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Science teachers' attitudes toward flipped learning based on their experience implementing it in high schools

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Abstract

Flipped learning is the opposite of traditional classroom learning; students learn the lesson at home before class, then the assignment is completed in class. This study aims to fill this literature gap on science teachers' perspectives on flipped learning, based on their experiences. This study employed a qualitative approach using semi-structured interviews with nine science teachers. The results show that science teachers seem to know what flipped learning is and how to use it, and they have sufficient information about flipped learning. The most significant advantage of this teaching strategy is that it saves time and effort during class, whereas the most significant disadvantage of flipped learning is the differences among individual students' levels due to a lack of awareness of the educational content sent to them while at home.

Keywords: flipped learning, science learning strategy, teachers' attitudes

INTRODUCTION

As technology evolves and is being incorporated into our daily lives, it has become increasingly important in teaching and learning. Science education has seen tremendous development and significant technological advancements. Flipped learning strategies are among the most important ways to teach science using technology (Anjass et al., 2025; Sezer, 2017).

Technology can be effectively integrated into teaching methods to foster dynamic and engaging learning environments. This integration resonates with students who incorporate technology into their daily lives and increasingly leverage it for educational use. Many educators are shifting from traditional lecture-based teaching to interactive pedagogical designs that leverage technology (Abouhashem et al., 2021). The flipped classroom model has attracted considerable attention. This approach shifts instruction from the classroom to homework (Danker, 2015).

Combined with self-regulated learners, who actively manage their learning and metacognitive strategies, flipped learning has become even more effective in science education. Students in the self-regulated flipped learning group surpassed their peers in academic performance, attitudes, self-regulation, and motivation, providing valuable guidance for enhancing educational practices in science instruction and the use of technology (Ateş, 2024).

LITERATURE REVIEW

Defining Flipped Learning

Flipped learning, also known as the flipped classroom, is considered the opposite of traditional learning. According to Fulton (2012), "the 'flipped' part of the flipped classroom means that students watch or listen to lessons at home and do their 'homework' in class" (Herreid & Schiller, 2013). In flipped learning, students interact with content outside the classroom through pre-recorded lectures from teachers or online materials sent by teachers before coming to school. Students actively participated in discussions, problem-solving activities, and collaborative projects during class. Similarly, Nja et al. (2022) explain that a flipped classroom is a reverse version of the classical way of teaching, where teachers teach the material in the classroom and then students are given homework. However, in the flipped teaching method, instructors start by giving students videos of the lesson to watch at home before attending or conducting related activities in class. In this method, teachers provide students with

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Contribution to the literature

- In this study, science teachers' perceptions of flipped learning contribute to the literature and enhance the context for further research on technology-integrated pedagogies, especially in Middle Eastern educational systems.
- The study contributes to expanding the literature on science teachers' attitudes toward implementing instructional innovations by examining the perceived effectiveness and implementation challenges of flipped learning.
- This study provides a structured framework for understanding teachers' attitudes toward flipped learning, which can contribute to curriculum design and policy development in science education and pre-service teacher education.

further proficiency support, and active learning is given more time and promoted in class when students engage with their teachers and ask them questions encountered in the process of learning (Cabi, 2018; Hessler, 2016). According to Osman et al. (2023), technology plays an important role in supporting flipped learning. For example, the use of Google applications was found to enhance students' acceptance of the flipped learning approach, while also encouraging engagement and promoting positive attitudes toward this approach.

Bergmann and Sams (2012) clarified that in the conventional teaching method, confusion among students may usually occur following homework the night before coming to class. When starting the session the following day, approximately half an hour may be used for a warm-up activity to solve homework-related problems and clear any confusion. Thereafter, new instructional material would be delivered to students within 30-45 minutes, followed by independent practice or work in the lab. However, time is organized differently in flipped learning. In the first few minutes of class, students ask teachers questions about the video content that they have already watched. In this way, any confusion and misunderstanding will be resolved before students begin the activities and apply what they have learned (**Table 1**).

Table 1. Comparison of class time in traditional versus flipped classrooms

Classroom	Time
Traditional classroom	
Warm-up activity	5 min.
Go over the previous night's homework	20 min.
New lecture content	30-45 min.
Guided and independent practice and/or lab activity	20-35 min.
Flipped classroom	
Warm-up activity	5 min.
Q&A time through video	10 min.
Guided and independent practice and/or lab activity	75 min.

Effectiveness of Flipped Learning

Flipped learning supports student-centered learning

Science education that focuses on teaching and learning has shifted from teacher-centered instruction to learner-centered approaches. Teachers now serve not only as knowledge providers but also as facilitators who encourage students' active knowledge construction. The flipped classroom is an innovative teaching strategy that replaces traditional direct teaching and emphasizes guiding students toward applying knowledge and achieving higher-level learning objectives (Güler et al., 2023; Hwang et al., 2015).

Fulton (2012) (cited in Herreid & Schiller, 2013) listed seven advantages of the flipped classroom. First, students are able to study at their own pace. Second, teachers will be more aware of students' challenges and learning styles when the latter are doing homework in class. Third, teachers can modify and tailor the curriculum to suit the students' abilities at all times. Fourth, classrooms can be used in an effective and innovative manner. Fifth, achievement, interest, and engagement among students are high, as reported by teachers. Sixth, these new approaches are supported by learning theory. Finally, the method is flexible and suitable as it utilizes technology.

Studies have indicated that flipped classrooms offer positive educational outcomes. In a study conducted by Leo and Puzio (2016), student achievement and scientific interest were enhanced when flipped instruction with active learning was used. The students in this study indicated that they enjoyed the flipped learning approach and various active learning activities. Furthermore, students in the flipped learning condition performed better on quizzes and the final post-test compared to the those in the traditional instruction condition. For example, in the flipped model, student learning achievement and satisfaction may be enhanced (Missildine et al., 2013). Students may be more satisfied with the flipped method, and it can be more economical than traditional instruction (O'Flaherty & Phillips, 2015). A recent study by Eltahir and Alsalhi (2025) also reported that the flipped classroom approach positively influenced students' academic achievement, motivation, and engagement in higher education settings. However, other studies have highlighted the limitations of flipped classrooms. According to Akçayır and Akçayır (2018),

students and teachers may face difficulties when using the flipped learning method, such as increased workload outside school time and limited access to technology. The teachers may also face resistance from students who are not accustomed to the self-paced learning model.

Teachers' productivity using flipped learning

Teachers' positive perceptions and beliefs about flipped learning are vital for enhancing their productivity and refining their teaching practices, ultimately increasing their overall effectiveness. They often report higher motivation levels and greater enjoyment in delivering lessons when using flipped learning than when using traditional methods. Furthermore, many educators have expressed a preference for continuing to implement the flipped learning model in future classrooms (Alali, 2020; Unal & Unal, 2017).

Challenges of flipped learning

The literature indicates that the flipped teaching model encompasses both opportunities and challenges. In Herreid and Schiller's (2013) study, teachers highlighted two challenges associated with the flipped learning approach. The first challenge concerns learners' unfamiliarity with the approach, as they need to do the assigned work at home, which they have not been taught or exposed to at school. The second challenge was teachers' struggle to find high-quality videos. Moreover, designing and producing such videos is time-consuming for teachers. This is also supported by Akçayır and Akçayır (2018) and Schlairet et al. (2014), who propose that recreating course materials to suit this approach requires more time from teachers. Sun et al. (2017) point out that learners may find it difficult to manage their feelings and behaviors toward this way of learning. Consequently, these students would not succeed in managing their time to understand the tasks they had to perform at home. Al-Zahrani (2015) contends that the implementation of this approach requires students' preparation before practice because learners may be reluctant to change. Thus, introducing learners to the model's aims and tasks before undertaking a plan is significant. Video lectures, along with learning tools and resources, must be readily available to enhance students' creativity and ability to find solutions to problems.

Science teachers and flipped learning

Flipped learning approaches are particularly effective in science education. During class, students can watch videos of scientific experiments and participate in discussions or group activities that allow them to apply what they have learned. Students can also use this approach at their own pace, as they can pause, rewind, or replay the pre-recorded lectures at any time (Ateş et al., 2024).

Moreover, studies have found that pre-service science teachers who use flipped classrooms have better outcomes than those who do not. This is because of their ability to dynamically engage students with scientific concepts. Studies have also examined the emotional impact of flipped learning on science education. Compared with students in traditional classrooms, those exposed to the flipped classroom approach report more positive emotions that affect their performance (Jdaitawi, 2020; Jeong et al., 2018).

Problem Statement

Following the recent educational reforms in Saudi Arabia, teachers can now manage all course materials on learning platforms that students can access immediately. Documents can be uploaded, announcements made, e-mails sent, and online assessments created. Students can access course documents and send files to their teachers (Ministry of Education, 2020). As mandated by the Ministry of Education (2020), science teachers were required to implement flipped learning during the COVID-19 pandemic to ensure the continuity of education (Aljermawi et al., 2024). For further clarification, physical student school attendance was suspended, and distance education was decided upon for two months. Months later, student attendance was partially approved, with half the number of students in each class attending and the other half being taught remotely to adhere to the spacing requirements between students inside the classroom. Therefore, science teachers were obligated to apply flipped learning. Their opinions were not considered when applying it because the pandemic was unplanned. A few studies in Saudi Arabia have applied flipped learning in science classrooms since the end of the pandemic.

Research Questions

Teachers who used the flipped learning method during the COVID-19 pandemic and in current normal circumstances have a choice whether to use this method. However, science teachers' opinions and attitudes toward flipped learning remain unclear and require further investigation. Therefore, to explore the opinions and attitudes of Saudi science teachers who have used flipped learning toward its implementation, this study was guided by two primary research questions (RQs) and related sub-questions:

1. RQ1. What do Saudi science teachers think about flipped learning?
    a. What do Saudi science teachers understand about flipped learning?
    b. How do Saudi science teachers employ flipped learning?
2. RQ2. What are the attitudes of Saudi science teachers toward flipped learning?

Table 2. Participants' information

No	Teachers' names (pseudonyms)	Science major	Years of teaching experience	Years of teaching experience with flipped learning
1	Ahmed	Physics	14	1
2	Emad	Physics	9	1
3	Bader	Physics	12	1
4	Hamza	Physics	15	1
5	Ibrahim	Chemistry	7	1
6	Mohammed	Chemistry	9	1
7	Hamad	Biology	12	1
8	Omar	Biology	10	1
9	Salem	Biology	14	1

a. What do Saudi science teachers think about the effectiveness of flipped learning?

b. How do Saudi science teachers describe the challenges of implementing flipped learning?

MATERIALS AND METHODS

This study used a qualitative approach and a phenomenological research design. Creswell (2013) defines phenomenology as "an emphasis on a phenomenon to be explained, phrased in terms of a single concept or idea, such as educational idea of 'professional growth'" (p. 78). To answer the RQs, semi-structured interviews were conducted with science teachers to obtain in-depth and detailed data. Convenience sampling was used to select science teachers who had implemented flipped learning in high schools, as the researcher had easy access to the participants. The participants were also interviewed about their experiences of using flipped learning for at least one year and their attitudes toward using this method in the current situation. In the sample selected from the Eastern Region of Saudi Arabia, forty-three high school science teachers were asked to participate. The Ministry of Education (2024) was instructed to implement flipped learning in high schools, and nine teachers agreed to participate in this study. According to internal data from the Ministry of Education (2024), there are a total of 144 high school science teachers in the Eastern Region.

These high school science teachers had nine to fifteen years of experience. The highest level of education of all participants was a bachelor's degree. An average of 30 to 45-minute interviews were conducted face-to-face or remotely using the Zoom application. The data were compiled from recorded interviews. **Table 2** lists the participants of the study using pseudonyms to maintain confidentiality.

Table A1 in **Appendix A** presents the demographic information. **Table A2** in **Appendix A** presents the interview questions designed to obtain information to answer the RQs. **Table A3** in **Appendix A** presents the codebook. The interview protocol was validated by identifying and verifying interview questions with colleagues from similar disciplines. The interviews were recorded and transcribed. The researchers used pseudonyms throughout the study and created codes and themes based on the interview scripts. Scripts from the two interviews were analyzed by two colleagues.

RESULTS AND DISCUSSION

The results and discussion are organized based on the main RQs and sub-questions.

RQ1. What Do Saudi Science Teachers Think About Flipped Learning?

Two sub-questions were asked, which helped answer the main question.

Sub-question 1. What do Saudi science teachers understand about flipped learning?

At the beginning of the interview, the participants were asked how they had learned about the flipped learning strategy. Eight out of nine interviewees indicated that they had learned about flipped learning from workshops. For example, Ahmed said:

> First time, I know flipped learning is from workshops to improve teachers (transcript lines 21-22).

However, only one teacher had learned flipped learning autonomously through reading. Salim said,

> I used to read about modern teaching strategies, and flipped learning is one of these strategies I learn from self-learning (transcript line 20).

The participants were then asked to discuss what they knew about flipped learning. All participants explained that flipped learning is the opposite of traditional learning; a teacher sends educational material to the students to review online at home. The next day, they discuss the material and engage in activities in class. For example, Emad said:

> A video clip or documents about the lesson are sent to the students a day before the class so that the student can see it at home so that he is ready

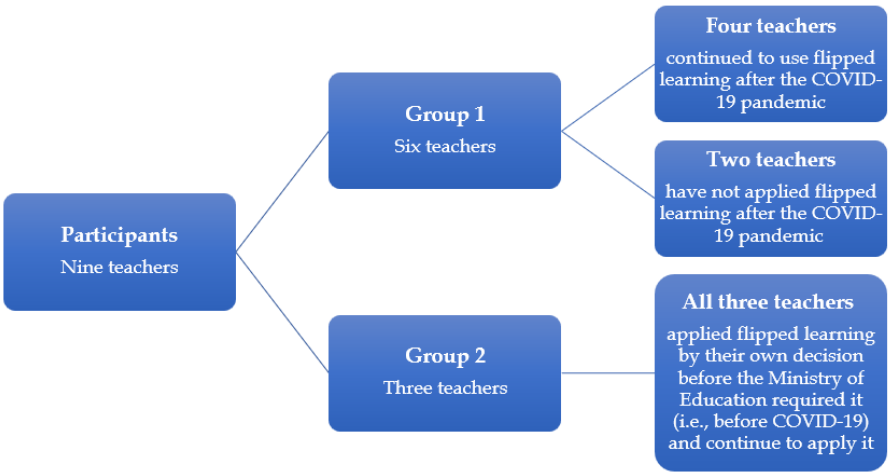

Figure 1. The two groups of interviewees who applied flipped learning (Source: Author's own elaboration)

> for the lesson. During the class, deeper questions are asked and discussed (transcript lines 33-35).

Similarly, Hamad commented:

> By sending a video, which has an explanation of a new lesson to the students a day before the lesson and then discussing it in the classroom. So that the student enters the site and sees what has been sent, and it is discussed the next day in the classroom, this strategy is using opposite of traditional learning (transcript lines 45-44).

Omar said:

> This method is considered the opposite of traditional learning … However, in flipped learning, it is the opposite. I present to them the scientific material such as a video clip, PowerPoint, or any other scientific material, and the student studies them at home, then comes the next day to the class, and my role as a teacher is only directed to the educational process by presenting the scientific activities that the students do (transcript lines 29-44).

The teachers' information about flipped learning gained from workshops is consistent with the literature. For example, the flipped learning model reverses the traditional lecture-assignment model (Brewer & Movahedazarhouligh, 2018).

Sub-question 2. How do Saudi science teachers employ flipped learning?

All the teachers in the sample indicated that they had used flipped learning in their classes. The interviewees were then divided into two groups based on their answers, as shown in **Figure 1**.

The first group, comprising six teachers, mentioned that they began using flipped learning because the Saudi Ministry of Education (2024) ordered its use during the COVID-19 pandemic. However, four of the six teachers in this group mentioned that they continued to use flipped learning occasionally after the pandemic ended, even when the students' class attendance returned to normal, because these teachers found that flipped learning was useful for their teaching and their students. For example, Ahmed said:

> In most of the schools in Saudi Arabia, during the pandemic, the Ministry of Education approved a specific system to deal with the pandemic that is in each class there are two groups: the first group attends school, and the second group learns at home through flipped learning. The next day, the second group attends, and the first group learns at home, and so on. So, we applied flipped learning at that time as the Ministry of Education required. I found this strategy very useful, so I continued to apply it from time to time to my students even after the end of the pandemic and the return of full-time classes, and I think I will continue to use it in the future (transcript lines 47-54).

In addition, Bader mentioned:

> At the beginning of my use of this method, it was under the directives of the Ministry of Education due to the COVID-19 pandemic. But after the Corona pandemic, I continued to use this method because it was successful with my students (transcript lines 45-47).

The two remaining teachers in the first group did not apply flipped learning after the COVID-19 pandemic ended because they preferred using other teaching strategies, even though they believed that flipped learning was a beneficial strategy during the COVID-19 crisis. For example, Omar said:

> Flipped learning is one of the good strategies in some circumstances as the COVID-19, but in the normal days, I stopped use it because I prefer to

> use other strategies that give more benefit to students as a cooperative learning strategy and problem-solving (transcript lines 39-38).

The three teachers in the second group mentioned that they had applied flipped learning at their own discretion before the Ministry of Education (2024) requested it (i.e., before COVID-19) and continued to apply it. For example, Hamza said:

> I use flipped learning with some lessons during my teaching since four years … Then, the ministry of education order to use it and I have an experience because I use it before their order, and I continue to use it in current days (transcript lines 44-48).

All the science teachers in the sample indicated that they had applied flipped learning, mainly because the Ministry of Education (2024) required them to use this strategy during the COVID-19 pandemic. The teachers were split into two groups according to their answers. The first group comprised the majority of teachers, four of whom continued to apply flipped learning after the Ministry of Education's (2024) COVID-19 requirement because they considered it a beneficial strategy. According to Gopalan et al. (2021), the COVID-19 pandemic necessitated the transition to online teaching. The flipped teaching model, which is known for engaging students through active learning strategies and incorporating both synchronous and asynchronous elements, has become a practical option for educators already accustomed to this approach.

An unexpected finding was the extent to which the remaining two teachers from the first group stopped using flipped learning after the pandemic, even though they thought it was a beneficial strategy during the pandemic. However, in normal situations, they indicated that they preferred other teaching strategies to flipped learning. However, three of the nine teachers in the second group stated that they used flipped learning independently before the Ministry of Education (2024) required it and continued to apply it.

Thus, the science teachers in this study had experience in applying flipped learning. The main reason for using this strategy was that the Ministry of Education (2024) imposed it on them due to exceptional circumstances. Interestingly, most participants continued to apply this method even though they were allowed and were not obligated to do so after the circumstances ended.

RQ2. What Is the Attitude of Saudi Science Teachers Toward Flipped Learning?

The second RQ also has two sub-questions:

Sub-question 1. What do Saudi science teachers think about the effectiveness of flipped learning?

When the teachers were asked about their opinions regarding applying flipped learning, seven of the nine teachers mentioned saving time and effort for teachers, as students learned about the lesson at home before attending class. For example, Emad said:

> Flipped learning saves my time and effort because the students watched the video at home, and they get an idea of the topic, and they may understand the lesson at home. So, I do not need to spend a lot of time and effort in the class (transcript lines 44-48).

Two teachers added that flipped learning allows the teacher to ask more questions and use more activities than the other strategy because the student learns theoretical information at home using this model; therefore, learning lessons using the flipped learning strategy becomes deeper than using the traditional teaching strategy. Mohammed said,

> This strategy helps me to ask a lot of questions and activities more than usual (transcript lines 35-37).

Omer added,

> Because students learn theoretical information at home, this gives me more time to ask a large number of questions and implement activities during class time that helped us to go deeper in learning (transcript lines 33-34).

Finally, four teachers indicated that when applying flipped learning, students watch a video clip or scientific material about the lesson at home, which increases their motivation and excitement about the subsequent class. For example, Emad stated,

> When I use flipped learning, I notice that my students get quite excited in class from the videos that they watched at home (transcript lines 41-42).

Omar added,

> The documents, that I send to my students, increase their motivation, so when the students are very willing to do the activities and worksheets (transcript lines 53-55).

None of the teachers indicated that they had never used flipped learning.

The next interview question asked the informants about their opinions on whether the flipped learning strategy increased teachers' productivity compared to other strategies that they usually used. Six of the nine teachers thought that flipped learning strategies did not increase their productivity or develop their skills,

although they helped save effort and time. For example, Omer said,

> I see this strategy [flipped learning] helps me save time and effort, but it does not develop me as a teacher (transcript lines 68-69).

However, three teachers believed that flipped learning improved their teaching abilities, allowing them to reach lesson goals more easily and teach more deeply. For example, Ahmed said,

> I think flipped learning improves me and my teaching, so I can reach lesson goals easier than before I use it (transcript lines 81-82).

Furthermore, the teachers were asked whether the flipped learning strategy contributed to improving the quality of learning compared with other strategies that they usually used. Most (seven) of the teachers indicated that flipped learning contributed to increasing the quality of learning for two reasons. First, flipped learning has a positive impact on students because it is more attractive to them. The materials and videos sent to the students before class increase their excitement to learn. Second, flipped learning increases the quality of learning because it increases the depth of knowledge of students who learn the lesson at home and come to school; thus, there is more time in class to delve into the details of the subject than when using other teaching methods. For example, Omer said:

> I achieve the highest possible quality by using the flipped learning strategy, as the student is introduced to the main concept and main objectives of the lesson via a video clip at home, and then there is dialogue and discussion, and then move to more profound exercises and assignments, so the lesson is richer than the other strategies (transcript lines 99-104).

Amer added:

> Of course, this method has a positive impact on learning because it attracts the student more than traditional methods, and because there is a diversity in teaching methods, the student is accustomed to traditional methods, but when new methods are used, they would be more attracted to video clips and what I send to them (transcript lines 85-88).

However, three teachers thought that the quality of learning using the flipped learning strategy depends on the students and their motivation to review scientific materials at home, rather than on the flipped learning strategy itself. For example, Hamza stated:

> For this method to become of high quality, it differs from one student to another. The student must rely on himself at home. Therefore, this method helps the student to rely on himself and learn how to obtain information. However, there are some students who are not studying at home and not looking at the materials that I send. Therefore, this strategy is not considered good for them and will greatly affect the quality of learning if the students do not study at home (transcript lines 113-116).

The above results indicate that teachers think flipped learning helps save time and effort because students study at home; therefore, more questions and activities are used by the teachers than in other strategies. In other teaching strategies, the teacher spends a long time explaining and teaching a lesson during the class period, whereas the flipped learning strategy helps the teacher, as the students come to school after having studied the lesson sufficiently. Pre-learning materials reduce class time as instructors can skip traditional in-class lectures by providing content before attending the actual class (Park & Kim, 2020).

In addition to providing important insights into how flipped learning contributes to student learning, several interviewees suggested that the quality of learning depends on the students themselves and their motivation to review further scientific materials at home. Therefore, the role of students is important for the success of the strategy and for making it more effective. According to Lee et al. (2021), e-learning approaches have a positive impact on student motivation, including flipped learning in high school. Furthermore, previous studies indicated that flipped learning positively impacts teachers' productivity in their instructional practices (Alali, 2020; Unal & Unal, 2017). However, most of the teachers in the current study did not consider this strategy for improving teachers' productivity. This strategy is considered an aid to teachers, but it does not improve their productivity. The discrepancy between previous studies and the present one may be attributed to the quality of training received by teachers and implementation mechanisms that may not motivate them.

Sub-question 2. How do Saudi science teachers describe the challenges of implementing flipped learning?

The teachers mentioned three challenges a teacher is likely to face when implementing flipped learning.

First, five of the nine participating teachers mentioned that some students did not complete the flipped learning tasks at home before class, leading to a large discrepancy in their educational level. The following reasons for not completing the tasks were mentioned by the participants: low motivation among some students, a lack of electronic devices for students at home, technical difficulties experienced by the teacher or student, and some parents do not follow up on their

children and encourage them to complete their assignments on time at home. For instance, Emad stated:

> One of the most important problems is that some students do not perform the tasks required of them before class … there are reasons for lack of interest and motivation of students and lack of follow-up by parents. Also, some of them do not have devices such as iPads and laptops to complete tasks at home (transcript lines 121-123).

Second, four teachers mentioned that there is an obstacle faced by teachers, which is when they need to prepare scientific material that will be sent to the student ahead of time, and may put more effort into it than in other teaching strategies. For example, Omer said:

> This strategy requires more time and effort from the teacher compared to other strategies, and this may be an obstacle for the teacher to use it because he needs longer time in early preparation and sending it to students days before class, unlike other strategies (transcript lines 117-120).

Third, as mentioned by six teachers, in some cases, flipped learning causes misconceptions among some students because they look at the material before class and may not understand it. For example, Bader said,

> Some students may have misunderstood the material because they reviewed it prior to class, so they may have misconceptions (transcript lines 132-133).

Teachers mentioned several solutions for overcoming these obstacles. First, teachers should convince and motivate students that the scientific material sent to them is important and related to the lessons. The technical challenges, which include the lack of devices and the issue of slow Internet connection at home can be resolved by providing devices at school, which students can use to review scientific material before or at the beginning of class. For example, Mohammed said,

> When a teacher convinces his students and increases their motivation to watch videos at home, this will help to make students watch the videos (transcript lines 122-123).

In addition, Ibrahim said,

> Students face problems with the internet and technician problems with websites, so schools should provide devices that could be used by students to see the material before or during the class (transcript lines 136-137).

Thus, significant differences in student levels are caused by the fact that some students may not complete tasks at home before going to school. These differences in students' levels will cause problems for the teacher, as the teacher will have to re-explain the tasks in class, making it difficult for the teacher to complete the flipped learning lesson plan. The reasons for students not completing assignments at home may be a lack of interest, an inability to access the assignments due to technical problems, or a lack of the necessary devices at home. These findings are consistent with Aidoo et al. (2022), who reported that student teachers also faced challenges in implementing flipped classrooms, particularly inadequate information and communication technology infrastructure. Therefore, the participants suggested that teachers could motivate the students to perform the task at home, and schools could provide the necessary devices so that the students could access scientific content before attending class. In this way, all students will be prepared for the class as planned. Other limitations of flipped learning are that, first, teachers are required to put additional efforts into the process of preparation, which entails designing or producing scientific content before attending class, and second, misconceptions could occur among students as they review the scientific content on their own at home. Teachers should consider and attempt to overcome these obstacles. As mentioned by Lee et al. (2021), flipped learning should be cautiously adopted in science classes, carefully considering students' abilities, agency, and interactions in the context of science education.

CONCLUSION

Flipped learning is a teaching strategy that provides learning through technology, and it places the student at the center of the educational process. This study targeted teachers who had experienced flipped learning to determine their attitudes toward it. The study employed a qualitative approach through semi-structured interviews with nine science teachers.

A significant finding of this study is that the participating science teachers had sufficient knowledge about flipped learning and had attended training workshops. While teachers were required to adopt flipped learning for approximately a year in response to the COVID-19 pandemic, most continued to use it occasionally, even under normal circumstances.

Furthermore, flipped learning has advantages such as saving time and effort during classes because students learn at home using learning content that their teachers have already sent. Consequently, teachers use class time to teach the lessons in greater depth. However, the most significant disadvantage of flipped learning, according to teachers, is the individual differences in students' lack of awareness of the educational content sent to them for study and review at home. This ignorance is due to reasons beyond their control, such as the lack of Internet or necessary devices at home, students' lack of motivation, and lack of encouragement from parents at

home. To address these challenges, teachers recommend motivating and convincing students about the importance of studying materials at home. Additionally, they suggest that schools should provide devices for students to access materials both before and at the start of class.

This study suggests that future studies should focus on motivating students to learn independently and improving their access to educational materials at home to enhance the effectiveness of flipped learning. Additionally, future studies should focus on using student-centered strategies to help students engage in lifelong self-directed learning. Finally, future studies should be conducted on enhancing parents' role in this teaching method, which requires students to learn at home, outside school.

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AI statement: The author declares that no generative AI or AI-based tools were used in any part of the study, including data analysis, writing, or editing.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the author.

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APPENDIX A

Table A1. Demographic information

Demographic information	Answers
Education experience	
The grades you have taught	
Specialization in science (physics, chemistry, or biology)	
How would you rate your level of digital skills and technology use (high/medium/low)	

Table A2. Interview questions

RQs	Research sub-questions	Interview questions
RQ1. What do science teachers think about flipped learning?	What do Saudi science teachers understand about flipped learning?	How did you learn about the flipped learning strategy? (tell me about the first time you heard about flipped learning) What do you know about flipped learning?
	How do Saudi science teachers employ flipped learning?	Have you ever applied flipped learning during your teaching? Are you planning to implement it now or in the future?–Why? Why not?
RQ2. What is science teachers' attitude toward flipped learning?	How do Saudi science teachers think about the effectiveness of flipped learning?	- (*If the teacher has used flipped learning*) What do you think about using the flipped learning strategy? - (*If the teacher has not used flipped learning*) Why do you not use flipped learning in your classes?
	How do Saudi science teachers describe the challenges of implementing flipped learning?	How effective is the flipped learning strategy compared to other strategies that you usually use based on the following points: - Increases your productivity as a teacher (Why? Why not?) - Improves the quality of learning/Does not improve the quality of learning (please explain your answer). From your point of view, what are the challenges and obstacles faced by science teachers when applying flipped learning? Is there a downside to the flipped learning strategy? (If any, state it)

Table 3A. Codebook

Themes	Codes	Definitions and explanations	Examples of responses
Learning strategy	Workshops	Teachers learned about the flipped learning strategy at workshops	Ahmed said, "First time, I know flipped learning is from workshops to improve teachers" (transcript lines 21-22).
	Self-learning	First-time teachers learn about flipped learning through self-learning	Salim said, "I used to read about modern teaching strategies, and flipped learning is one of these strategies I learn from self-learning" (transcript line 20).
Opposite	Opposite of traditional learning	The opposite of the steps of traditional learning. For illustration, students receive online educational materials from their teachers to review at home. The next day, they discuss the material and engage in activities.	Hamad said, "By sending a video, which has an explanation of a new lesson, to the students a day before the lesson and then discussing it in the classroom. So that the student enters the site and sees what has been sent, and it is discussed the next day in the classroom, this strategy is using opposite of traditional learning" (transcript lines 45-44). Omar said, "This method is considered the opposite of traditional learning … However, in flipped learning, it is the opposite. I present to them the scientific material such as a video clip, PowerPoint, or any other scientific material, and the student studies them at home, then comes the next day to the class, and my role as a teacher is only directed to the educational process by presenting the scientific activities that the students do" (transcript lines 29-44).
Applying flipped learning	By Saudi Ministry of Education, & continuing after the COVID-19 pandemic	Saudi Arabia's Ministry of Education instructed teachers to implement the flipped learning strategy during the COVID-19 pandemic and continued to do so afterward.	Ahmed said, "In most of the schools in Saudi Arabia, during the pandemic, the Ministry of Education approved a specific system to deal with the pandemic that is in each class there are two groups: the first group attends school, and the second group learns at home through flipped learning. The next day, the second group attends, and the first group learns at home, and so on.

Table 3A (Continued). Codebook

Themes	Codes	Definitions and explanations	Examples of responses
			So, we applied flipped learning at that time as the Ministry of Education required … I found this strategy very useful, so I continued to apply it from time to time to my students even after the end of the pandemic and the return of full-time classes, and I think I will continue to use it in the future" (transcript lines 47- 54).
	By the Saudi Ministry of Education, and then stopping after the pandemic	During the COVID-19 pandemic, the Saudi Ministry of Education instructed teachers to implement the flipped learning strategy. Once the pandemic was over, the teachers stopped implementing the strategy.	Omar said, "Flipped learning is one of the good strategies in some circumstances as the COVID-19, but in the normal days, I stopped use it because I prefer to use other strategies that give more benefit to students as a cooperative learning strategy and problem-solving" (transcript lines 39-38).
	Own decision	Teachers who are applying flipped learning by their own decision.	Hamza said, "I use flipped learning with some lessons during my teaching since four years … Then, the ministry of education order to use it and I have an experience because I use it before their order, and I continue to use it in current days" (transcript lines 44-48).
Effective	Saves time and effort	The teachers think the flipped learning strategy saves time and effort	Emad said, "Flipped learning saves my time and effort because the students watched the video at home, and they get an idea of the topic, and they may understand the lesson at home. So, I do not need to spend a lot of time and effort in the class" (transcript lines 44-48).
Deeper than other strategies	More questions and more activities	Flipped learning allows the teacher to ask more questions and use more activities than the traditional strategy.	Mohammed said, "This strategy helps me to ask a lot of questions and activities more than usual" (transcript lines 35-37). In addition, Omer said, "Because students learn theoretical information at home, this gives me more time to ask a large number of questions and implement activities during class time that helped us to go deeper in learning" (transcript lines 33-34).
Motivation	Enhances motivation and excitement	Using flipped learning enhances students' motivation and excitement because they watch a video clip or scientific material before class.	Emad said, "When I use flipped learning, I notice that my students get quite excited in class from the videos that they watched at home" (transcript lines 41-42). In addition, Omar said, "The documents, that I send to my students, increase their motivation, so when the students are very willing to do the activities and worksheets" (transcript lines 53-55).
Productivity	Does not increase productivity	Flipped learning does not increase teachers' productivity.	Omer said, "I see this strategy [flipped learning] helps me save time and effort, but it does not develop me as a teacher" (transcript lines 68-69).
	Improves teaching abilities	Flipped learning improves teaching abilities.	Ahmed said, "I think flipped learning improves me and my teaching, so I can reach lesson goals easier than before I use it" (transcript lines 81-82).
Increasing the quality of learning	Is more attractive	Flipped learning makes lessons more attractive.	Omer said, "I achieve the highest possible quality by using the flipped learning strategy, as the student is introduced to the main concept and main objectives of the lesson via a video clip at home, and then there is dialogue and discussion, and then move to more profound exercises and assignments, so the lesson is richer than the other strategies" (transcript lines 99-104).
	Enhances the depth of knowledge	Flipped learning enhances the depth of knowledge.	Amer said, "Of course, this method has a positive impact on learning because it attracts the student more than traditional methods, and because there is a diversity in teaching methods, the student is accustomed to traditional methods, but when new methods are used, they would be more attracted to video clips and what I send to them" (transcript lines 85-88).
	Depends on the students	Increasing the quality of learning depends on the students themselves	Hamza said, "For this method to become of high quality, it differs from one student to another.

Table 3A (Continued). Codebook

Themes	Codes	Definitions and explanations	Examples of responses
		and their motivation to review scientific materials at home.	The student must rely on himself at home. Therefore, this method helps the student to rely on himself and learn how to obtain information. However, there are some students who are not studying at home and not looking at the materials that I send. Therefore, this strategy is not considered good for them and will greatly affect the quality of learning if the students do not study at home" (transcript lines 113-116).
Challenges	Large discrepancy	Some students did not complete flipped learning tasks before class, leading to a large discrepancy.	Emad said, "One of the most important problems is that some students do not perform the tasks required of them before class … there are reasons for lack of interest and motivation of students and lack of follow-up by parents. Also, some of them do not have devices such as iPads and laptops to complete tasks at home" (transcript lines 121-123).
	More effort	Teachers should prepare the scientific material sent to the students ahead of time.	Omer said, "This strategy requires more time and effort from the teacher compared to other strategies, and this may be an obstacle for the teacher to use it because he needs longer time in early preparation and sending it to students days before class, unlike other strategies" (transcript lines 117-120).
	Misconception	Flipped learning causes misconceptions among some students because they look at the material themselves before class.	Bader said, "Some students may have misunderstood the material because they reviewed it prior to class, so they may have misconceptions" (transcript lines 132-133).
Overcoming obstacles	Solutions: motivate the students	Teachers should motivate the students about the importance of the scientific material sent to them and that the material is related to the lesson.	Mohammed said, "When a teacher convinces his students and increases their motivation to watch videos at home, this will help to make students watch the videos" (transcript lines 122-123).
	Providing devices at schools	To solve technical problems and the lack of good internet devices for students at home or providing the devices at school.	Ibrahim said, "Students face problems with the internet and technician problems with websites, so schools should provide devices that could be used by students to see the material before or during the class" (transcript lines 136-137).