti & Hardeli, 2023
	Learning Games	Learner's Understanding	Shobirin et al., 2023
	GNT-based modules	Chemistry Learning	Suriani & Utami, 2022
	Artificial Intelligence Technology	21st Century Skills	Prastika et al., 2024
	Google Slide	Concept of Understanding	Zulfadli et al., 2022
	Chemistry Structure Sheet	Concept of Understanding	Aris et al., 2020

Type of Research	Specific Approach	Bound Variables	Reference
	Stem-Based E-LKPD	Learning Motivation	Zuliatin et al., 2022
	Game-Based Learning	Success of Independent Learning	Wiranti et al., 2021
	Modul Berbasis *Guided Discovery Learning*	Learning Motivation	Yondriadi & Yerimadesi, 2019
Learning Model	Discovery Learning	Learning Outcomes	Husniarti, 2023
	Cooperative Team Games Tournament Type	Learning Outcomes	Ambarita et al., 2023
	Blended Learning Berbasis Community Of Inquiry	Learning Outcomes	Kinanti & Refelita, 2022
	Problem-Based Learning	Learning Achievement	Langitasari et al., 2021

3. Types of learning innovations

Based on the framework of learning innovation, the relationship between individuals and other individuals has a significant role. This update not only includes the interaction between learners and educators, but also brings changes in Education management. Educators must change from mere informants to learning facilitators who utilize innovation. Decisions related to learning innovation must be based on the learning needs and development of students, not solely on individual desires or the desires of school leaders. By improving the quality of relationships between individuals in the learning environment, this innovation can create a more inclusive, mutually supportive and motivating atmosphere (Sepmi, 2021).

Several selected articles have successfully shown that the increasing publication trend is in line with the challenges in chemistry learning, especially in understanding basic materials that are considered abstract. Innovation is the key to making the material more acceptable to students. Learning media is the main focus of innovation, followed by learning methods and instruments. With learning media, it can provide interactivity, independent access and wider possibilities of use. But apart from the media, innovation in methods is also important because without the right approach, the media will be less effective. So learning innovation is the main goal is to improve the quality of education that takes place. Through the application of innovation concepts, learning can become more dynamic, relevant and effective. Thus, chemistry learning innovations can not only improve quality, but also provide students with preparation to face future challenges, encourage sustainability and promote research and innovation in the field of chemistry. This provides a solid foundation for improving the quality of chemistry learning in the future.

Based on the analysis of the 24 selected articles, learning innovations in atomic structure materials were predominantly implemented through learning media and learning models, with learning media being the most frequently explored and empirically supported form of innovation.

Learning Media Innovations

Various types of learning media were proven to enhance different aspects of student learning. Several studies demonstrated that interactive and visual-based media significantly improved learning outcomes and conceptual understanding. For instance, the use of Word Square media was reported to improve student learning outcomes (Muttakin et al., 2022), while Video Stop Motion effectively enhanced students' understanding of atomic structure concepts (Arfah & Fatisa, 2020). Similarly, the application of Digital Flipbook media (Djarwo & Handasah, 2022) and E-Modul Kimia (Mufida et al., 2022) contributed to better learning outcomes through structured and visually rich content.

Technologically advanced media also showed strong impacts on student motivation and interest. The use of AR-based Android applications significantly increased students' learning interest (Putra & Fajri, 2022),

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while Virtual Reality applications were found to improve students' learning motivation (Novianty et al., 2020). In line with this, STEM-based E-LKPD (Zuliatin et al., 2022) and Guided Discovery-based modules (Yondriadi & Yerimadesi, 2019) were shown to foster learning motivation and engagement in atomic theory topics.

Game-based and interactive media were also effective in supporting independent and active learning. Studies on Game Slash Man (Lutfi & Nugroho, 2019), Learning Games (Shobirin et al., 2023), and Game-Based Learning (Wiranti et al., 2021) consistently reported improvements in learning interest, conceptual understanding, and independent learning success. Additionally, Chemical Carpet props (Ruslan & Mutmainnah, 2019) and Chemistry Structure Sheets (Aris et al., 2020) supported hands-on and concrete learning experiences, helping students better visualize abstract atomic concepts.

Furthermore, innovation in digital and intelligent technology also emerged in recent studies. The use of Artificial Intelligence technology was reported to support the development of 21st-century skills in chemistry learning (Prastika et al., 2024), indicating a shift toward more adaptive and personalized learning environments.

Learning Model Innovations

In addition to learning media, several studies highlighted the effectiveness of innovative learning models.

Discovery Learning was found to improve student learning outcomes (Husniarti, 2023), while the Cooperative Team Games Tournament (TGT) model also positively affected student achievement (Ambarita et al., 2023).

Similarly, Problem-Based Learning (PBL) significantly enhanced learning achievement in atomic structure topics (Langitasari et al., 2021), and Blended Learning based on the Community of Inquiry framework was proven to improve learning outcomes through the integration of face-to-face and online learning (Kinanti & Refelita, 2022).

Synthesis of Findings

Overall, the reviewed studies confirm that learning innovations in atomic structure materials are most effective when learning media and learning models are integrated. In particular, digital, interactive, and game-based media, supported by student-centered learning models such as Discovery Learning, PBL, and cooperative learning, consistently improved learning outcomes, motivation, conceptual understanding, and independent learning.

Compared to learning media and models, innovation in learning instruments was less frequently addressed, indicating a potential gap for future research.

4. Benefits of learning innovation

Learning is an activity that involves interaction between students and a learning strategy. This interaction can be done both in person and remotely. The limited sources of information in learning activities cause a lack of achievement of learning objectives, so special strategies are needed, such as the use of media or learning models as auxiliary tools. Many teachers use various ways to convey material through learning media, especially innovative media so that the learning process is not monotonous and learning goals can be achieved properly. With the application of learning innovations by educators, it is hoped that students can understand and apply the material in their daily lives.

Some of the benefits of innovation in chemistry learning are as follows:

a) The learning process becomes more interactive

The application of media innovations and models in chemistry teaching can increase the active involvement of students in the learning process. With innovations such as the use of *Augmented Reality* (AR) and technological advancements or project-based learning models, chemistry learning has become more engaging and enjoyable. Students not only receive information passively, but also actively participate in the learning process, which increases their understanding and retention of the subject matter.

b) The learning process becomes clearer and more interesting.

Innovations in chemistry teaching methods can make learning more interesting and challenging for students. The application of technology, practical experiments, or interactive approaches can increase students' interest in chemistry subjects. Innovation in learning often involves the use of visual tools and interactive methods that help students understand complex concepts more easily. This visualization makes the information clearer and easier to remember.

c) The delivery of subject matter can be standardized.

Through learning innovation, the teaching process can be carried out in a consistent and uniform way across different classes and schools. Learning innovations allow educators to use the same methods and technologies to deliver subject matter. This helps ensure that all students receive the same information with uniform quality, regardless of who the teacher is or where the school is located.

d) Efficiency in time and effort.

New innovations in chemistry teaching can reduce the time and effort spent so that learning objectives can be achieved. Updates in learning methods allow for more flexible scheduling, and with an online platform, learners can view the subject matter anytime and anywhere without having to wait for class schedules.

e) Improving the quality of student learning outcomes

Applying new methods and technologies in teaching chemistry can improve students' understanding of the material, extend information retention, and increase the effectiveness of applying the knowledge they have. This innovation allows the use of simpler and more appropriate approaches to daily life, thus allowing students to better understand complex chemical concepts.

f) Fostering students' positive attitudes towards the material and learning process.

The application of innovation in chemistry learning can increase students' interest, motivation, and positive perception of chemistry subjects and the learning process as a whole. Thus, this will build a positive attitude of students towards the material and learning process. This positive attitude has an important value because it can increase student motivation, engagement, and learning outcomes.

g) Promoting Sustainability and Innovation in the Chemical Field

With innovative learning, learners can be inspired to develop an interest in chemistry, encouraging the creation of new innovations in chemistry for a more sustainable future.

4. CONCLUSION

Based on the results of the literature review, it can be concluded that innovation in chemistry learning has a significant role in improving the quality of chemistry learning. This innovation can be realized through various forms, such as learning media, learning models and learning methods. The main focus of innovation is learning media, which is supported by learning models and methods. The benefits of innovation include the learning process becoming more interactive, the learning process becoming clearer and more interesting, the delivery of subject matter can be standardized, efficiency in time and energy, improving the quality of student learning outcomes, changing the role of educators in a more positive and productive direction and encouraging sustainability and innovation in the field of chemistry.

The research is limited by its reliance on secondary data from a literature review, lacking empirical evidence from classroom-based experiments or direct observations. Additionally, the analysis may not fully capture the diversity of innovations across different educational contexts and student groups.

Further studies should incorporate empirical data to assess the real-world effectiveness of various technological innovations in chemistry learning. Comparative studies across different regions, educational levels, and student demographics could provide a more comprehensive understanding of the impact of innovation. Future research could also explore the long-term effects of integrating technology in chemistry education on student performance and engagement.

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