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Literature Review: The Effect of the Flipped Classroom on Student Chemistry Learning

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Abstract: The research delves into the impact of the flipped classroom model on student learning outcomes in chemistry education, utilizing a literature review methodology and systematically analyzing nine scopus-indexed articles. The flipped classroom, characterized by independent pre-class learning and in-class interactive activities, consistently demonstrates positive effects on academic performance, engagement, and motivation in chemistry education. The synthesis encompasses diverse methodologies, educational levels, and outcomes, highlighting the model's adaptability across different contexts. Critiques, including uncertainties about contributing factors, prompt recommendations for future research, such as exploring blended learning models and integrating Artificial Intelligence for personalized learning experiences. In conclusion, while acknowledging variations and critiques, the literature underscores the flipped classroom's effectiveness and advocates for ongoing research to refine its implementation in diverse educational settings.

Keywords: Flipped classroom, chemistry education, educational technology, literature observation

Abstrak: *Penelitian ini menggali dampak model flipped class terhadap hasil belajar siswa pada pendidikan kimia, dengan menggunakan metodologi tinjauan pustaka dan menganalisis sembilan artikel terindeks scopus secara sistematis. Kelas terbalik, yang ditandai dengan pembelajaran mandiri sebelum kelas dan aktivitas interaktif di dalam kelas, secara konsisten menunjukkan efek positif terhadap kinerja akademik, keterlibatan, dan motivasi dalam pendidikan kimia. Sintesis ini mencakup beragam metodologi, tingkat pendidikan, dan hasil, menyoroti kemampuan adaptasi model dalam konteks yang berbeda. Kritik, termasuk ketidakpastian tentang faktor-faktor yang berkontribusi, memberikan rekomendasi yang cepat untuk penelitian di masa depan, seperti mengeksplorasi model pembelajaran campuran dan mengintegrasikan Kecerdasan Buatan untuk pengalaman pembelajaran yang dipersonalisasi. Kesimpulannya, meskipun mengakui adanya variasi dan kritik, literatur menggarisbawahi efektivitas kelas terbalik dan menganjurkan penelitian yang sedang berlangsung untuk menyempurnakan penerapannya dalam lingkungan pendidikan yang beragam.*

Kata kunci: *Flipped classroom, pendidikan kimia, teknologi pendidikan, tinjauan literatur*

▪ INTRODUCTION

In recent years, there has been a growing interest in exploring the effectiveness of flipped classrooms on student learning outcomes in various educational contexts. Several studies have investigated the impact of the flipped classroom model on student learning outcomes in the field of chemistry education (Pattiserlihun & Setiadi, 2020). One notable study conducted by Baepler, Walker, & Driessen (2014) found that the use of flipped instruction in a college chemistry course resulted in learning outcomes that were either statistically equal to or superior to traditional classrooms (Martin et al., 2016).

This finding is particularly significant considering that the traditional classroom format consisted of three weekly meetings with a lecture format, while the flipped classroom was restructured to meet only once a week, with instructional videos and online discussions. This restructuring of the classroom format not only saved valuable in-class time but also allowed students to engage in more interactive and collaborative learning experiences.

Furthermore, the positive impact of flipped classrooms on student learning outcomes is supported by the findings of other studies. For instance, a study conducted by Jdaitawi examined the impact of flipped classroom strategies on student learning outcomes and found that flipping the classroom was more effective than traditional teaching methods in improving students' academic performance.

In addition to academic performance, the flipped classroom model has also been found to enhance student participation and learning motivation. A study conducted by Raza focused on the impact of case analysis within a flipped classroom and found that it not only increased student participation but also improved students learning motivation and overall academic performance (Li et al., 2023). These findings are consistent with the feedback received from students who have experienced flipped learning, as they reported having a positive and engaging learning experience (Ying & Ayub, 2022).

The benefits of the flipped classroom model extend beyond chemistry education. Research has shown that flipping the classroom can improve student achievement across various domains (Lawson et al., 2019). Overall, research on the effectiveness of flipped classrooms for student achievement has yielded mixed results .

Many studies, including those conducted by Baepler, Walker, & Driessen (2014) and Jdaitawi (2020), indicate that the flipped classroom is a promising pedagogical approach that can lead to improved learning outcomes, increased student engagement, and enhanced academic performance. However, although there is evidence to support its effectiveness, there is still a need for a deeper understanding of the extent to which the flipped learning model can consistently improve student learning outcomes, especially in chemistry subjects. In addition, it is necessary to make a more detailed comparison between the learning outcomes of students who follow the flipped learning model and those who follow the traditional learning approach. These questions form the basis for formulating more specific research questions to explore more deeply the impact and potential of the flipped learning model in improving chemistry learning.

Understanding Chemistry Education in The Flipped Classroom learning

The basic concept of the flipped classroom involves delivering instructional material outside the classroom through media such as online videos, enabling students to access it independently. Class time is then utilized to support concept comprehension

through discussions, Q&A sessions, and other interactive activities. Bergmann and Sams (2012) highlight several benefits of the flipped classroom, including increased student engagement, providing opportunities for deeper conceptual understanding, and allowing teachers to focus on individual guidance. Furthermore, this concept offers flexibility for students to learn at their own pace. The flipped classroom has evolved into various forms and variations across different educational levels and subjects, continually studied and updated by educators and researchers to ensure its effectiveness in diverse learning contexts. This approach creates a new learning paradigm by moving content delivery outside the classroom and using class time to support concept understanding through practical activities. For instance, Sojayapan and Khlaisang (2018) describe flipped learning as an instructional strategy advocating a reversed version of the traditional learning environment by delivering instructional content online outside the class. Technology, particularly online video media, plays a key role in flipped learning implementation. De-Lozier and Rhodes (2017) mention that the use of online videos optimizes lecture time, allowing students to independently review material and maximizing their active class time for more interactive learning activities. This creates opportunities for cooperative and practical learning. Munir et al. (2018) emphasize that the flipped classroom model creates a unique combination of traditional and online education systems, directing both in-class and out-of-class time to provide effective learning opportunities and a broader perspective. This approach gives students the chance to develop a deeper understanding of concepts. Not only focusing on cognitive aspects, but the flipped learning approach has also proven to impact students' metacognitive and affective aspects. Yilmaz (2017) notes that this approach promotes self-regulation, enhances student engagement, and builds a sense of responsibility towards their work. Similarly, Panich (2013) found that the flipped classroom model improves teamwork and student participation in class activities. With these theoretical foundations and empirical findings, further research is needed to consistently investigate the impact of flipped learning on student learning outcomes in various educational contexts. This approach holds the potential to transform the dynamics of traditional learning and prepare students for the challenges of deeper conceptual understanding, particularly in chemistry and other fields of study.

▪ METHOD

The research method employed in this study adopts a literature review approach. The initial steps of this research involve identifying the subjects of the literature review, in line with the methodology outlined by Cronin et al. (2008) and the perspective of L. Cohen, L. Manion, and Morrison (2018). This method was chosen to comprehensively investigate and analyze previous studies relevant to the study's topic. The literature review approach enables the researcher to gather and synthesize key findings, ideas, and methodologies that have been tested and applied by previous researchers.

The literature review in this study is designed to provide in-depth insights into the conceptual framework related to the research subject. Additionally, this method establishes a solid knowledge foundation to detail key concepts, identify research gaps, and build a strong theoretical basis for further research.

This research specifically applies a descriptive approach, referring to the research effort to present, describe, and explain phenomena or specific characteristics found in the reviewed literature. With the descriptive method, the researcher aims to provide a general

overview of key concepts, findings from previous research, and the development of knowledge related to the research topic.

The use of the descriptive method in the literature review provides a structured framework for detailing previous research findings systematically and objectively. It allows the researcher to compile a comprehensive synthesis of information and present it in an easily understandable manner, providing a solid basis for designing the conceptual and methodological foundations of this article.

Search Strategy

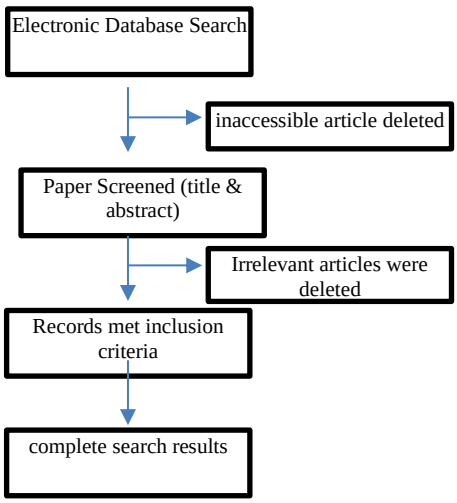
To gather relevant literature, a systematic search strategy was employed using the Publish or Perish application, aiding in the identification and access of academic articles from various sources. The literature search timeframe was set from 2022 to 2023 to ensure inclusivity of recent literature pertinent to the latest developments in the flipped classroom field.

The keywords chosen for this literature search were designed to encompass key aspects related to the use of the flipped classroom in chemistry education. The specific keywords used were "Flipped Classroom in Chemistry Education." The careful selection of appropriate keywords is pivotal in locating articles truly relevant to the research focus.

With the assistance of the Publish or Perish application, the literature search was conducted meticulously, yielding a total of 26 articles from various Scopus-indexed international journals. These articles were then further filtered to identify those most relevant to this study, resulting in a final selection of 9 articles. This step demonstrates the availability of a substantial body of literature discussing the impact of using the flipped classroom in chemistry education during the specified time period.

The discovered articles will serve as the foundation for further research, enabling researchers to delve deeper into key findings, methodologies employed, and the evaluation of the impact of using the flipped classroom in the context of chemistry learning. Through this approach, the study aims to provide a comprehensive overview of the contribution of the flipped classroom approach to chemistry learning and student outcomes.

The overall flow of this study can be observed in the diagram below.



PRISMA modification research flow (Liberati A., et al 2009)

he modified PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) research flow refers to a systematic method introduced by Liberati and colleagues in 2009. This adaptation of PRISMA follows standard guidelines for structuring reports of systematic research and meta-analyses with the aim of enhancing research methodology quality. The modified steps involve adjusting search procedures, inclusion and exclusion criteria, as well as bias risk assessment. By implementing the modified PRISMA study flow, researchers can ensure that the presentation of systematic research reports is more structured, transparent, and reliable, thereby contributing more valuable insights to scientific understanding

▪ RESULT AND DISCUSSION

The research data included in this literature review consists of analyses and summaries derived from documented articles related to the impact of Flipped Classroom on students' Chemistry learning. The findings of these studies are presented in detail in the table below.

Table 1. Research results on the impact of learning using the flippedclassroom approach

No.	Journal (author and year)	Main Finding	Intervention, Outcome Measureed, Study Design, Pulation, Participation age, Region, Limitation
1	Journal Heliyon (Etebong, E. E. 2020)	The main findings of the study, as stated in [T4], are that the flipped classroom strategy had a positive effect on students' attitudes towards chemistry and academic performance in chemistry. The flipped classroom approach provided a platform for students to learn at their own pace and repeatedly to gain understanding of abstract chemistry concepts. It also assisted students to learn according to their individual differences, which led to better understanding of abstract chemistry concepts. The study suggests that the flipped classroom could be used to improve students' academic performance in chemistry and enhance positive attitudes towards chemistry.	**The intervention** in this study was the use of the flipped classroom strategy for teaching chemistry to the experimental group, while the control group was taught using the conventional method. **The outcomes measured** in this study were students' attitudes towards chemistry and their academic performance in chemistry. Attitude was categorized as positive and negative, and a questionnaire was used to measure it. Academic performance was measured using a post-test. **Study Design** used in this research was a factorial 2 x 2 design, which is a modification of pretest posttest control group design with one treatment variable and one moderator variable. **The population** of this study was undergraduate students of the University of Calabar in Nigeria who were enrolled in a chemistry course during the first semester of the 2019/2020 academic year. The age range of the participants was not specified in the text. The study was conducted at the University of Calabar in **Nigeria**. The text does not explicitly mention the limitations of the study.

No.	Journal (author and year)	Main Finding	Intervention, Outcome Measureed, Study Design, Pulation, Participation age, Region, Limitation
2	Research in Science & Technological Education (Arslan, O., Kılıç, S., & Çalışkan, İ. 2021).	The main finding of the research synthesis is that flipped classroom practices have a positive effect on student academic achievement in Science courses (Phisic & Chemistry). The overall effect size of the studies included in the meta-analysis was found to be 0.727, indicating a moderate to large effect. The findings suggest that flipped classroom practices can be an effective teaching strategy for improving student academic achievement in Science courses across various levels of education and regions around the world. However, it should be noted that the studies included in the meta-analysis were not discriminated in terms of research design, measures of academic achievement, or types of pre-class and in-class activities used for flipped classes, which may limit the generalizability of the findings. Additionally, the meta-thematic analysis should be carefully assessed with the limitations of qualitative research in mind.	**The intervention** in this research synthesis is the use of flipped classroom practices in Science education. **The Outcome measured** in this research synthesis is student academic achievement in Science courses. **The study design** used in this research synthesis is a meta-analysis of 346 studies on flipped classroom practices in Science education. **The population studied** in this research synthesis is students in Science courses at various levels of education, including primary, secondary, and tertiary education. **The participation age** of the students studied in this research synthesis varies depending on the level of education, but includes students from primary school to university. **Region:** The studies included in this research synthesis were conducted in various regions around the world, including North America, Europe, Asia, and Australia. **Limitation:** The research synthesis acknowledges several limitations, including the lack of grouping according to publication type, research design, and measures of academic achievement used in the studies. Additionally, the synthesis may not fully capture the unique teaching characteristics of each sub-branch of Science. Finally, the meta-thematic analysis should be carefully assessed with the limitations of qualitative research in mind.
3	Science Education International (Oppong, J. K., Adu-Gyamfi, K., & Osei, J. Y.)	The study aimed to improve pre-service science teachers' performance in organic chemistry by using a student-centered approach. The main finding was that the intervention significantly improved the pre-service teachers' performance in naming and writing structural, condense, and line-angle formulae of alkanes, alkenes, and alkynes.	**The intervention** involved a student-centered approach to teaching organic chemistry, which included interactive and discovery-based teaching methods. **The outcome measured** was the pre-service teachers' performance in naming and writing structural, condense, and line-angle formulae of alkanes, alkenes, and alkynes. **The study design** used a pre-intervention, intervention, and post-intervention design. **The population** studied was pre-service science teachers at a college in Ghana. **The participation age** of the pre-service science teachers was not specified in the text. **Region:** The study was conducted at a college in Ghana. Limitation: One limitation of the study was that the COVID-19 pandemic affected the data collection process.

No.	Journal (author and year)	Main Finding	Intervention, Outcome Measureed, Study Design, Pulation, Participation age, Region, Limitation
4	Science Education International (Gallagher, T. (2022)	the application of the flipped classroom model to the teaching of Leaving Certificate Chemistry in Irish secondary schools can be effective in enhancing students' learning outcomes. The study found that the use of online technology, including video lessons and assessment resources, can support students' active learning and collaboration, and can provide teachers with more flexibility in conducting laboratory practical work and other forms of active learning in the classroom. However, the study also found that the flipped classroom model may not be effective when used in isolation, and that it is important to consider how teachers utilize blended learning in the classroom.	**The intervention** in the study was the application of the flipped classroom model to the teaching of Leaving Certificate Chemistry in Irish secondary schools. The intervention involved the use of online technology, including video lessons and assessment resources, to support students' active learning and collaboration. **The study measured** the effectiveness of the flipped classroom model in enhancing students' learning outcomes in Leaving Certificate Chemistry. The outcomes measured included students' self-efficacy and self-confidence, as well as their performance on assessments and laboratory practical work. **Study design:** The study used a mixed-methods design, which involved the collection of both quantitative and qualitative data. The study collected 410 questionnaires from students and teachers, as well as interview data from 16 students and 8 teachers. The study was conducted over two cycles, with the first cycle involving the trialing of the resources on the website and the second cycle involving the implementation of additional resources based on feedback from the first cycle. **The study population** consisted of Irish secondary school students studying Leaving Certificate Chemistry. **Participation age:** The study did not specify the age range of the participants, but it did mention that written consent from parents/guardians was obtained for participants under the age of 18. Region: The study was conducted in Ireland. **Limitation:** The study noted that the flipped classroom model may not be effective when used in isolation, and that it is important to consider how teachers utilize blended learning in the classroom. The study also noted that there were a significant number of variables that need to be considered to determine the merits of the flipped classroom, such as how much of the course can or should be flipped, and whether variables such as age and gender play a role in determining the success of the flipped classroom.
5	Journal of Technology and Science Education (García-Sánchez, E., & Martínez-Arbelaiz, A. 2021)	The main finding of the study is that the use of a flipped classroom model combined with cooperative learning strategies can enhance student learning and academic performance in a General Chemistry course.	**The intervention** used in the study was a flipped classroom model combined with cooperative learning strategies. **The outcomes measured** in the study were student learning and academic performance, as well as student satisfaction with the course. These outcomes were measured through questionnaires, interviews, and analysis of course grades. T**he study design** used in the research was a quasi-experimental design with a pre-test and post-test. **The population** in the study was undergraduate students enrolled in a General Chemistry course at a university in Spain. **The participation age** is not explicitly stated in the article, but it can be inferred that the students were likely college-aged. The

No.	Journal (author and year)	Main Finding	Intervention, Outcome Measureed, Study Design, Pulation, Participation age, Region, Limitation
			study was conducted in **Spain**. **The limitations** of the study include the small sample size, the lack of a control group, and the fact that the study was conducted in a single course at a single institution. These limitations suggest that further research is needed to confirm the effectiveness of the flipped classroom model and cooperative learning strategies in other contexts.
6	Science Education International (J. K., Adu-Gyamfi, K., & Osei, J. Y. 2022).	the article discusses the results of a study that aimed to investigate the effectiveness of the flipped classroom approach in teacher training during the COVID-19 pandemic. The study found that the approach was effective in improving teacher competencies and student engagement.	**The intervention** refers to the implementation of the flipped classroom approach in the study. The study involved a group of teacher educators who were trained to use the flipped classroom approach in their teaching practices. The effectiveness of the intervention was evaluated through class observations and interviews with the participants. **The outcome measured** was the effectiveness of a student-centered approach in improving pre-service science teachers' conceptual understanding of the IUPAC nomenclature of aliphatic hydrocarbons, namely alkanes, alkenes, and alkynes. **The study design** used a pre-intervention, intervention, and post-intervention design. **The population** studied was pre-service science teachers at a college in Ghana. **The participation age** of the pre-service science teachers was not specified in the text. **Region:** The study was conducted at a college in Ghana. **One limitation** of the study was that the COVID-19 pandemic affected the data collection process.
7	Journal of Chemical Education (Eichler, J. F. 2022).	the flipped classroom structure has become more widely accepted in the chemistry education community, there is still a lack of clarity on what aspects of the flipped classroom contribute most to the observed effects on student performance outcomes. The article suggests that the preclass learning is more critical than typically acknowledged and encourages the chemistry education community to transition the focus from probing the general efficacy of the flipped classroom to investigating how the preclass learning and in-person instruction can be optimized to address chemistry-specific learning objectives. The article also suggests that the flipped classroom can foster deeper conceptual understanding of chemical ways of thinking.	**Intervention:** The article discusses the efficacy of the flipped classroom structure in chemistry education. **Outcome measured:** The article discusses the impact of the flipped classroom structure on student learning outcomes relative to "teaching as usual" comparison groups. **Study design:** The article is a literature review that synthesizes the findings of various studies on the flipped classroom structure in chemistry education. **Population:** The article discusses studies on the flipped classroom structure in chemistry education that have been conducted with various populations, including undergraduate and graduate students. **Participation age:** The article does not specify a particular age range for the participants in the studies discussed. **Region:** The article discusses studies on the flipped classroom structure in chemistry education that have been conducted in various regions around the world. **Limitation:** The article notes that while the flipped classroom structure has become more widely accepted in the chemistry education community, there is still a lack of clarity on what aspects of the flipped classroom contribute most to the observed effects on student performance outcomes.

No.	Journal (author and year)	Main Finding	Intervention, Outcome Measureed, Study Design, Pulation, Participation age, Region, Limitation
8	International Journal of Instruction. (Widyasari, Masykuri, Mahardiani, Saputro, and Yamtinah 2022).	that subject-specific pedagogy (SSP) combined with flipped learning in e-learning classrooms can significantly improve pre-service chemistry teachers' Technological Pedagogical Content Knowledge (TPACK). The study found that SSP and flipped learning can enhance pre-service teachers' understanding of chemistry concepts, improve their pedagogical skills, and increase their confidence in using technology for teaching.	**The intervention** in the study was subject-specific pedagogy (SSP) combined with flipped learning in e-learning classrooms. **The outcome measured** in the study was the effectiveness of using SSP through flipped learning on pre-service chemistry teachers' TPACK. **The study design** used a pre-test and post-test design to measure the effect of the intervention on pre-service chemistry teachers' TPACK. **The population** of the study was pre-service chemistry teachers. **The participation** age of the pre-service chemistry teachers was not specified in the study. **The region** where the study was conducted was not specified in the study. One of the **limitations** of the study was the small sample size of pre-service chemistry teachers.
9	International Journal of Science, Mathematics and Technology Learning. (Stackpool, L. 2023).	The main finding of the study presented in this PDF file is that implementing a flipped classroom teaching/learning model in conjunction with supplemental instruction faculty-facilitated learning enhancement tutoring significantly enhances student academic achievements and leads to a decrease in the academic equity gaps among several groups of students in a gateway General Chemistry course 1.	**Intervention:** Flipped classroom teaching approach with supplemental instruction faculty-facilitated learning enhancement tutoring. **Outcome measured:** Student academic achievements and academic equity gaps in a gateway General Chemistry course. **Study design:** Quasi-experimental study. **Population:** Students enrolled in General Chemistry course at a Midwestern university in the United States. **Participation age:** Not specified. **Region:** Midwestern United States. **Limitation:** The study was conducted at a single institution, and the results may not be generalizable to other institutions or contexts.

Flipped classroom approaches have emerged as a promising pedagogical strategy with substantial impacts on learning outcomes, particularly in the realms of chemistry education. The studies discussed offer insights into the success of flipped classrooms at both higher education and school levels, presenting a nuanced understanding of its efficacy.

Success of Learning with Flipped Classroom

The discussed research indicates that the flipped classroom model has a positive impact on students' learning outcomes. For instance, Etebong (2020) revealed that implementing the flipped classroom strategy at the university level improved students' attitudes and academic performance in chemistry. Similarly, Arslan et al. (2021) conducted a meta-analysis demonstrating the effectiveness of flipped classroom practices across various educational levels, including higher education, with a positive impact on students' academic achievement in science courses.

Comparison between Higher Education and School Levels

While the flipped classroom has proven successful at both levels of education, contextual differences and student characteristics may influence its implementation. Gallagher's (2022) study in Irish secondary schools showed that implementing the flipped classroom model effectively improved students' learning outcomes in chemistry. On the other hand, Arslan et al.'s (2021) research found that flipped classroom practices were effective across various educational levels, including higher education. This difference

suggests that the flexibility of the flipped classroom model allows for adoption in diverse educational contexts.

Critiques from the Literature

However, as noted by Eichler (2022), despite the increasing acceptance of the flipped classroom model in the chemistry education community, there remains uncertainty about which aspects of the flipped classroom contribute most to student learning outcomes. Other critiques include uncertainties about its effectiveness without considering specific variables such as age and gender (Gallagher, 2022). Meanwhile, Stackpool's (2023) study highlighted that the research was conducted at a single institution, potentially limiting the generalizability of the findings.

Recommendations for Further Research

To address some of the critiques raised in the literature, future research could explore blended learning models that combine elements of the flipped classroom with traditional face-to-face approaches. For example, Gallagher (2022) suggests that the flipped classroom model may be more effective when used in conjunction with face-to-face teaching, providing additional advantages in terms of interactivity and direct guidance from instructors.

The integration of emerging technologies, such as Artificial Intelligence (AI), could represent an innovative step towards enhancing the flipped classroom model. Widyasari et al.'s (2022) study demonstrates that combining AI with flipped learning significantly improves pre-service teachers' pedagogical content knowledge. AI could aid in providing personalized feedback, adapting learning materials to individual student needs, and even facilitating adaptive assessments.

▪ CONCLUSION

In conclusion, the discussed research provides evidence that the flipped classroom model can successfully enhance student learning outcomes at both the higher education and school levels. While acknowledging some critiques and shortcomings, such as those highlighted in the literature, the incorporation of blended learning models and the utilization of emerging technologies like AI could be the next steps to enhance the effectiveness of the flipped classroom.

It has been found to improve student engagement, motivation, perceptions, exam scores, course grades, and retention rates in chemistry courses. However, the effectiveness of the flipped classroom approach in improving content learning compared to traditional classrooms may vary and more research is needed to determine the specific conditions under which the flipped classroom approach can be most effective (Boesdorfer et al., 2023).

Overall, the literature suggests that the flipped classroom approach has a positive impact on student chemistry learning outcomes (Casselman et al., 2019). The flipped classroom approach in chemistry education has shown positive outcomes in terms of student learning and engagement (Casselman et al., 2019, Ojennus, 2015, Karyadi et al., 2020). While the flipped classroom approach has been shown to improve student engagement, motivation, perceptions, exam scores, course grades, and retention rates in chemistry courses, more research is needed to fully understand its effects on content learning and to identify the factors that contribute to its

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