An Application Study of the UTAUT Methodology for the Flipped Classroom Model Adoption by Applied Sciences and Technology Teachers

https://doi.org/10.3991/ijet.v18i02.35585

Antonios Plageras[1(✉)], Apostolos Xenakis[2], Konstantinos Kalovrektis[3], Denis Vavougios[1]
[1]Department of Physics, University of Thessaly, Lamia, Greece
[2]Department of Digital Systems, University of Thessaly, Larisa, Greece
[3]Department of Computer Science and Telecommunications, University of Thessaly, Lamia, Greece
aplageras@uth.gr

Abstract—The teaching method of flipped classroom (FC), gives students the opportunity to participate actively during class, while the teacher's role is supportive than intrusive. The application of FC improves teaching and learning process, especially in applied sciences and technology, as literature study reveals. The current study aims to investigate the application of Unified Theory of Acceptance and Use of Technology (UTAUT) methodology, by applied sciences and technology teachers, who combine FC to improve learning results and better meet their teaching goals. To this end, we apply quantitative research, exploit, and discuss our data findings. A total number of 65 high school teachers, around the area of Central Greece, in the region of Thessaly, took part in our research. Our data is analyzed via Structural Equation Models (SEMs) which belong to a family of multivariable statistical analysis that refer to linear correlations among quantitative mainly variables, with confirmatory role. The results of our study reveal that social influence is significant for the prediction of teachers' intention (current of future) to apply flipped classroom model approach. Additionally, our study claims to support that flipped classroom model plays a crucial role in updating educational demands of the 21st century, especially in guaranteeing the use of technology tools in equally during teaching and learning process. Finally, this study may assist teachers to adjust and reinforce flipped classroom's approach, by distinguishing the technology acceptance factors inside a contemporary classroom.

Keywords—flipped classroom, UTAUT application, acceptance of technology, technological and pedagogical content knowledge, Education 4.0

1 Introduction

The World is constantly changing due to the rapid evolution of digital technologies and communication systems. Information is easily accessible in almost every inch of the Globe, via Internet connection [1]. This also means that knowledge is open and accessible to everyone, anytime, in any place. Knowledge about technology, as part of

an integrated learning environment, is very common in the prism of Education 4.0 era. [2, 3]. Internet has transformed young peoples' beliefs and opinions regarding knowledge mining, as they use their Smartphone's daily, for both pleasure and learning activities [4]. Students learn easily about gadgets and digital items, such as sensors, circuits, IoT platforms, microprocessors etc., via social media sources like YouTube and other MOOCs. To this end, information and communication technologies (ICT) have been developed in order to also assist and enhance students' learning process [5].

Nevertheless, due to the restricted infrastructures and budget, in many schooling environments, ICT tools are not used satisfactory and to the extent that efficiently support learning and teaching [5]. Nowadays, the majority of education activities, focus on supplying students with new digital skills to prepare them for the challenges they are going to face as professionals [6]. These skills also include creativity, critical thinking, communication, collaboration and leadership [7]. Hence, online MOOC learning and real time Internet based learning, has a lot of potential and thus many software packages, learning platforms, virtual and remote labs are being developed daily [8]. According to literature, the adoption of digital learning environments [9] enhances the effectiveness of an integrated education process in students' acquiring computational thinking skills.

However, ICT tools are not enough if they are not combined with students' learning styles [10]. According to literature [11], studies try to reveal potential correlation among individual learning styles and their effect of students' performance [12, 13. etc.]. The term *learning style* is used to highlight individual pace and learning depth. It is based on the premise that each student has a unique way of learning, aggregate and process information and translates information into knowledge [14, 15]. Therefore, it is quite difficult to apply a single teaching technique to optimize every individual learning process. Each style is acknowledged to act as a multidimensional parameter, which depends on the cognitive processes, personality and social background of each student. All the aforementioned factors define the ways with which the learning function outcome is optimized. According to [16], some students better learn through oral presentation of educational materials, while others through their participation in experimental activities. However, the majority of students learn deeply by designing and working with artifacts.

Over the past few years, there has been an attempt by researchers to classify and group learning styles, depending on the following models [17]:

a. Models which highlights the choice of the learning environment, according the its characteristics and how they affect the students' learning ability.
b. Models based on personality criteria, i.e. how personality characteristics affect the way information is processed.
c. Social interaction models, which are based on students' behavior inside classroom
d. Information processing models, based on how students process experiences.

A special aid to enhance individual learning styles and succeed better and stronger learning results, is through asynchronous teaching methods, in which the teaching phase is strongly correlated with the application of technology [18]. In many cases, students, who are familiar with digital technology means, prefer online lessons, in an on

demand basis. Moreover, video lessons with optical and visual stimuli affect learning superficially. However, no matter how attractive are video lessons or real time internet lessons, the research community [19] do not point out significant differences in terms of students' learning outcomes, between asynchronous and synchronous in situ teaching.

2 Motivation and background concepts

2.1 Flipped classroom model

Flipped Classroom teaching model has become a popular in all educational levels all over the world. The basic idea of FC is to relocate the teaching process outside the classroom, so that students share their time among problem – solving activities during learning process. The model of FC has been studied as far as its effectiveness, especially in University education. According to [e.g., 20, 21, 22, 23, 24, 25, 26], it is clear that FC offers teachers and tutors to dedicate more of their teaching momentum inside classroom to enhance students' skills and work with them on real complex multidisciplinary problems. Students' opinions regarding FC and its potential to lead to better learning outcomes is generally positive. By engaging themselves in STEM activities, they grow stronger communication and leadership skills, while working with artifacts [27]. Moreover, the adoption of FC lead to better performance outcomes, even for students with lower scores.

One of the main problems that arise from the adoption of FC, involves the significant increase in teachers' workload to create new digital material and how to encourage students to change their learning habits. According to literature, [28] some students may not be familiar with this new learning process, nor with the use of digital technology, thus they neglect to perform their out of the classroom activities. We may not neglect that, in some cases, a significant amount of students appear to be displeased with FC [29]. While the majority of the studies, regarding the effectiveness of FC, focus on University education [e.g., 21, 23, 24], others focus on post – secondary (i.e. nursery) or technical education [e.g., 26, 30]. So far, to the best of our knowledge, there are none or very few studies which focus on FC application in high school students, oriented to applied sciences and technical studies (i.e. electricians, mechanics etc.). Consequently, in this work, we try to fill this gap and we believe that a systematic research is necessary to investigate the efficiency of FC in enhancing learning outcomes and grow new skills, for high school students.

Therefore, according to [31], the adoption of FC within the teaching process will upgrade the level of education as offered nowadays, especially in high school level. Our research focuses on the estimation of this advantage, as a case study in Greek High schools. We argue that the quality of teaching subjects, related to technology and applied sciences, is going to improve, which will open new horizons for students' interests. In our paper, we apply the Unified theory of Acceptance and Use of Technology (UTAUT), to estimate the efficiency of FC in accordance with applied sciences learning subjects. We think that it is important to measure the acceptance of FC by both the teachers and students, in order to ensure its effectiveness in teaching technology subjects. Our findings relates to the prediction of teachers' intention to apply FC.

Education 4.0 is a new paradigm in teaching and learning process, which aims to prepare students and learners for the upcoming Industrial revolution, which requires strong STEM skills, like robotics, Internet of Things (IoT), 3D printing, circuits etc. Under this framework, social environment and economy play an important role in guaranteeing sustainability. Moreover, technology comprehension and application in designing artifacts by young students is a valuable asset. Educating students on technology focuses on the environmental sustainability through educational exploitation practices. Moreover, technical education focuses on the implementation of sustainable forms of energy through educational practice and development of innovative solutions in the near future.

The European Union (EE) has renewed the initiative policy "The Digital Education Action Plan (2021–2027) [32] by supporting the sustainable and effective adaptation of the educational and professional training systems. This plan offers a long-term strategic vision about digital education. It deals with the obstacles and the opportunities created during the period of the pandemic COVID-19 by promoting the significance of collaboration in order for education to enter the digital age. In the sequel, it focuses on the quality of teaching through digital learning systems, which are required for distance learning [32]. It is also noticed [4] that there many students do not make use of digital means and online MOOCs to grow their critical thinking and problem solving skills, but use them only for communication through social networks. According to literature, many works propose and compare pedagogical methods in high schools [33]. Some of basic pedagogy pillars, like inclusive and collaborating educational process, cross – disciplinary methods end experimentation, highlight and enhance the student – oriented and interactive approaches during teaching and learning phases. According to more recent studies [34, 35], the pandemic COVID – 19 has led to rapid changes in education and created the need for the transition (partially or in a blended framework) to online teaching and learning process. To this end, one of the dominant pedagogical methods to support this claim is FC, which reinforces learning with technology means and WEB 2.0 tools.

2.2 TPACK model

Shulman [36], first introduces the Pedagogy and Content Knowledge (PCK) model, which led to the proposition of the Technological, Pedagogical and Content Knowledge (TPACK) model. Shulman supports that any teaching process that focuses individually to the content or to knowledge or to pedagogical principles, has a high chance of failing. To this end, several years later, Shulman's proposition is revised by adding the technology component. TPACK is a model which shows that any new knowledge offered in school education, leads to better learning outcomes if is produced with the help of technological supervisory teaching means [37]. In TPACK model, there is a strong relationship among the content, the pedagogical framework and the use of technology. Therefore, according to Figure 1, in TPACK model we see three joining dimensions, the Technological Knowledge (TK), the Pedagogical Knowledge (PK) and the Content Knowledge (CK).

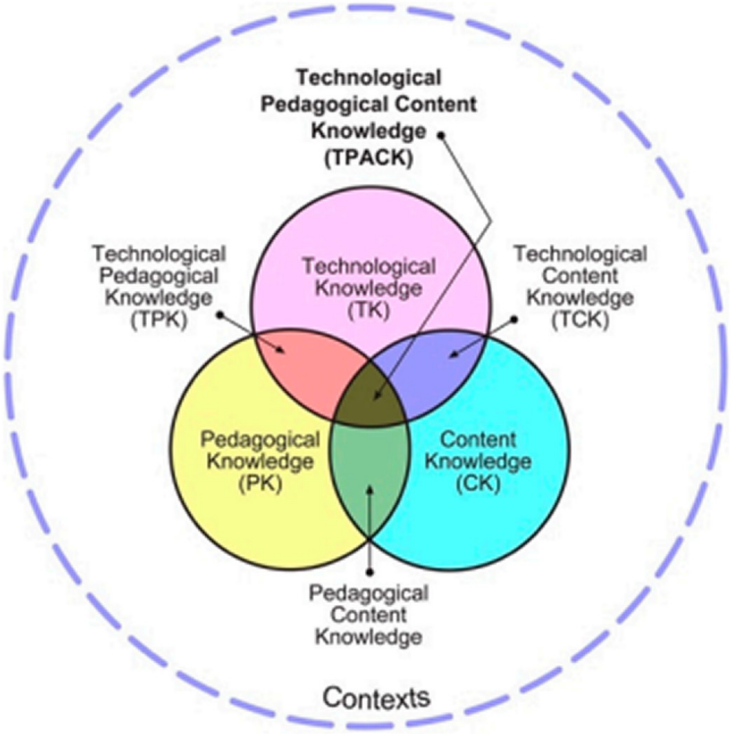

Fig. 1. The dimensions of TPACK model of technological pedagogical content knowledge (TPACK) by [37]

According to [37], technology may improve learning outcomes, give more chances to students to participate longer and motivate teachers to enhance their knowledge and to fight against school dropout phenomenon. In essence, the underlying idea of TPACK is not to just incorporate technology at the center of teaching and learning, but more to improve the process. This means that teachers need to be more familiar with digital means and upgrade their pedagogical approach to a more technology oriented and blended model [38]. Teachers need to argue when and how they need to adopt technological means according to the teaching content, in order to guarantee better learning outcomes for all students [39].

2.3 Unified Theory of Acceptance and Use of Technology model (UTAUT)

The Unified Theory of Acceptance and Use of Technology (*UTAUT*) [40], estimates the technology acceptance in a quantitative manner. It consists of eight (8) main elements. These include: 1) The *Theory of Reasoned Action (TRA)*, 2) *The Technology Acceptance Model (TAM),* 3) *The Motive model*, 4) The *Theory of Programmed Behavior (TPB)*, 5) The *combined model of TAM and TPB*, 6) *The model of the Computer Use*, 7) The *Theory of Innovation Diffusion* and 8) The *Social Cognitive theory* [41].

Moreover, the behavior intent, is a basic prediction factor, supported by UTAUT. According to Figure 2, [40] proposed UTAUT, which includes four (4) basic factors. These are: 1) *Performance Expectancy* 2) *Effort Expectancy* 3) *Social Influences* and 4) *Facilitation Conditions*. In essence, performance expectancy, is defined as the degree to which the subject (i.e. in our study this represents five teachers), believes that the use of technology is going to help them achieve their teaching aims in High school. Venkatesh et al. [41], claim that the performance expectation is the most powerful factor of UTAUT. Therefore, in our work, we consider that the adaptation of performance expectancy within this framework, suggests that technology teachers will apply FC methodology.

Following, the effort expectancy is defined as the degree of convenience associated with using a system. Literature supports that a method oriented towards effort expectancy is expected to have positive results in the initial stages of new behavior creation [42, 41]. Hence, the adaptation of the effort expectancy, suggests that teachers consider the adoption of FC in technology teaching, an easy effort to do so. Finally, social influence is defined as the degree to which a teacher thinks of other teachers as important influence factors, irrelevant of their hierarchy, who in the end will apply FC. This concept is correlated with the idea someone has and how his idea is affected, by others, who believe that the adoption of technology will lead to better results. The importance of social factors becomes even more significant, in instructions – oriented teaching environments, as supported by [42]. The facilitation conditions concern the degree to which a teacher thinks that a well organized technology teaching infrastructure (i.e. a lab) is essential in order to support the adoption of technology. To this end, these four (4) factors are necessary for the prediction of teachers' intention to use FC and technology during teaching process.

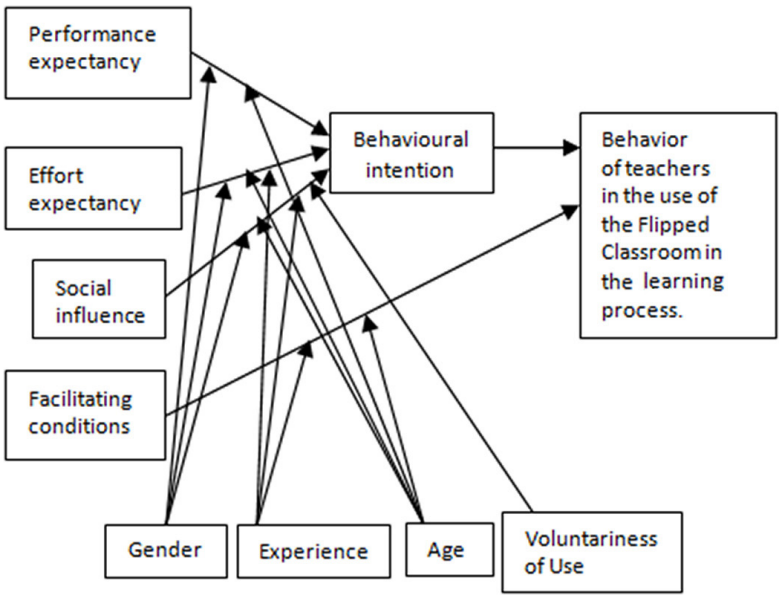

Fig. 2. The unified theory of technology acceptance and use of technology (UTAUT) model by [41]

3 Methodology

In this work, we investigate whether the aforementioned factors (i.e. performance expectancy, effort expectancy, social influence and facilitating conditions) lead to some important relation as to the intention of teachers, who teach technology related subjects, will adopt FC or not. Our research follows a quantitative approach. In order to investigate our claims, technology teachers volunteered to participate, mainly from the Region of Thessaly, central Greece. Group sampling is used for the high schools selection, as it is the most effective planning method and time effective for large geographical areas [43]. During sampling classification, we used numbering from 1 to 15. Additionally, we focused on high schools, in capital cities of Thessaly region, such as Larissa, Volos, Trikala and Karditsa. Our research hypotheses (H), are as follows:

Hypothesis 1 (H1): The performance expectancy has no significant effect on the teachers' intention to use the flipped classroom.
Hypothesis 2 (H2): The expected effort has no significant effect on the teachers' intention to use the flipped classroom.
Hypothesis 3 (H3): Social influence has no significant effect on the teachers' intention to use the flipped classroom.
Hypothesis 4 (H4): Facilitating conditions have no significant effect on the teachers' intention to use the flipped classroom.

Hence, the aim of the study is to investigate the application of UTAUT to predict the intention of applying FC during technology related lessons. The research questions are as follows:

1. Does the teachers' intention to use the flipped classroom affect significantly the performance expectancy?
2. Does the teachers' intention to use the flipped classroom affect significantly the effort expectancy?
3. Does the social influence affect significantly the teachers' intention to use the flipped classroom?
4. Do the facilitating conditions affect significantly the teachers' intention to use the flipped classroom?

The total number of teachers in high schools, which are selected, is unknown. In order to estimate the size of the sample, the Cochran formula is used [4]. Cochran formula is used because it allows researchers to estimate a sample according to the preferred level of accuracy, the preferred level of trust and the analogy of characteristics in a population [4]. The Cochran formula is widely used for the estimation of unknown size samples in comparison with other formulas [4]. Therefore, based on this formula, the estimated size of the sample was 75. Nevertheless, 114 Technology teachers answered a digitally designed questionnaire.

As far as the data collection is concerned, we initially asked the school Principles to provide a formal letter of consent, which is attached to the electronic survey. The questionnaire used with Google forms and a short introduction regarding the aim of this research was provided. A period of one month is given for the process completion and data analysis. Finally, for the analysis, the authors rely on approaches from [44] and some

adjustments are made to achieve the research objective. For example, we differentiated the subject, the grade of the school where the intervention took place and the subject.

4 Results

Table 1 shows the data obtained from the processing of the questionnaire adapted from [44] and the reliability of the scale of the Cronbach's alpha value for each approach. From the processing of the questions, the factors that give us acceptance were found. The rest of the answers that do not give us acceptance are not mentioned.

Table 1. Research results

Factor	Approach	Total Correlation	Decision	Cronbach's Indicator α
Performance Expectancy (PE)	I think that the flipped classroom is a useful tool for teaching Technology.	0,725	Acceptance	0.889
	I think that the use of flipped classroom for Technology instruction will facilitate interaction among then students.	0,845	Acceptance	
	I think that it is easy for me to become competent in the implementation of the flipped classroom in Technology instruction.	0,658	Acceptance	
Effort Expectancy (EE)	The use of the flipped classroom in the instruction of Technology has become an easy process for me.	0,845	Acceptance	0,879
	I find the implementation of the flipped classroom attractive if the majority of the teachers do it.	0,756	Acceptance	
	I would use the flipped classroom in the instruction of Technology if the school principal had encouraged me in its use.	0,801	Acceptance	
Social Influence (SI)	I would use the flipped classroom if the school Principal convinced me of its value in teaching.	0,785	Acceptance	0,869
	I would probably have more preparation for the instruction of technology if I used the flipped classroom.	0,797	Acceptance	
Facilitating Conditions (FC)	All the necessary resources are available to me in order to use the flipped classroom in my Technology instruction.	0,602	Acceptance	0,778
	I possess all the necessary knowledge in order to use the flipped classroom in the Instruction of Technology.	0,685	Acceptance	
	There is a specific person available for help in any technical problem that may arise or I may deal with concerning the flipped classroom.	0,617	Acceptance	

The questionnaire was measured using a five-point Likert scale. There are five response options, 5 – strongly agree, 4 – agree, 3 – slightly agree, 2 – disagree and 1 – strongly disagree. The questionnaire was adapted from [45].

5 Conclusions

In conclusion, performance expectancy, effort expectancy and facilitating conditions do not correlate with the Technology teachers' intention to use the flipped classroom approach. Nevertheless, social influence was found to be important. This shows that the influence coming from another teacher is the most important factor of prediction for the teachers if they are to decide whether or not to use the flipped classroom. With the present study our goal is to give information to teachers and students for the reinforcement of the critical thinking skills through the use of technology in teaching. Based on the results, certain consequences have arisen. As far as the positive effect is concerned, it can be seen that social influence is a powerful prediction factor for defining the teachers' intention to use the flipped classroom approach. In this study we used the Unified Theory of Acceptance and Use of Technology (UTAUT) and the data have proven to be even more powerful in the methodological approach. We ended up with similar findings with previous studies [4].

The pedagogical effect from this study is definitely a significant aspect that must be emphasized to assist teachers in defining the powerful prediction factors. Their analysis could help teachers incorporate flipped classroom especially when dealing with projects that involve workshop exercises, virtual and remote workshops, online platforms for the creation of distance learning which could be combined with classroom activities. An important proposition could be that the flipped classroom method be used in all schools, public and private of secondary education. The ones responsible for the designing of educational policy could examine the possibility to urge teachers to use the flipped classroom specially to manage technology for the improvement of teaching. They could also examine the possibility to offer a better environment for the incorporation of technology in education, especially in the realization of workshop activities in virtual classrooms. Additionally, further study conduct is recommended for the four prediction factors: performance expectancy, effort expectancy, social influence and facilitating conditions as the researchers had a relatively small number of participants. A larger sample could potentially lead to more powerful results.

6 References

[1] Yemma, D. M. (2015). *Impacting learning for 21st century students: A phenomenological study of higher education faculty utilizing a flipped learning approach* (Doctoral dissertation, Robert Morris University). In Abd Rahman, S. F., Md Yunus, M., & Hashim, H. (2021). Applying UTAUT in predicting ESL lecturers intention to use flipped learning. *Sustainability*, *13*(15), 8571. https://doi.org/10.3390/su13158571 [Accessed: May 24, 2022].

[2] Yeop, M. A., Yaakob, M. F. M., Wong, K. T., Don, Y., & Zain, F. M. (2019). Implementation of ICT policy (Blended Learning Approach): Investigating factors of behavioural intention and use behaviour. *International Journal of Instruction*, *12*(1), 767–782. https://doi.org/10.29333/iji.2019.12149a [Accessed: May 24, 2022].

[3] Sun, Y., & Gao, F. (2019). Exploring the roles of school leaders and teachers in a school-wide adoption of flipped classroom: School dynamics and institutional cultures. *British Journal of Educational Technology*, *50*(3), 1241–1259. https://doi.org/10.1111/bjet.12769 [Accessed: May 23, 2022].

[4] Abd Rahman, S. F., Md Yunus, M., & Hashim, H. (2021). Applying UTAUT in predicting ESL lecturers intention to use flipped learning. *Sustainability*, *13*(15), 8571. https://doi.org/10.3390/su13158571 [Accessed: June 23, 2022].

[5] Saad, N. S. M., Yunus, M. M., & Embi, M. A. (2013). The intersection between Out-of-Class language learning strategies and In-Class activities. *Advances in Language and Literary Studies*, *4*(2), 132–140. https://doi.org/10.7575/aiac.alls.v.4n.2p.132 [Accessed: May 23, 2022].

[6] Zainuddin, Z., & Perera, C. J. (2019). Exploring students' competence, autonomy and relatedness in the flipped classroom pedagogical model. *Journal of Further and Higher Education*, *43*(1), 115–126. https://doi.org/10.1080/0309877X.2017.1356916 [Accessed: May 23, 2022].

[7] Vockley, M. (2007). Maximizing the Impact: The Pivotal Role of Technology in a 21st Century Education System. *Partnership for 21st Century Skills*. https://eric.ed.gov/?id=ED519463 [Accessed: May 23, 2022].

[8] Alebrahim, F. H. (2016). *Implementation evaluation study: Flipped classroom professional development with faculty members to enhance students' engagement in higher education*. University of Northern Colorado. https://www.proquest.com/openview/c49ef77e6fbbe4ba4b24a5f3b643ab24/1?pq-origsite=gscholar&cbl=18750 [Accessed: June 23, 2022].

[9] Sun, Z., Lin, C. H., Wu, M., Zhou, J., & Luo, L. (2018). A tale of two communication tools: Discussion-forum and mobile instant-messaging apps in collaborative learning. *British Journal of Educational Technology*, *49*(2), 248–261. https://bera-journals.onlinelibrary.wiley.com/doi/pdf/10.1111/bjet.12571 [Accessed: May 23, 2022].

[10] Cagiltay, N. E. (2008). Using learning styles theory in engineering education. *European Journal of Engineering Education*, *33*(4), 415–424. https://doi.org/10.1080/03043790802253541 [Accessed: May 2, 2022].

[11] Kolb, D. A. (2007). *The Kolb Learning Style Inventory*. Boston, MA: Hay Resources Direct. https://www.researchgate.net/search.Search.html?query=Kolb%2C+D.+A.+%282007%29.+The+Kolb+learning+style+inventory.+Boston%2C+MA%3A+Hay+Resources+Direct&type=publication [Accessed: May 23, 2022].

[12] Lehman, M. E. (2011). Relationships of learning styles, grades, and instructional preferences. *Nacta Journal*, *55*(2), 40–45. https://www.jstor.org/stable/nactajournal.55.2.40 [Accessed: May 23, 2022].

[13] Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education*, *78*(7), 674–681. http://117.202.29.23:8080/jspui/handle/1/297 [Accessed: May 13, 2022].

[14] Jones, R. J., Muller, J., Haynes, D., & Schreiber, U. (2003). Effects of herbicides diuron and atrazine on corals of the Great Barrier Reef, Australia. *Marine Ecology Progress Series*, *251*, 153–167. https://doi.org/10.3354/meps251153 [Accessed: May 12, 2022].

[15] Adam, A. (2018). *Adaptive teaching system based on learning style* (Master's thesis, University of Piraeus). https://dione.lib.unipi.gr/xmlui/handle/unipi/11183 [Accessed: May 25, 2022].

[16] Curry, L. (1990). A critique of the research on learning styles. *Educational Leadership*, *48*(2), 50–56. https://www.academia.edu/search?q=Curry,%20L.%20(1990).%20A%20critique%20of%20the%20research%20on%20learning%20styles.%20Educational%20leadership,%2048(2),%2050-56 [Accessed: May 15, 2022].

[17] Fahy, P. J., & Ally, M. (2005). Student learning style and asynchronous computer-mediated conferencing (CMC) interaction. *The American Journal of Distance Education*, *19*(1), 5–22. https://www.tandfonline.com/doi/abs/10.1207/s15389286ajde1901_2 [Accessed: May 23, 2022].

[18] Johnson, G., & Johnson, J. (2006). *Learning style and preference for online learning support: Individual quizzes versus study groups* (pp. 1861–1868). Association for the Advancement of Computing in Education (AACE). https://files.eric.ed.gov/fulltext/ED493999.pdf [Accessed: May 23, 2022].

[19] Bishop, J., & Verleger, M. A. (2013, June). The flipped classroom: A survey of the research. In *2013 ASEE Annual Conference & Exposition* (pp. 23–1200). https://peer.asee.org/the-flipped-classroom-a-survey-of-the-research [Accessed: May 7, 2022].

[20] Chua, J. S. M., & Lateef, F. A. (2014). The flipped classroom: Viewpoints in Asian universities. *Education in Medicine Journal*, *6*(4). https://doi.org/10.5959/eimj.v6i4.316 [Accessed: May 2, 2022].

[21] Giannakos, M. N., Krogstie, J., & Chrisochoides, N. (2014, November). Reviewing the flipped classroom research: reflections for computer science education. In *Proceedings of the computer science education research conference* (pp. 23–29). https://doi.org/10.1145/2691352.2691354 [Accessed: May 2, 2022].

[22] O'Flaherty, J., Phillips, C., Karanicolas, S., Snelling, C., & Winning, T. (2015). "The use of flipped classrooms in higher education: A scoping review": Corrigendum. https://www.sciencedirect.com/science/article/pii/S109675161500038X?via%3Dihub [Accessed: May 2, 2022].

[23] Seery, M. K. (2015). Flipped learning in higher education chemistry: Emerging trends and potential directions. *Chemistry Education Research and Practice*, *16*(4), 758–768. https://pubs.rsc.org/en/content/articlehtml/2015/rp/c5rp00136f [Accessed: May 2, 2022].

[24] Zainuddin, Z., & Halili, S. H. (2016). Flipped classroom research and trends from different fields of study. *International Review of Research in Open and Distributed Learning*, *17*(3), 313–340. https://doi.org/10.19173/irrodl.v17i3.2274 [Accessed: May 2, 2022].

[25] Betihavas, V., Bridgman, H., Kornhaber, R., & Cross, M. (2016). The evidence for 'flipping out': A systematic review of the flipped classroom in nursing education. *Nurse Education Today*, *38*, 15–21. https://doi.org/10.1016/j.nedt.2015.12.010 [Accessed: May 2, 2022].

[26] Lo, C. K., & Hew, K. F. (2017). A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. *Research and Practice in Technology Enhanced Learning*, *12*(1), 1–22. https://telrp.springeropen.com/articles/10.1186/s41039-016-0044-2 [Accessed: May 22, 2022].

[27] Chen, Y., Wang, Y., & Chen, N. S. (2014). Is FLIP enough? Or should we use the FLIPPED model instead?. *Computers & Education*, *79*, 16–27. https://www.sciencedirect.com/science/article/abs/pii/S0360131514001559 [Accessed: May 2, 2022].

[28] Enfield, J. (2013). Looking at the impact of the flipped classroom model of instruction on undergraduate multimedia students at CSUN. *TechTrends*, *57*(6), 14–27. https://link.springer.com/article/10.1007/s11528-013-0698-1 [Accessed: May 2, 2022].

[29] Presti, C. R. (2016). The flipped learning approach in nursing education: A literature review. *Journal of Nursing Education*, *55*(5), 252–257. https://journals.healio.com/doi/abs/10.3928/01484834-20160414-03 [Accessed: May 23, 2022].

[30] Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. International society for technology in education. https://books.google.gr/books?hl=el&lr=&id=-YOZCgAAQBAJ&oi=fnd&pg=PR7&dq=Bergmann,+J.,+%26+Sams,+A.+(2012).+Flip+your+classroom:+Reach+every+student+in+every+class+every+day.+International+society+for+technology+in+education.&ots=AGhhJLlplj&sig=vDo-_wgJTk95FeL6MJQ0bbmoj88&redir_esc=y#v=onepage&q&f=false [Accessed: May 23, 2022].

[31] Marchisio, M., Barana, A., Fissore, C., & Pulvirenti, M. (2021, September). Digital education to foster the success of students in difficulty in line with the digital education action plan. In *EDEN Conference Proceedings* (No. 1, pp. 353–363). https://www.eden-online.org/proc-2485/index.php/PROC/article/download/1887/1595 [Accessed: May 23, 2022].

[32] Albareda-Tiana, S., García-González, E., Jiménez-Fontana, R., & Solís-Espallargas, C. (2019). Implementing pedagogical approaches for ESD in initial teacher training at Spanish universities. *Sustainability*, *11*(18), 4927. https://doi.org/10.3390/su11184927 [Accessed: May 23, 2022].

[33] Bojović, Ž., Bojović, P. D., Vujošević, D., & Šuh, J. (2020). Education in times of crisis: Rapid transition to distance learning. *Computer Applications in Engineering Education*, *28*(6), 1467–1489. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7461294/ [Accessed: May 6, 2022].

[34] Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of COVID-19 pandemic. *International Journal of Educational Research Open*, *1*, 100012. https://www.sciencedirect.com/science/article/pii/S2666374020300121 [Accessed: May 6, 2022].

[35] Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x [Accessed: May 6, 2022].

[36] Zucker, A. A. (2008). *Transforming schools with technology: How smart use of digital tools helps achieve six key education goals*. Harvard Education Press.

[37] Plageras, A., Kourtis, S., Xenakis, A. C., Kalovrektis, K., Psycharis, S., & Vavougios, D. (2020). Understanding ancient greek civilizations: A steam teaching perspective. *Hellenic Journal of STEM Education*, *1*(2), 45–57. https://doi.org/10.51724/hjstemed.v1i2.9 [Accessed: May 2, 2022].

[38] Mokhtar, R., & Karim, M. A. (2021). Exploring students behaviour in using google classroom during covid-19 pandemic: Unified Theory of Acceptance and Use of Technology (UTAUT). *Education*, *3*(8), 182–195. https://doi.org/10.35631/IJMOE.380015 [Accessed: May 2, 2022].

[39] Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 425–478. https://doi.org/10.2307/30036540 [Accessed: May 23, 2022].

[40] Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science*, *46*(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926 [Accessed: May 23, 2022].

[41] Bougie, R., & Sekaran, U. (2019). *Research Methods for Business: A Skill Building Approach*. John Wiley & Sons. https://books.google.gr/books?hl=el&lr=&id=ikI6EAAAQBAJ&oi=fnd&pg=PA21&dq=Bougie,+R.,+%26+Sekaran,+U.+(2019).+Research+methods+for+business:+A+skill+building+approach.+John+Wiley+%26+Sons.&ots=tfMYo8wKwj&sig=0rEL4M_1SLRAKHyt7wacT_ZTrPo&redir_esc=y#v=onepage&q=Bougie%2C%20R.%2C%20%26%20Sekaran%2C%20U.%20(2019).%20Research%20methods%20for%20business%3A%20A%20skill%20building%20approach.%20John%20Wiley%20%26%20Sons.&f=false [Accessed: May 23, 2022].

[42] Embi, M. A. (2018). Factors influencing polytechnic English as second language (ESL) learners' attitude and intention for using mobile learning. *The Asian ESP Journal*, 195. https://www.researchgate.net/publication/331272907_Factors_influencing_polytechnic_English_as_second_language_ESL_learners'_attitude_and_intention_for_using_mobile_learning [Accessed: May 23, 2022].

[43] Teo, T., & Van Schalk, P. (2009). Understanding technology acceptance in pre-service teachers: A structural-equation modeling approach. *Asia-Pacific Education Researcher*, *18*(1), 47–66. https://doi.org/10.3860/taper.v18i1.1035 [Accessed: May 2, 2022].

[44] Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educ. Res., 15*, 4–14. In Engels, F. (2018). Pharmacology education: Reflections and challenges. *European Journal of Pharmacology*, *833*, 392–395. https://www.sciencedirect.com/science/article/pii/S0014299918303625 [Accessed: May 2, 2022].

[45] van Schaik, P. (2009). Unified theory of acceptance and use for websites used by students in higher education. *Journal of Educational Computing Research*, *40*(2), 229–257. https://www.learntechlib.org/p/69272/ [Accessed: December 26, 2022]; https://doi.org/10.2190/EC.40.2.e

7 Authors

Antonios Plageras, PhD Cand., Department of Physics, University of Thessaly, Lamia, Greece.

Apostolos Xenakis, Assistant Professor, Department of Digital Systems, University of Thessaly, Larisa, Greece. E-mail: axenakis@uth.gr

Konstantinos Kalovrektis, Department of Computer Science and Telecommunications, University of Thessaly, Lamia, Greece. E-mail: kkalovr@uth.gr

Denis Vavougios, Professor, Department of Physics, University of Thessaly, Lamia, Greece. E-mail: dvavou@uth.gr

Article submitted 2022-09-24. Resubmitted 2022-11-13. Final acceptance 2022-11-14. Final version published as submitted by the authors.