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Flipped Classroom and Improving Students' Academic Results in the Field of Sciences

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Abstract
The flipped classroom (FC) teaching method gives students the opportunity to actively participate during the lesson, while the teacher's role is supportive and less intrusive. The implementation of FC improves the teaching and learning process, especially in applied sciences and technology, as revealed by our research. The present study aims to investigate the implementation of the Unified Acceptance and Use of Technology (UTAUT) methodology by applied sciences and technology teachers, who combine FC to improve learning outcomes and better achieve their teaching objectives. For this purpose, we implemented a quantitative research, utilizing the findings of our data. A total of 120 high school teachers, in the region of Thessaly, participated in our research. Our data are analyzed with the SPSS tool. The results of our study reveal that social influence is important in predicting teachers' intention to implement the flipped classroom model approach and educational digital tools. Furthermore, our study argues that the flipped classroom model plays a crucial role in updating the educational demands of the 21st century, especially in ensuring the use of technological tools equitably during the teaching and learning process. Finally, the present study can help teachers adapt and enhance the flipped classroom approach by discerning the factors of technology acceptance within a modern classroom.

Keywords: Flipped Classroom, UTAUT Application, Acceptance of Technology, Technological and Pedagogical Content Knowledge, Education 4.0

1. Introduction

To create schools that can meet the needs of the future, we need to enrich teaching with new educational methods, develop innovation and harness technology. The learning sciences show us how to design environments that teach the deep knowledge and adaptive expertise needed in an age of innovation. These references began with the US Research Council's How People Learn (Bransford, *et al*., 2000) [1]. Since the publication of the first edition of this handbook in 2006, the OECD has published several important reviews of this research, including Innovative Learning Environments (2013) [5], The Nature of Learning: a) Using Research to Inspire Practice (2010) [4] and Innovation for Learning, b) Learning with Innovation (2008). Societies that can effectively reshape their schools in the learning sciences will lead the way in the 21st century (OECD, 2000, 2004 [2], 2008 [3], 2010 [4], 2013 [5]). The issues facing the learning sciences have been identified as critical in all 28 of the countries studied by ISTE (Kozma, 2003) [6]. The leaders of these countries agree that the global economy has changed and is now based on innovation and knowledge, and that education must also change to successfully support this transition (Plageras, 2018). Therefore, an important issue that arises is the articulation of an increasingly concrete vision for the future of learning. The STEAM approach combines innovation with teaching and enables students to construct and implement new ideas and practices as well as to engage in problem solving, even in subjects outside the field of positive sciences such as History (Plageras *et al*., 2021). At the same time, we aim to shape a creative, original, different and at the same time impressive learning environment, which will offer students a unique learning experience compared to the conventional classroom learning environment.

2. Student interaction with content in flipped classrooms

Student interaction is the other positive impact in a flipped classroom environment that enhances learning both inside and outside the classroom. Interaction mainly refers to the communication of students with all the cognitive content material, including the teacher. (Woo & Reeves, 2007) [9]. It proves that the interaction of students in the flipped classroom environment and technology is more effective than that in the traditional classroom without the use of technology. Students in the traditional classroom interact only in the classroom and only during teaching hours (Wang, 2013) [10]. It can be assumed that student interactions will increase when technological tools are integrated into learning activities. The use of technology will really help students interact easily with others inside and outside the classroom. According to (Moore, 1989) [11], there are three fundamental principles of interaction that should be established for successful teaching with the use of technology: First, student interaction with the content, second, student interaction with the teacher, and third, student interaction with his classmate.

(Hillman, *et al*., 1994) [12] proposed another axis of interaction between students and technological tools. This axis constitutes the fourth principle of interaction to complete Moore's idea. All these interactions are very important elements to be applied in the flipped classroom in which technology is used as a means to achieve better learning results. According to research (Roach, 2014) [13] students responded positively to the implementation of the flipped classroom when they had the appropriate instructions to be able to interact, both with the material and with each other to solve problems. The flipped classroom enables students to create learning communities and exchange ideas with each other to solve problems (Kim *et al*., 2014) [14]. (Love *et al*., 2014) [15] compared the effectiveness of two teaching methods, a traditional presentation of content and a flipped model, in a secondary school algebra course. The findings showed that students had positive attitudes towards the flipped classroom. They reported that they had more opportunities to interact with each other, which helped them learn better and collaborate more effectively with their classmates. Missildine *et al*. (2013) [16] reported that the integration of technology into traditional classroom teaching enabled students to develop interactive learning, especially outside the classroom, with the help of a learning management system (LMS). On the other hand, Kim *et al*. (2014) [14] reported that there is no evidence that the flipped classroom improves students' assessment results. In fact, they suggest that there should be further research in areas such as assessing student achievement, the use of technology in teaching and finally, how the pedagogical dimension of integrating technology into teaching should be investigated. In addition to the challenges faced by students, we should also mention the difficulties that teachers faced in implementing the flipped classroom, as they should spend more time on content design to ensure that students are motivated to watch and interact with the material before coming to class. (Milman, 2012) [17] noted that poor video quality usually creates a problem in implementing the flipped model. (Enfield, 2013) [18] also emphasized that if the content and design of a video lecture are not attractive, students will find it boring and will not watch it.

3. The Pedagogical Approach of the Flipped Classroom

The flipped classroom is a new pedagogical method that uses asynchronous digital lectures and reflection activities, as homework, and active, individual and group problem-solving activities in the classroom. It represents a unique combination of learning theories that were once considered incompatible, namely, learning activities based on real problems based on constructivist learning theory and didactic lectures derived from direct teaching methods based on the principles of behaviorism (Bishop & Verleger, 2013, June) [19]. So, define the flipped classroom as an educational technique that consists of two parts: Interactive group learning activities in the classroom and direct individual teaching based on technological means, outside the classroom (Bishop & Verleger 2013, June) [19].

The COVID-19 pandemic has greatly disrupted the conventional education system. Therefore, there is a need to create online learning models to meet the needs of students from various levels of education (Salehudin *et al*., 2021; Rostyawati *et al*., 2021; Mahendra *et al*., 2021) [20, 21, 22]. However, many studies address e-learning issues from a conceptual approach by analyzing general perceptions of user acceptance behavior, but there is a lack of studies that focus on specific technology or service areas (Abuzant *et al*., 2021; Al-Maroof *et al*., 2021; Herwin *et al*., 2021) [23, 24, 25]. Also, there are limited studies that examine the factors that influence behavioral intention to use specific emerging technologies, especially e-Flipped Classroom. Online learning has been a problem for schools and universities that do not yet have an organized online learning system. In addition, online learning presents some difficulties in terms of the full participation of all students in learning, such as students from low-income families, as well as students from vulnerable groups such as students with hearing, vision problems, etc. (Safsouf *et al*., 2020) [26]. The e-Flipped Classroom is an emerging learning technology that utilizes various platforms, such as e-classroom, and utilizes desktop, web or mobile applications based on Android or IOS. The use of the flipped classroom is starting to be increasingly adopted by teachers and students because it is considered a very useful methodology for reducing gaps in learning. The flipped classroom enables the teacher to utilize time for the face-to-face teaching process, in order to achieve better learning results and be more effective in his work. At the same time, it saves educational costs, helps in better classroom coordination, and encourages interaction between teacher and students. Although the flipped classroom offers excellent benefits in learning, it was necessary for the COVID-19 epidemic to occur, which caused teachers to adopt technology in the learning process (Zain, *et al*., 2021) [27]. Therefore, understanding the factors that influence teachers' acceptance of the flipped classroom is essential to know what aspects could shape teachers' perception, intention, and behavior regarding its use in teaching the Technology subject in High School. Trust is a very critical factor and should be included in predicting the acceptance of the flipped classroom by teachers and students. (Hamidi & Chavoshi, 2018; Garaika, 2020 [29]). Trust has been reported as a key factor for e-learning or learning with the use of technology (Al-Adwan, *et al*., 2017; Dubey *et al*., 2018) [30, 31]. However, some researchers found that trust does not affect the acceptance of online learning (Salloum *et al*., 2019 [28]; Almaiah *et al*., 2020). This creates contradictory conclusions, according to the effect of trust on e-learning or the adoption of online learning. However, trust has not yet been adequately addressed. Therefore, we need to research and test teachers' trust in learning with the use of technology. Furthermore, from our literature review, Trust of the Internet has not been tested as of the time of writing the research, in online learning areas and especially in e-Flipped Classroom (FC). The aim of this research is to examine how well the Flipped Classroom (FC) is used in education in Greece and in which areas improvements need to be made. With this study we believe that the acceptance of technology by teachers can be improved by applying the Unified Acceptance and Use of Technology (UTAUT) theory to high school students who were tested with this model and the findings could be applied to future education.

Many teachers state that e-learning does not contribute significantly to student personal or group interaction. Online learning is referred to as a lack of literacy and social interaction (Saavedra, & Opfer, 2012) [33]. Also, online learning is considered an easy way to graduate and obtain academic qualifications. This will be detrimental to graduates, but also to online learning students, because they will follow the stereotype (Saavedra, & Opfer, 2012) [33]. However, Zucker, (2008) [34] emphasized that technology can improve student learning, provide more opportunities for disadvantaged students, make school more attractive to students, and improve the professional development of teachers. Teachers must not only be knowledgeable about technology, but they must also integrate all elements of technology, content, and pedagogy into teaching and learning (Koehler, *et al*., 2007) [35]. In other words, teachers must know when and how to integrate appropriate technology into their content and instructions in the teaching and learning process of specific subjects.

4. Main research methodology- research strategy

A research strategy is considered to be the set of procedures and interventions that the researcher uses to maximize the validity (internal and external) of the results of his research. Depending on the degree of interventions deemed necessary, they are distinguished into 4 types of research strategies: Experimental, comparison of different groups, correlational, and exploratory-descriptive (Paraskevopoulos, 1993) [36]. The greatest possible certainty about the actual descriptive characteristics and the true nature of the relationship between the two variables is achieved with the experimental strategy. The main feature of experimental research is that the researcher controls and manipulates the conditions that determine the process for which we want to activate the interest of the students (Cohen & Manion, 2000) [37]. In summary, our research plan includes the following steps:

a) We identify the independent and dependent variables. In our case, we consider the teaching approach, the web 2.0 educational tools and the artifacts as independent variables and the degree of understanding of the students corresponding to the learning outcomes as dependent.
b) We defined for the comparative study the variable: teaching approach, for the levels corresponding to the teaching interventions i) Teaching with the traditional teaching methodology in the technology laboratory, having at their disposal, sensors, LEDs, microcontroller, resistors and connecting wires, for the construction of electrical circuits, ii) Teaching with the flipped classroom method and the use of web 2.0 educational tools (virtual laboratories, simulations, etc.) and sensors, LEDs, microcontroller, resistors and connecting wires, for the construction of electrical circuits,
c) We formed 10 groups of students, 5 for each teaching approach, which are equivalent in terms of the characteristics of the students. The groups of students per teaching approach who participated in the research are presented in the following table.

Table 1: Student groups by teaching approach

Teaching approach	Team name	Number of students
Teaching with traditional methodology in the technology lab	Control Group (C.G)	70
Teaching with the flipped classroom method and the use of web 2.0 educational tools for the construction of electrical circuits	Experimental Group (EG)	68

Because there was no exclusion of any student from the experimental process, we ensure the randomness of the sample of subjects. The equivalence of the groups in terms of cognitive level in the area of electrical circuit concepts is also checked by the application of the Pre-Test (application of the D.I.R.E.C.T. V.1.1 test) in both groups.

d) Care has been taken to ensure that the total time period for all activities, per teaching approach, is the same. In detail, the time duration per teaching intervention is given in Table 2.

Table 2: The duration per teaching approach

Teaching approach	Team name	Duration of intervention
Teaching with traditional methodology in the technology lab	Control Group (C.G)	6 hours
Teaching with the flipped classroom method and the use of web 2.0 educational tools for the construction of electrical circuits	Experimental Group (EG)	6 hours (in the classroom)

e) We ensured that during the period of conducting the research, nothing would happen that would affect part or all of the students in the groups. This was ensured on the one hand by the fact that the students are from different sections of the High School and there is no direct contact between them and on the other hand the experimental interventions are implemented in a short period of time (three 2-hour periods). The timetable is not disrupted and there is no time for interaction between them during the implementation of the experimental process. However, the participating students were advised not to comment on the activities implemented with classmates from other sections until the process was completed.

f) We ensured a reliable and valid means with which to measure the dependent variable, at the beginning and at the end of the process. The means used in this research, as mentioned in the introduction, is the D.I.R.E.C.T. assessment test. v.1.1 acronym for the words Determining and Interpreting Resistive Electric Circuits Concepts Test, one of the most reliable and valid assessment tests used in the area of electrical circuits and whose validity and reliability were also tested for the Greek reality (Tsichouridis, 2013) [38].

g) We compare, using the appropriate statistical method, the measurements of the dependent variable between the research groups. In the above plan, we must add one more step before the teaching intervention. It is the step of measuring the dependent variable before the effect of the independent variable (teaching approach). The purpose is, on the one hand, to record the initial ideas and performance of the students, regarding the cognitive object of the study, and on the other hand, to establish the equivalence of the groups, regarding their cognitive characteristics. In this case, both the reliability and validity of the D.I.R.E.C.T. v.1.1 assessment test will be investigated, as a basic tool for recording research data. In general, the organization of the teaching interventions by the researcher himself and for the three teaching approaches ensures the parity of the groups, with respect to the other variables, so that any differences that will be recorded after the end of the process, can be attributed exclusively to the teaching approach, given that the equivalence of the three groups has been initially checked.

h) The results of the teaching intervention were then presented to the teachers in a 2-hour meeting.

i) After the presentation of the questionnaire results to the teachers, the teachers completed a new questionnaire. The aim of the second questionnaire was to investigate teachers' expectations from the use of technological educational tools and accessories in the flipped classroom method.

j) By utilizing the UTAUT model questionnaire, as adapted for the needs of our research (Venkatesh *et al*., 2003), we detected the reasons why teachers accept technological materials (sensor kits and Arduino) for the implementation of their activities in the classroom. Subsequently, the same groups of students were given questions of graded difficulty, to check whether the differentiation in the degree of understanding is enhanced. The results were presented to teachers who teach the Technology course and they were asked to answer the UTAUT model questionnaire. The UTAUT model questionnaire was given to detect teachers' expectations from the acceptance of technological materials (sensor kits and Arduino), for the implementation of their activities in the classroom, as educational aids in the flipped classroom teaching methodology. Table 3 lists the reliability indices of the scales related to flipped classroom teaching. The reliability index (Cronbach's Alpha) takes values from -1 to 1, with values close to 1 indicating high correlation. All scales have high correlation, with the reliability indices being analytically the following: Performance Expectancy (.850), Effort Expectancy (.636), Facilitating Conditions (.842), Technological Anxiety (.884), Social Influence (.639), Personal Innovation (.781), Attitude (.723), Behavioral Intention (.907), Intention to Use (.933), Internet Trust (.933). Finally, Table 3 reports the mean values and standard deviations for each scale separately.

Table 3: Δείκτης αξιοπιστίας για τις κλίμακες που αφορούν την αντεστραμμένη τάξη

Scale	*M*	*SD*	*N*	*Cronbach's Alpha*
Performance Expectation	17.59	4.336	5	.850
Effort Expectancy	15.56	3.046	5	.636
Facilitating Conditions	16.00	4.422	5	.842
Technological Stress	10.16	4.546	5	.884
Social Impact	10.14	2.213	3	.639
Personal Innovation	17.95	4.096	5	.781
Attitude	11.89	2.458	3	.723
Behavioral Intention	18.01	4.526	5	.907
Intention of Use	18.25	4.645	5	.933
Trust of Internet	17.64	4.917	5	.933

Table 4 lists the reliability indices of the questions concerning the factors that influence teachers in teaching with technology. The reliability index (Cronbach's Alpha) takes values from -1 to 1, with values close to 1 indicating high correlation. High correlations are observed in all questions and more specifically, Computer Software Knowledge (.898), Frequency of Software Use (.799), Computer Attitudes (.885), Perceived Self-Efficacy (.764) and School Climate and Support (.827). Finally, Table 4 reports the mean values and standard deviations for each part of the questions separately.

Table 4: Reliability index for questions regarding factors that influence teachers in teaching with technology

Questions	*M*	*SD*	*N*	*Cronbach's Alpha*
Computer software knowledge	37.53	8.855	14	.898
Frequency of software use	34.83	6.961	15	.799
Attitudes towards computers	59.88	7.169	15	.885
Perceived Self-Certification	30.96	3.784	8	.764
School climate and support	40.21	5.946	12	.827

In Table 5, multiple comparisons were made between the dimensions of the reversed order. Starting from the comparison of technological anxiety with the other dimensions, statistically significant differences were observed with the following dimensions: "Facilitating Conditions" (Test Statistic = 2.411, $p < 0.05$, Adj. Sig < 0.05), "Social Influence" (Test Statistic = -2.938, $p < 0.05$, Adj. Sig < 0.05), "Performance Expectation" (Test Statistic = 3.507, $p < 0.05$, Adj. Sig < 0.05), "Trust in the Internet" (Test Statistic =- 3.555, $p < 0.05$, Adj. Sig < 0.05), "Personal Innovation" (Test Statistic =- 3.623, $p < 0.05$, Adj. Sig < 0.05), "Behavioral Intention" (Test Statistic =- 3.863, $p < 0.05$, Adj. Sig < 0.05), "Intention to use" (Test Statistic =- 4.212, $p < 0.05$, Adj. Sig < 0.05) and "Attitude" (Test Statistic =- 5.425, $p < 0.05$, Adj. Sig < 0.05), indicating that technological anxiety differs significantly from these dimensions and presents a different frequency. Regarding the comparison of effort expectancy with the other variables, statistically significant differences were recorded between effort expectancy and the following variables: "Performance expectancy" (Test Statistic =2.014, $p < 0.05$, Adj. Sig =0.03), "Internet trust" (Test Statistic =-2.062, $p < 0.05$, Adj. Sig =0.002), "Personal innovation" (Test Statistic =-2.130, $p < 0.05$, Adj. Sig =0.001), "Behavioral intention" (Test Statistic =-2.370, $p < 0.05$, Adj. Sig <0.05), "Intention to use" (Test Statistic =-2.719, $p < 0.05$, Adj. Sig <0.05) and "Attitude" (Test Statistic =-3.932, $p < 0.05$, Adj. Sig <0.05), indicating that effort expectancy differs significantly from the other variables and occurs with a different frequency. Furthermore, facilitation conditions differ statistically significantly from the following variables: "Intention to use" (Test Statistic =-1.801, $p < 0.05$, Adj. Sig =0.15) and "Attitude" (Test Statistic =-3.014, $p < 0.05$, Adj. Sig <0.05), indicating that it occurs with a different frequency than the other two variables. In addition, statistically significant differences were recorded between the "social influence" and the "Attitude" dimension (Test Statistic =-2.486, p <

0.05, Adj. Sig <0.05, in the “Performance Expectation” and “Attitude” dimensions (Test Statistic =-2.486, p < 0.05, Adj. Sig =0.006), as well as in the “Internet Trust” and “Attitude” dimensions (Test Statistic =1.870, p < 0.05, Adj. Sig =0.009). Finally, a statistically significant difference was recorded between the “Personal Innovation” and “Attitude” dimensions (Test Statistic =-1.801, p < 0.05, Adj. Sig =0.015). It is concluded that technological stress has lower scores than the other variables, therefore it has a lower impact on the participants than those that have higher scores, such as for example the dimension "Attitude".

	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj. Sig.[a]
Technological Anxiety - Effort Expectancy	1.493	.501	2.980	.003	.130
Technological Stress-Facilitating Conditions	2.411	.501	4.811	.000	.000
Technological Stress-Social Impact	-2.938	.501	-5.863	.000	.000
Technological Anxiety-Performance Expectation	3.507	.501	6.998	.000	.000
Technological Anxiety - Trust of Internet	-3.555	.501	-7.093	.000	.000
Technological Anxiety-Personal Innovation	-3.623	.501	-7.230	.000	.000
Technological Anxiety-Behavioral Intention	-3.863	.501	-7.708	.000	.000
Technological Anxiety-Intention to Use	-4.212	.501	-8.405	.000	.000
Technological Anxiety-Attitude	-5.425	.501	-10.825	.000	.000
Expectancy of Effort - Facilitating Conditions	-.918	.501	-1.831	.067	1.000
Effort Expectancy - Social Impact	-1.445	.501	-2.884	.004	.177
Effort Expectancy - Performance Expectancy	2.014	.501	4.018	.000	.003
Expectancy of Effort - Trust of Internet	-2.062	.501	-4.114	.000	.002
Effort Expectancy - Personal Innovation	-2.130	.501	-4.251	.000	.001
Effort Expectancy-Behavioral Intention	-2.370	.501	-4.729	.000	.000
Effort Expectancy - Intention to Use	-2.719	.501	-5.426	.000	.000
Effort Expectancy - Attitude	-3.932	.501	-7.845	.000	.000
Enabling Conditions - Social Impact	-.527	.501	-1.052	.293	1.000
Facilitation Conditions - Performance Expectation	1.096	.501	2.187	.029	1.000
Conditions of Facilitation - Trust of Internet	-1.144	.501	-2.282	.022	1.000
Facilitating Conditions - Personal Innovation	-1.212	.501	-2.419	.016	.700
Facilitating Conditions - Behavioral Intention	-1.452	.501	-2.898	.004	.169
Conditions of Facilitation - Intention of Use	-1.801	.501	-3.595	.000	.015
Facilitating Conditions-Attitude	-3.014	.501	-6.014	.000	.000
Social Impact - Performance Expectation	.568	.501	1.134	.257	1.000
Social Influence -Trust of Internet	-.616	.501	-1.230	.219	1.000
Social Impact - Personal Innovation	-.685	.501	-1.367	.172	1.000
Social Influence - Behavioral Intention	-.925	.501	-1.845	.065	1.000
Social Impact - Intention to Use	-1.274	.501	-2.542	.011	.496
Κοινωνική Επίδραση -Στάση	-2.486	.501	-4.961	.000	.000
Performance Expectation-Trust on the Internet	-.048	.501	-.096	.924	1.000
Performance Expectation - Personal Innovation	-.116	.501	-.232	.816	1.000
Performance Expectation - Behavioral Intention	-.356	.501	-.711	.477	1.000
Performance Expectation-Intention to Use	-.705	.501	-1.408	.159	1.000
Performance Expectation-Attitude	-1.918	.501	-3.827	.000	.006
Trust of Internet - Personal Innovation	.068	.501	.137	.891	1.000
Trust of Internet - Behavioral Intention	.308	.501	.615	.539	1.000
Trust of Internet - Intention to Use	.658	.501	1.312	.189	1.000
Trust of Internet -Attitude	1.870	.501	3.731	.000	.009
Personal Innovation - Behavioral Intention	-.240	.501	-.478	.632	1.000
Personal Innovation-Intention to Use	-.589	.501	-1.175	.240	1.000
Personal Innovation-Attitude	-1.801	.501	-3.595	.000	.015
Behavioral Intent-Use Intent	-.349	.501	-.697	.486	1.000
Behavioral Intention-Attitude	1.562	.501	3.116	.002	.082
Intention of Use-Attitude	1.212	.501	2.419	.016	.700

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is,05.

a. Significance values have been adjusted by the Bonferroni correction for multiple tests.

5. Conclusions

Concluding our research, we conclude that the factors technological stress, effort expectancy, facilitating conditions, social influence and attitude are those that statistically influence secondary education teachers the most to integrate the flipped classroom into their teaching. Assistance should be provided with regard to the material, software and the way to create efficient activities. The school must function in a supportive and encouraging manner towards teachers, so that they can overcome technological stress and integrate the tools into the flipped classroom. On the other hand, the factors “Attitude” and “Personal innovation” seem to have a strong influence on the prediction of differentiation of teaching by teachers with the flipped classroom and on the integration of web 2.0 educational tools into teaching. Ultimately, it is proven that if the school functions as a learning community, then the conditions can be created for the improvement of learning outcomes and teacher performance.

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