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Evaluating science teachers’ flipped learning readiness: a GETAMEL approach test

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ABSTRACT
Flipped learning has become an ally in education. However, although the literature has identified multiple benefits of using this strategy to improve student learning outcomes, its adoption and implementation by teachers in science education remain scarce. This study examines antecedents of science teachers’ flipped teaching readiness to act, aiming to encourage more teachers to use this strategy. The study implemented the General Extended Technology Acceptance Model for E-Learning (GETAMEL) approach as the theoretical framework. A cross-sectional research design study, including 398 in-service science teachers, was implemented in five Turkish cities during the first semester of 2022. The results indicated that the GETAMEL approach provided adequate prediction power to explain science teachers’ flipped teaching readiness. It was also shown that all hypotheses were supported, and constructs of the conceptual model were significant activators of intention to use the flipped learning approach for science teaching. Moreover, subjective norm, experience, perceived enjoyment, anxiety, and self-efficacy on perceived usefulness, attitude, and intention acted as mediator constructs. Overall, this study guides researchers and practitioners to better comprehend science teachers’ flipped teaching readiness.

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KEYWORDS
Flipped learning; GETAMEL; science education; teacher readiness; technology acceptance model

1. Introduction

The advancement of technology has drastically affected several aspects and domains of everyday life, and the educational domain is no exception. Traditional teaching and learning methods must be adapted to address the rapid pace at which society evolves (Roig-Vila, 2016). Teachers should also become acquainted with new technologies and pedagogical approaches to meet students’ needs (Konopka et al., 2015). The new pedagogical approaches should offer personalized learning experiences, promote active participation, and be flexible enough to adjust to the upcoming changes (Colomo-Magaña et al., 2020).

Flipped learning is a novel pedagogical approach that offers flexibility, dynamic environments, and students’ autonomy and uses both face-to-face and virtual teaching (Fernández-Martín et al., 2020). This approach can effectively transform and enrich traditional education and facilitate the adoption and integration of Information and Communications Technologies (ICT) in education (Cevikbas & Kaiser, 2020; He, 2020), thus, accelerating the digital transformation. Flipped learning is a student-centered and blended learning approach in which students familiarize themselves with the instructional material of the course curricula before the face-to-face lesson with the

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teacher. Subsequently, they carry out problem-solving, critical thinking, and collaborative activities during class under teachers' guidance and supervision (Bergmann & Sams, 2012; Enfield, 2013). This approach aligns with twenty-first-century pedagogy and can potentially address the educational challenges that arise (Fulton, 2014).

Flipped learning constitutes an expansion of the existing curriculum as it involves personalized computer-based learning outside the classroom and interactive group-based learning activities inside it (Bishop & Verleger, 2013). This approach is characterized by its out-of-class learning hours, well-structured and highly organized learning material and environment, collaborative, problem-solving, and cooperative activities, and teachers' assessment of students' pre-class activities and knowledge acquisition (McGivney-Burelle & Xue, 2013). Within this approach, teachers do not merely deliver information (Lai & Hwang, 2016) but spend class time strategically and creatively (Fulton, 2014) by providing personalized feedback (Bhagat et al., 2016), as well as engaging students in problem-solving, inquiry-based, hands-on activities, and deep discussions (Chuang et al., 2018; Schmidt & Ralph, 2016). Therefore, teachers are expected to design interactive activities, to support students and encourage them to be actively involved, inquire, think, communicate, and adopt flexible and dynamic evaluation methods (Bergmann & Sams, 2012).

As flipped learning capitalizes on various pre-class and in-class activities (Lo & Hew, 2017), it is not restricted to the classroom. It enables students to learn interactively at their own pace (Davies et al., 2013) while studying concepts repeatedly and working collaboratively with their peers (Gopalan, 2019). Through these activities, students can increase their knowledge acquisition and understanding (Newman et al., 2016), achieve better learning outcomes (Awidi & Paynter, 2019), and cultivate the necessary twenty-first-century competencies (Santos & Serpa, 2020).

Flipped learning has gained popularity in science education due to its potential to improve student engagement and understanding of complex scientific concepts (Ateş, 2024; Gilboy et al., 2015). This approach is particularly effective in science education because it allows students to interact dynamically and engage with scientific concepts. For example, students can watch videos of scientific experiments before class and then engage in a discussion or group activity that allows them to apply what they have learned. This approach also allows students to work at their own pace, as they can pause, rewind, or replay the pre-recorded lectures as many times as needed.

As for science teachers, the flipped learning approach provides an opportunity to create a student-centered learning environment that fosters active participation, inquiry, and collaboration (Jong, 2019; O'Flaherty & Phillips, 2015; van Vliet et al., 2015). Ultimately, flipped learning can help science teachers improve their students' engagement, motivation, and academic achievement in science and prepare them for success in the twenty-first-century workforce, where scientific literacy and critical thinking skills are increasingly in demand (Ateş, 2024; Hao & Lee, 2016; Lee et al., 2021; Leo & Puzio, 2016).

Despite the benefits offered by the flipped learning approach, remain open challenges that must be addressed (Akçayır & Akçayır, 2018). Students' unfamiliarity with the approach, lack of self-discipline and attentiveness, and teachers' increased start-up effort are some of the most frequently reported challenges (Lo et al., 2017). Furthermore, the outbreak of the COVID-19 pandemic unveiled additional challenges for integrating flipped learning into educational practices (Lo, 2023). Students' negative emotions, instructors' lack of technological skills, and ineffective communication were major challenges to this instructional approach during the pandemic. Therefore, strategies must be established to overcome such challenges and promote effective flipped learning practices throughout the educational scenario.

Accordingly, this study aims to examine the antecedents of science teachers' readiness to act to encourage other teachers to adopt this strategy. The study utilizes the General Extended Technology Acceptance Model for E-Learning (GETAMEL) approach as a theoretical framework to accomplish this goal. The GETAMEL approach comprehensively explains the factors influencing teachers' readiness to adopt and integrate new technologies into their practices, including their attitudes, beliefs, perceived usefulness, ease of use, and behavioral intention. This study aims to contribute to the literature on technology integration in education by providing insights for teachers who wish to incorporate the flipped learning approach into their teaching practices. Specifically, the study investigates the factors that affect science teachers' readiness to adopt the approach. The study poses that the successful adoption and integration of the flipped learning approach can lead to personalized and engaging learning experiences for students, promote active participation, and address the educational challenges that arise in the twenty-first-century.

1.1. Flipped learning in science education

Many studies have described how the flipped learning approach can significantly benefit science-related subjects. For example, Hibbard et al. (2016) investigated the use of flipped learning in science courses. The authors concluded that students using the flipped learning approach outperform those using traditional methods. Furthermore, the students highly valued teachers' increased availability, personalized learning opportunities, and ability to learn at their own pace.

Similarly, Sletten (2017) investigated the impact of flipped learning on students' viewpoints, achievement, and self-regulated learning in a biology course. The students' perceptions positively predicted their self-regulated learning. Flipped learning enabled constructive teaching methods which actively engaged the students who highly valued their active involvement in educational activities.

Barral et al. (2018) carried out a study to assess the influence of a flipped learning environment on student learning outcomes in a biology course. Their results revealed significant differences only for low-level learning objectives. Thus, it was concluded that the positive effect of flipped learning was due to students' improved recall of basic concepts and a better understanding.

Bokosmaty et al. (2019) explored the effect of flipped learning in science courses. Students were highly satisfied with the approach and achieved significantly higher grades. The approach effectively supported the learning activities, increased student engagement, and positively influenced academic performance and retention.

Finally, Jdaitawi (2020) evaluated the impact of flipped learning on promoting positive emotions in science education. A significant increase in learning emotions was observed in students taught using flipped learning, showing higher learning emotions during and after the experiment.

1.2. The GETAMEL framework

GETAMEL is a theoretical framework that seeks to understand the factors influencing an individual's acceptance and usage of e-learning technology (Abdullah & Ward, 2016a). The model builds upon the well-established Technology Acceptance Model (TAM), which posits that an individual's intention to use technology is primarily determined by their perception of how useful and easy it is to use (Davis, 1989).

GETAMEL extends TAM by incorporating additional factors specific to the e-learning context (Matarirano et al., 2021). For example, it considers the role of social influence on an individual's perception of technology. Social influence refers to the degree to which an individual perceives that their peers or colleagues are using or accepting the technology. If individuals perceive that their peers are using e-learning technology, they may be more likely to adopt it themselves. Another factor considered in GETAMEL is perceived enjoyment. This refers to the degree to which an individual finds using e-learning technology enjoyable or pleasurable. If an individual finds using e-learning technology enjoyable, they may be more likely to continue using it. GETAMEL also considers the role of personal innovativeness. This refers to an individual's willingness to embrace new and innovative technologies. If an individual is an "early adopter," they may be more likely to adopt e-learning technology than someone less innovative.

In addition to these individual factors, GETAMEL considers the technology's role (Strzelecki et al., 2022). For example, the model considers factors such as the technology's design, usability, and user support. If the technology is well-designed and user-friendly, and adequate user support is available, individuals may be more likely to accept and use it. Finally, GETAMEL recognizes the importance of contextual factors, such as organizational support and incentives for using e-learning technology. For example, if an organization provides financial incentives for using e-learning technology, individuals may be more likely to adopt and use it.

In conclusion, GETAMEL is a comprehensive framework that seeks to understand the complex relationships between the multiple factors that influence e-learning technology acceptance. By considering individual, technological, and contextual factors, GETAMEL provides a rich and nuanced understanding of the drivers of e-learning technology adoption and usage (Doleck et al., 2018). This understanding can improve the design and implementation of e-learning technology and increase user satisfaction and engagement.

1.3. Purpose of the study and research hypotheses

GETAMEL is widely applied and validated (Strzelecki et al., 2022) to assess people's acceptance and intention to use ICT in e-learning contexts. GETAMEL constitutes an extension of the TAM (Davis, 1989) and differs from it in that it includes external factors affecting perceived usefulness and ease of use (Abdullah & Ward, 2016a). It is regarded as a generalizable model for analyzing users' e-learning acceptance and intention of use (Doleck et al., 2018). However, it can also be used to evaluate general technology acceptance (Yulianto et al., 2021). Consequently, GETAMEL is an accurate model for evaluating teachers' readiness to adopt and implement new approaches and technologies in their teaching practices.

Perceived usefulness and perceived ease of use have been extensively described as determinants of individuals' use of technology (Abdullah & Ward, 2016a; Revythi & Tselios, 2019; Venkatesh et al., 2003). Perceived usefulness involves one's feeling that the work's success will increase when adopting and using specific technological applications and tools. Similarly, perceived ease of use refers to how people believe tasks can be completed faster and more easily using technology (Davis, 1989). Five external factors, namely subjective norms, experience, perceived enjoyment, anxiety, and self-efficacy are the most common external factors influencing perceived usefulness and perceived ease of use in the e-learning contest (Abdullah & Ward, 2016a; Hanif et al., 2018).

Subjective norm is related to one's perception of social influence to use ICT about what others would consider acceptable and proper (Venkatesh et al., 2003). That is, individuals' perception of social pressure and expectations from others has a positive impact on their perception of the usefulness of a particular subject or object. When people believe that others value and endorse something, it enhances their perception of its usefulness, potentially due to the desire to conform to social norms or the assumption that others' opinions are reliable indicators of usefulness (Kemp et al., 2019). In this regard, we propose our two first hypothesis as:

H1: Subjective norm positively affects perceived usefulness.

H2: Subjective norm positively affects perceived ease of use.

Similarly, experience refers to the type and amount of one's ICT knowledge and familiarity with using ICT (Smith et al., 1999). In that sense, when people have firsthand experience with using something, they are more likely to perceive it as useful and easy to use. This may be due to the increased familiarity, confidence, and understanding gained through direct interaction and usage (Durodolu, 2016). By examining the impact of experience on perceived usefulness and ease of use, researchers can better understand how prior interactions shape individuals' perceptions and attitudes towards technology and other products. Consequently, we establish hypothesis H3 and H4 as:

H3: Experience positively affects perceived usefulness.

H4: Experience positively affects perceived ease of use.

As for perceived enjoyment it is regarded as the degree to which the use of ICT is enjoyable in itself (Kemp et al., 2019). When individuals find a particular activity enjoyable, they are more likely to perceive it as useful and easy to use (Agarwal & Karahanna, 2000). The positive emotional experience associated with enjoyment can enhance their overall perception and attitude towards the product, making it more likely for them to see it as useful and easy to engage with. By examining the relationship between perceived enjoyment and perceived usefulness and ease of use, researchers can gain insights into the role of emotions in shaping individuals' perceptions and adoption of technology or other products. Thus, we proposed hypothesis H5 and H6 as:

H5: Perceived enjoyment positively affects perceived usefulness.

H6: Perceived enjoyment positively affects perceived ease of use.

Anxiety involves emotional reactions and uneasiness related to ICT use (Kemp et al., 2019). Anxiety can heighten individuals' attention to potential difficulties or challenges, leading them to perceive a product as less useful or less easy to use. However, it's important to note that the exact nature of this relationship may vary depending on the specific context and individuals involved (Abdullah & Ward, 2016a). Further research is needed to understand the complexities of how anxiety influences perceived usefulness and perceived ease of use. Therefore, Hypothesis H7 and H8 are defined as:

H7: Anxiety affects perceived usefulness.

H8: Anxiety affects perceived ease of use.

Finally, self-efficacy is related to one's judgment of the ability to perform a particular task and the perceived competence to use ICT systems (Bandura, 1982; Kemp et al., 2019). Self-efficacy can enhance motivation, reduce perceived difficulty, and increase the belief that the product will be beneficial. Further research can provide deeper insights into the relationship between self-efficacy, perceived usefulness, and perceived ease of use. Accordingly, hypotheses H9 and H10 are established as follows:

H9: Self-efficacy positively affects perceived usefulness.

H10: Self-efficacy positively affects perceived ease of use.

Consequently, through GETAMEL, it is possible to assess science teachers' readiness to use flipped learning based on different factors and the way these factors interact. Particularly, a comprehensive evaluation can be obtained through GETAMEL, as it allows the understanding of specific areas where teachers need support, what motivates them to adopt flipped teaching, and where the resources should be directed for better flipped learning implementation and better student outcomes.

As mentioned above, GETAMEL was built upon the TAM. Therefore, GETAMEL also proclaims that perceived ease of use and perceived usefulness are the primary factors influencing an individual's intention to use new technologies. In this regard, the model explains that perceived ease of use positively affects perceived usefulness (H11) and how these factors determine individuals' attitudes (H12 and H13) and intentions (H14 and H15) to use a specific system. Subsequently, we establish hypotheses H11 to H15 as follows:

H11: Perceived ease of use positively affects perceived usefulness.

H12: Perceived ease of use positively affects attitude.

H13: Perceived usefulness positively affects attitude.

H14: Perceived usefulness positively affects intention.

H15: Attitude positively affects intention.

Figure 1 summarizes the research hypotheses and presents the proposed model. It was built upon the GETAMEL and adapted for the purpose of this research.

2. Related work

Recent studies have explored users' readiness and willingness to integrate and use new tools and approaches in educational activities through the use of GETAMEL. Behavioral intention as well as perceived ease of use and usefulness (Kimathi & Zhang, 2019; Matarirano et al., 2021), enjoyment and self-efficacy (Cicha et al., 2021), subjective norm, experiences, attitudes, intention to use (Putri & Handayani, 2021), as well as attitudes and perspectives (Yulianto et al., 2021) can positively influence users' intention to use e-learning systems.

Some studies found no correlation between users' attitudes, self-efficacy, and enjoyment factors and their intention to use e-learning systems (Jiang et al., 2021). In addition, recent studies have revealed different interactions among the external factors that influence their technology acceptance. Particularly, behavioral intention to use e-learning is significantly affected by self-efficacy, social norms, and system access (Revythi & Tselios, 2019). Subjective norm and computer anxiety can positively affect perceived ease of use and usefulness. At the same time, experience and enjoyment can positively influence perceived ease of use which, in turn, affects perceived usefulness (Kimathi & Zhang, 2019).

On the other hand, experience was found to strongly impact perceived enjoyment, self-efficacy, and anxiety (Chang et al., 2017; Hajiyev, 2018; Ibili et al., 2023), while social norms, experience, self-efficacy, and anxiety can influence perceived ease of use (Ibili et al., 2023). Moreover, users' perceived enjoyment, perceptions, and social norms can affect their perceived usefulness of an e-learning system (Chang et al., 2017; Hanif et al., 2018; Ibili et al., 2023). Finally, the literature review conducted by Strzelecki et al. (2022) indicated positive relations among enjoyment, perceived usefulness, and perceived ease of use, while the relation between perceived usefulness and self-efficacy was not supported. Additionally, enjoyment had the strongest positive influence on perceived ease of use and usefulness, while self-efficacy significantly increased their perceived ease of use.

Although GETAMEL has been adopted and successfully used in various studies (Kemp et al., 2019) and its credibility has been further validated in the literature review (Strzelecki et al., 2022) and meta-analysis (Rahmi et al., 2018) studies, there remain very few empirical studies that have adopted this model in science education to evaluate teachers' readiness to adopt and integrate new approaches and e-learning systems in their teaching (Chang et al., 2017; Jiang et al., 2021). Therefore, to address

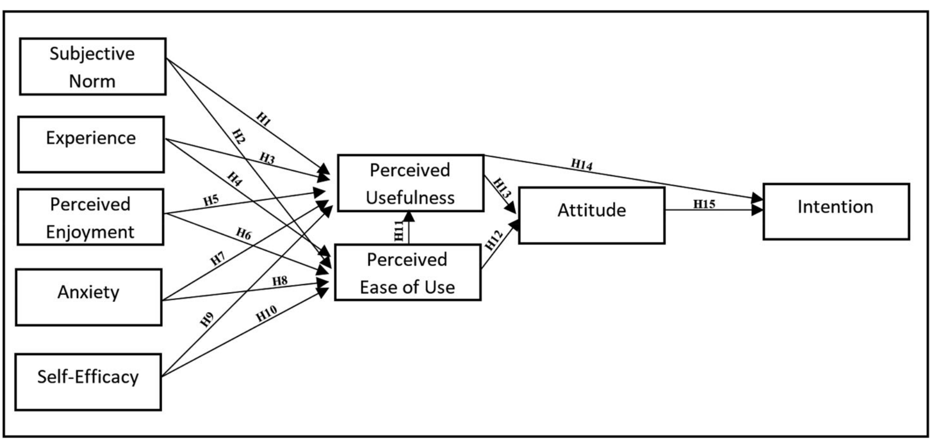

Figure 1. Proposed model.

this gap in the literature, this study aims to evaluate science teachers' flipped teaching readiness by utilizing GETAMEL as the theoretical framework.

3. Method

3.1. Participants and procedure

A cross-sectional study was conducted to gather information about science teachers' opinions and expectations regarding implementing flipped learning in science education. The study participants were science teachers in middle schools in Turkey's metropolitan cities. The study was conducted using a self-administered survey approach, and the participants were informed about the purpose of the study and their voluntary participation before it started. An in-service training session was conducted for a certain period to prepare the participants for the survey. During this session, the participants were given information about flipped learning, its benefits and challenges for students and teachers, and its potential applications in the science curriculum. The participants were also trained to prepare for a flipped learning setting. After the training session, the participants were asked to complete a survey, which took approximately 25 min.

During the initial phase of the research, a total of 495 surveys were disseminated to science educators employed in public schools located in metropolitan areas within Turkey, specifically targeting the first semester of the year 2022. Of these, 431 surveys were returned, and 33 were excluded due to incompleteness or carelessness in filling out the survey. The remaining 398 surveys were used for data analysis. The demographics of the participating science teachers showed that 53.52% were female and 46.48% were male, with the majority falling in the age range of 31–39 years old (32.66%). The next largest group of participants was in the age range of 22–30 years old (27.64%). The remainder of the participants were 40–48 years old (19.35%), 49–57 years old (14.82%), and over 58 years old (5.53%). Most respondents use technology in their daily lives (86%), with 38% using it in their science courses. However, the study found that using the flipped learning method in science courses was limited, with only 8% of the participants reporting its use. As the flipped learning method is not widely used in science education in Turkey, this study focused on understanding the antecedents of teachers' intentions to implement it in their teaching practices rather than their actual behavior.

3.2. Instruments

The instruments utilized in the current study were adapted from previous studies (Abdullah et al., 2016b; Ajzen, 2006; Davis, 1989; Lu et al., 2009; Moon & Kim, 2001; Nikou & Economides, 2017; Salloum et al., 2019; Taylor & Todd, 1995; Zhai & Ma, 2022). These instruments consisted of two sections: one for demographic information and one for the GETAMEL approach. The demographic information section asked questions about gender, age, work experience, technology usage in daily life, technology usage in science courses, and the flipped learning method. The GETAMEL approach section consisted of two parts: the original constructs from the Technology Acceptance Model (TAM), which included perceived ease of use (three items), perceived usefulness (three items), attitude (three items), and intention (three items), and external factors, including perceived enjoyment (three items), anxiety (three items), experience (three items), self-efficacy (three items), and subjective norm (two items). The scale used a five-point Likert-type scale, ranging from strongly disagree (1) to strongly agree (5), with 26 items.

The content validity of the survey items was ensured following the recommendations of Hinkin et al. (1997) and ensured through examination by three expert groups, including academic staff from the departments of science education and computer education and instructional technology, postgraduate students with proficiency in the field, and science teachers working in middle schools. Based on their opinions, the initial version of the scale was revised. Afterward, a pilot study was conducted with 122 science teachers to ensure item clarity and evaluate the suitability of the items for measuring the constructs of interest. The final version of the survey, as presented in Table 1, was developed after revisions were made.

3.3. Data analysis

The data collected from the surveys were analyzed using two statistical programs, the Statistical Package for the Social Sciences (SPSS) and Analysis of Moment Structures (AMOS). The data analysis process was conducted in two phases, which included testing the measurement and structural models using maximum likelihood estimation (Anderson & Gerbing, 1988). The measurement model was performed to assess the internal and external consistency of the measures, while the structural model was conducted to test the hypotheses and determine the relationships between the constructs involved in the GETAMEL approach.

Confirmatory Factor Analysis (CFA) was performed as part of the measurement model analysis to evaluate the reliability and validity of the scales. The results of the CFA indicated that the fit statistics

Table 1. Research items and sources.

Constructs and statements	Source
Perceived ease of use	Davis (1989); Nikou and Economide (2017)
I find the flipped classroom approach easy to use for science teaching.	
It is easy for me to become skillful at using the flipped classroom approach for science teaching.	
My interaction with the flipped classroom approach during science teaching is clear and understandable.	
Perceived usefulness	Davis (1989); Nikou and Economide (2017)
Using the flipped classroom approach for science teaching is useful for my study.	
Using the flipped classroom approach for science teaching enhances my effectiveness.	
Perceived enjoyment	Lu et al. (2009); Moon and Kim (2001)
Using the flipped classroom approach for science teaching is enjoyable to me.	
Using the flipped classroom approach for science teaching is fun to me.	
Using the flipped classroom approach for science teaching makes me happy.	
Anxiety	Zhai and Ma (2022)
I feel apprehensive about using flipped classroom approach for science teaching.	
It scares me to think that I could make mistakes I cannot correct when using flipped classroom approach for science teaching.	
Using the flipped classroom approach for science teaching is somewhat intimidating to me.	
Experience	Abdullah et al. (2016b)
I enjoy using the flipped classroom approach for science teaching.	
I am comfortable using the flipped classroom approach for science teaching.	
I am comfortable using technology when using the flipped classroom approach for science teaching.	
Self-efficacy	Salloum et al. (2019)
I feel confident when utilizing the flipped classroom approach for science teaching even when no one is there for assistance.	
I have sufficient skills to use the flipped classroom approach for science teaching.	
I feel confident when using the flipped classroom approach for science teaching.	
Attitude	Lu et al. (2009); Taylor and Todd (1995)
Using the flipped classroom approach for science teaching is a good idea.	
I like using the flipped classroom approach for science teaching.	
Using the flipped classroom approach for science teaching would be pleasant.	
Subjective norm	Ajzen (2006); Lu et al. (2009); Taylor and Todd (1995)
People who are important to me think that I should use the flipped classroom approach for science teaching.	
People who influence my behavior think that I should use the flipped classroom approach for science teaching.	
Intention	Ajzen (2006); Davis (1989); Nikou and Economide (2017)
I will use the flipped classroom approach for science teaching in the future.	
I plan to use the flipped classroom approach for science teaching in the future.	
I will try to use the flipped classroom approach for science teaching in the future.	

had an acceptable model fit ($\chi^2 = 875.25$, df = 311; $p < 0.05$; χ^2/df = 2.81; GFI = 0.92 TFI = 0.92; IFI = 0.91, TLI = 0.91 CFI = 0.93; RMSEA = 0.07; SRMR = 0.06) and all factor loadings were greater than 0.40 (Ford et al., 1986). The internal consistency of the items involved in the theoretical model was assessed using composite reliability, which ranged from 0.78 to 0.91, and Cronbach Alpha, which ranged from 0.82 to 0.92. These values supported the reliability of the measures as they were above 0.60 (Bagozzi & Yi, 1989; Nunnally, 1978). Additionally, the average variance extracted (AVE) values, which were between 0.59 and 0.77, were greater than 0.50, and the square of AVE values was higher than the correlations among the constructs in the model, validating the convergent and discriminant validity (Bagozzi & Yi, 1989; Fornell & Larcker, 1981). The results of the reliability and validity tests are presented in Tables 2 and 3.

4. Results

4.1. Structural model analysis

After the validation of the CFA, path analysis was conducted to test the fit indices of the GETAMEL approach. The results showed that the model fit indices were acceptable for structural model analysis, with χ^2/df = 2.90, GFI = 0.92, IFI = 0.93, TLI = 0.91, CFI = 0.93, RMSEA = 0.03, and SRMR = 0.03. The GETAMEL approach demonstrated good explanatory power, with an R^2 value of 0.50. The results of the model fit indices can be seen in Table 4.

Table 2. Validity and reliability of constructs in the GETAMEL approach.

Constructs and statements	Mean	Standard deviation	Factor loadings	Cronbach alpha	Average variance extracted	Composite reliability
Perceived ease of use (PEOU)				0.83	0.68	0.87
PEOU 1	3.22	1.02	0.81			
PEOU 2	2.94	1.10	0.83			
PEOU 3	2.99	0.96	0.84			
Perceived usefulness (PU)				0.82	0.60	0.82
PU 1	2.61	1.15	0.79			
PU 2	3.02	1.00	0.76			
PU 3	2.98	0.89	0.77			
Perceived enjoyment (PE)				0.83	0.74	0.90
PE 1	2.91	0.99	0.89			
PE 2	2.45	1.11	0.88			
PE 3	3.01	1.10	0.81			
Anxiety (ANX)				0.88	0.65	0.85
ANX 1	3.35	1.03	0.79			
ANX 2	3.24	1.17	0.81			
ANX 3	3.05	0.99	0.82			
Experience (EXP)				0.91	0.77	0.91
EXP 1	2.97	1.05	0.89			
EXP 2	2.78	1.09	0.88			
EXP 3	3.02	0.97	0.87			
Self-efficacy (SE)				0.90	0.59	0.81
SE 1	2.79	1.08	0.75			
SE 2	3.12	0.97	0.74			
SE 3	3.15	1.05	0.81			
Attitude (ATT)				0.87	0.59	0.81
ATT 1	3.41	1.17	0.79			
ATT 2	3.35	1.22	0.76			
ATT 3	3.44	1.08	0.75			
Subjective Norm (SN)				0.88	0.64	0.78
SN 1	3.10	1.22	0.79			
SN 2	2.92	0.98	0.81			
Intention (INT)				0.92	0.66	0.85
INT 1	3.08	1.11	0.79			
INT 2	3.11	1.04	0.83			
INT 3	2.99	1.09	0.82			

Table 3. Discriminant validity.

Constructs	1	2	3	4	5	6	7	8	9
1. PEOU	–								
2. PU	0.63	–							
3. PE	0.52	0.49	–						
4. ANX	0.46	0.45	0.45	–					
5. EXP	0.29	0.31	0.41	0.45	–				
6. SE	0.30	0.28	0.22	0.22	0.36	–			
7. ATT	0.33	0.34	0.25	0.58	0.23	0.33	–		
8. SN	0.22	0.25	0.29	0.44	0.47	0.39	0.49	–	
9. INT	0.36	0.39	0.37	0.23	0.22	0.45	0.55	0.59	–
$\sqrt{AVE}$	0.82	0.77	0.86	0.81	0.88	0.77	0.77	0.80	0.81

Note: *PEOU* = Perceived Ease of Use *PU* = Perceived Usefulness, PE = Perceived Enjoyment, ANX = Anxiety, EXP = Experience, SE = Self-Efficacy, ATT = Attitude, SN = Subjective Norm, INT = Intention, $\sqrt{AVE}$ = Square of Average Variance Extracted, $p < 0.01$.

4.2. Hypothesis testing

The maximum likelihood estimation method was used to test the structural model. The results showed that subjective norm ($\beta = 0.35$, $t = 7.20$), experience ($\beta = 0.22$, $t = 4.65$), perceived enjoyment ($\beta = 0.28$, $t = 5.48$), anxiety ($\beta = 0.45$, $t = 9.35$), and self-efficacy ($\beta = 0.36$, $t = 7.41$) had a significant impact on perceived usefulness and explained approximately 35% of the variance in this construct. These results supported hypotheses H1, H3, H5, H7, and H9. Additionally, subjective norm ($\beta = 0.45$, $t = 9.46$), experience ($\beta = 0.35$, $t = 7.30$), perceived enjoyment ($\beta = 0.53$, $t = 12.48$), anxiety ($\beta = 0.38$, $t = 7.76$), and self-efficacy ($\beta = 0.40$, $t = 8.02$) significantly influenced perceived ease of use and accounted for 40% of the total variance in the construct. This result confirmed hypotheses H2, H4, H6, H8, and H10. With regards to the original constructs of the Technology Acceptance Model (TAM), the results showed that perceived ease of use had a significant impact on perceived usefulness ($\beta = 0.22$, $t = 4.77$) and attitude toward using flipped learning ($\beta = 0.43$, $t = 8.64$), supporting hypotheses H11 and H12.

Moreover, the results indicated that perceived usefulness had a significant association with attitude ($\beta = 0.49$, $t = 10.87$) and intention to use flipped teaching ($\beta = 0.44$, $t = 8.99$), supporting hypotheses H13 and H14. Perceived ease of use and perceived usefulness explained 46% of the variance in attitude. Additionally, the results revealed a significant relationship between attitude toward using flipped learning and intention to use flipped teaching ($\beta = 0.48$, $t = 10.46$), supporting hypothesis H15. Approximately 50% of the total variance in intention to use flipped teaching was explained by perceived usefulness and attitude. The results of the hypothesis testing are presented in Table 5 and Figure 2.

Regarding mediating analysis (see Table 6), the indirect effects of external constructs including subjective norm ($\beta = 0.28$), experience ($\beta = 0.19$), perceived enjoyment ($\beta = 0.24$), anxiety ($\beta = 0.34$), and self-efficacy ($\beta = 0.29$) on perceived usefulness through perceived ease of use. In addition, external constructs were significantly and indirectly related to attitude through perceived usefulness and

Table 4. Fitting indices of the structural model.

Fit indices	Suggested value*	Model fit indices
χ^2		512.68
df		177
χ^2/df	≤2 to ≥5	2.90
GFI	≥0.90	0.92
IFI	≥0.90	0.93
TLI	≥0.90	0.91
CFI	≥0.90	0.93
RMSEA	≤0.08	0.03
SRMR	≤0.08	0.03
R^2		0.45

Note: *Hair et al. (2018); Hu and Bentler (1999); Kline (2005).

Table 5. SEM results of the GETAMEL approach.

Hypothesis number	Paths	Standardized coefficients (β)	*t*-value	Hypothesis situation
H1	SN → PU	0.35*	7.199	Supported
H2	SN → PEOU	0.45**	9.455	Supported
H3	EXP → PU	0.22*	4.654	Supported
H4	EXP → PEOU	0.35*	7.297	Supported
H5	PE → PU	0.28*	5.475	Supported
H6	PE → PEOU	0.53**	12.478	Supported
H7	ANX → PU	0.45**	9.347	Supported
H8	ANX → PEOU	0.38*	7.755	Supported
H9	SE → PU	0.36*	7.412	Supported
H10	SE → PEOU	0.40**	8.021	Supported
H11	PEOU → PU	0.22*	4.774	Supported
H12	PEOU → ATT	0.43**	8.641	Supported
H13	PU → ATT	0.49**	10.874	Supported
H14	PU → INT	0.44**	8.987	Supported
H15	ATT → INT	0.48**	10.459	Supported

Note: $^{*}p < 0.001$, $^{**}p < 0.0001$.

perceived ease of use ($\beta_{SN} = 0.25$; $\beta_{EXP} = 0.18$; $\beta_{PE} = 0.19$; $\beta_{ANX} = 0.27$; $\beta_{SE} = 0.25$) and intention to use flipped teaching through perceived usefulness and attitude ($\beta_{SN} = 0.35$; $\beta_{EXP} = 0.27$; $\beta_{PE} = 0.30$; $\beta_{ANX} = 0.38$; $\beta_{SE} = 0.32$). Considering the constructs of the original TAM model, perceived ease of use had a significant indirect effect on attitude ($\beta = 0.34$) through perceived usefulness and intention to use flipped teaching ($\beta = 0.36$) through perceived usefulness and attitude. Finally, the findings presented a significant indirect effect in the relationship between perceived usefulness and intention to use flipped teaching ($\beta = 0.37$) through attitude.

5. Discussion and implications

Bergmann and Sams (2012) introduced the concept of the flipped classroom model, an innovative pedagogical approach where students are exposed to learning content, such as instructional videos, at home prior to classroom interactions. This model facilitates the effective utilization of classroom time for active engagement activities such as problem-solving, teamwork, and project-oriented tasks (Chen et al., 2022; Johnson & Renner, 2012; Tucker, 2012). By doing so, it empowers teachers to offer personalized instruction tailored to unique student needs, thereby fostering an environment that promotes active learning (Akçayır & Akçayır, 2018; Bergmann & Sams, 2012). In light of this, the present study sets out to assess the readiness of science teachers for the implementation of the

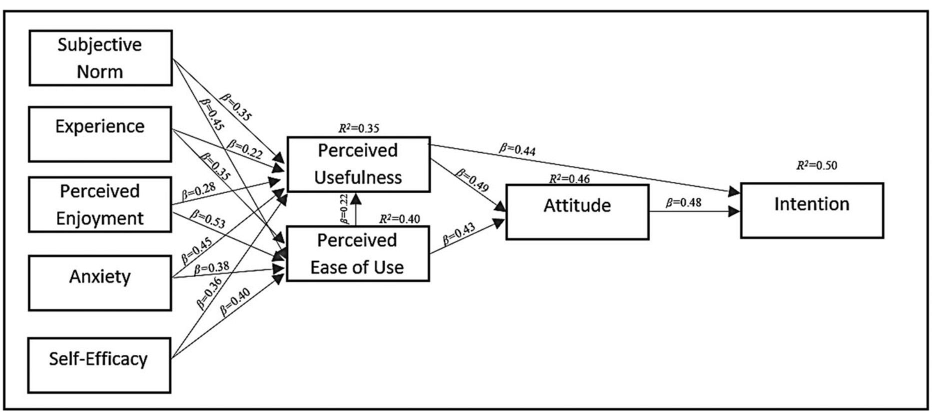

Figure 2. Results of hypothesis testing.

Table 6. Results of mediating analysis.

	On		
Indirect effect of	PU	ATT	INT
SN	0.28	0.25	0.35
EXP	0.19	0.18	0.27
PE	0.21	0.19	0.30
ANX	0.34	0.27	0.38
SE	0.29	0.25	0.32
PEOU	–	0.34	0.36
PU	–	–	0.37

Note: *Significant at 0.01.

flipped learning approach. The study employs the GETAMEL model, a widely recognized model within the realm of e-learning. This model is employed to comprehend the factors that motivate the adoption and acceptance of e-learning technologies (Abdullah et al., 2016b). The GETAMEL model presents a robust theoretical framework, accounting for both general factors that influence technology acceptance and those factors that are uniquely relevant to e-learning (Abdullah & Ward, 2016a).

In this study, we found that the perceived usefulness and ease of use of e-learning technology were significantly predicted by subjective norms, experience, perceived enjoyment, anxiety, and self-efficacy. Notably, perceived ease of use had a considerable relationship with perceived usefulness and attitudes towards the implementation of the flipped learning approach. These findings imply a noteworthy influence of the subjective norms held by colleagues on the decisions of science teachers regarding the adoption of the flipped learning approach. The crucial need for creating platforms for experience sharing, collaboration, and mentorship among teachers, especially those well-acquainted with the approach, is highlighted by these results. The past experiences of teachers significantly shape their attitudes towards the flipped learning approach. Those with prior exposure often display a more favorable disposition towards the approach, attributed to their comprehensive understanding of its potential benefits and effective implementation strategies. Similarly, the enjoyment derived from employing the flipped learning approach appears to foster a positive attitude among teachers, leading to a greater inclination to embrace it. On the contrary, teachers experiencing anxiety concerning the utilization of the flipped learning approach tend to display a lower tendency for its adoption. Consequently, it is of paramount importance to address these apprehensions and provide the necessary resources and support to assist teachers in overcoming potential challenges. Finally, our findings reveal that science teachers exhibiting a high level of self-efficacy in applying the flipped learning approach are more likely to adopt it. This tendency can be attributed to their confidence in their capabilities to successfully incorporate the approach into their pedagogical practices. The results provide crucial insights for the effective integration of the flipped learning approach in educational settings, emphasizing the role of teacher perceptions and attitudes in the adoption of this pedagogical model.

The literature examining the application of the flipped learning approach in K-12 and higher education contexts has expanded notably in recent years (Chen et al., 2022; Gao & Hew, 2022; Killian et al., 2023). Previous research accentuates the potential benefits of the flipped learning approach, including enhanced student outcomes, increased student engagement, and more efficient class time utilization (Akçayır & Akçayır, 2018; Canelas et al., 2017; Cheng et al., 2019; Olakanmi, 2017). A number of studies have ventured into identifying the elements influencing teachers' propensity to adopt and execute the flipped learning approach (Jiang et al., 2022; Kim et al., 2021; Lai et al., 2018). The insights from the present study align with previous research in several key dimensions. Our findings resonate with the consensus that perceived ease of use, perceived usefulness, subjective norms, experience, perceived enjoyment, anxiety, self-efficacy, and attitudes are instrumental in the successful adoption and implementation of the flipped learning approach (Chew, 2022; Yahaya et al., 2022). Moreover, our results endorse the GETAMEL model as an effective tool for assessing the factors influencing teachers' readiness to adopt the flipped learning approach. In essence, our study offers a holistic understanding of teachers' intentions are critical for the successful integration of the flipped learning approach into educational practices.

The theoretical implications of this study are multifaceted, shedding light on the dynamics of the flipped learning approach in education and its integration, specifically by science teachers.

Firstly, this study reinforces the pedagogical value of the flipped learning approach proposed by Bergmann and Sams (2012). It theoretically supports the efficacy of this model in fostering active learning and facilitating a more personalized instruction, validating the flipped learning approach as a viable alternative to traditional teaching methods. Secondly, the use of the GETAMEL model in this study offers a robust theoretical framework for understanding the adoption of e-learning technologies. Its application in this context, specifically for examining science teachers' readiness to implement the flipped learning approach, enriches the theory by extending its application to a specialized educational context. Next, the study expands the TAM by validating the significant roles of perceived usefulness, perceived ease of use, and the mediating effects of external factors such as subjective norms, experience, perceived enjoyment, anxiety, and self-efficacy. These elements fundamentally shape the attitudes and intentions of science teachers towards the adoption and execution of the flipped learning approach, thus contributing to a more nuanced understanding of the TAM in the context of education. Finally, this research aligns with previous studies on the flipped learning approach, thereby strengthening the theoretical foundation supporting its application in education settings. Therefore, this study contributes to the theoretical body of knowledge by providing a comprehensive understanding of the conditions necessary for successful integration of the flipped learning approach, thereby guiding future research and practice in this realm.

The practical implications of the findings in this study extend to various facets of the educational realm, and can be elaborated upon. The significant influence of subjective norms, experience, perceived enjoyment, anxiety, and self-efficacy on teachers' adoption of the flipped learning approach underscores the necessity for the creation of supportive and collaborative environments. This could involve facilitating the sharing of experiences, encouraging mentorship among teachers, and promoting a positive culture around the use of e-learning technology (Jiang et al., 2022; Kim et al., 2021; Lai et al., 2018). The study also brings attention to the role of teacher training and professional development programs. These programs should consider factors such as teachers' perceived ease of use and usefulness of e-learning technologies in order to bolster their self-efficacy, alleviate their anxiety, and foster their adoption of innovative pedagogical approaches (Abdullah & Ward, 2016a; Davis, 1989) like the flipped learning model. The interaction between teachers' attitudes, their perceptions of the usefulness and ease of use of the flipped learning approach, and their intention to adopt it suggests a need for a comprehensive, multi-faceted approach in the design of policies, strategies, and interventions aimed at encouraging the adoption of this pedagogical model. The practical implications extend to educational administrators and policymakers as well. The results could be leveraged to develop a greater understanding of the factors that influence teachers' attitudes towards, and the adoption of, the flipped learning approach. This knowledge could guide the development of institutional policies and strategies to support the integration of the flipped learning approach in educational practices (Ateş, 2024; Çakıroğlu & Öztürk, 2017; Lai & Hwang, 2016; Sun et al., 2018; Yoon et al., 2021).

5.1. Limitations and suggestions for future studies

Notwithstanding its considerable merits, this study is not without limitations, which future research endeavors should strive to address. Firstly, the data collection method was predominantly reliant on self-reported surveys, introducing potential bias and limiting the establishment of causal relationships. Moreover, the relatively modest sample size might not encapsulate the diversity and comprehensive representation of the entire community of science teachers. Another pertinent limitation resides in the geographical constraint of the study, as it primarily focuses on science teachers within a specific region. Consequently, the extent to which the results can be generalized to other regions, let alone other countries, may be circumscribed. Furthermore, while this study proffers substantial insights into the factors influencing science teachers' readiness for adopting flipped learning, it would be propitious to conduct further research to examine the implications of these factors on the actual adoption and enactment of this pedagogical approach within classroom settings. Additionally, an exploration of supplementary variables, such as the influence of school culture and the availability of technological support, which could shape the decisions around adoption, is warranted. To substantiate and enhance the robustness of these findings, replication of the study with a larger and more diverse cohort of science teachers is recommended. Inclusion of qualitative research methods, such as interviews or focus groups, could further illuminate science teachers' perceptions and experiences, providing a more holistic understanding. Future research endeavors should also consider investigating the influence of flipped learning on student engagement and achievement in science. The application of experimental designs to contrast its effectiveness with conventional teaching methodologies could provide more definitive evidence of its benefits, thereby informing policy and practice in science education.

6. Conclusion

The present study is dedicated to the investigation of the antecedents that influence teachers' readiness to implement flipped teaching methodologies in science education. This investigation was underpinned by the robust framework provided by the GETAMEL. The findings substantiate that GETAMEL efficaciously elucidates science teachers' preparedness for flipped teaching, thus corroborating all our postulated hypotheses. By doing so, this research offers indispensable insights into the realm of flipped learning in science education and emphasizes the necessity of continued exploration in this area. The implications of the study are noteworthy, as it validates the GETAMEL model as a credible theoretical framework for comprehending teachers' acceptance of technology in educational settings. The study offers a sturdy foundation for future scholarly endeavors focusing on the adoption of technology in education and the resultant impact on students' learning outcomes. Importantly, the study's insights into the mediating role of diverse factors in shaping teachers' readiness for flipped teaching, can inform the creation of effective training initiatives and support mechanisms. From a practical standpoint, this research delivers critical perspectives on the challenges and prospects accompanying the implementation of flipped learning within science education. The findings can inform and guide administrators, teachers, and practitioners in promoting the adoption of this innovative instructional strategy. Additionally, the study underscores the importance of integrating factors into the design of technology adoption programs. To conclude, this study marks a significant contribution to the field of science education and technology adoption. By offering insights into the precursors of teachers' readiness for flipped teaching and the role of intervening variables, it paves the way for future scholarly discourse and practice in this arena.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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