Developing flipped classroom educational material in the Greek curriculum for Chemistry: Examples from 8th to 12th grade students

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Abstract
The present study aims to implement the flipped classroom teaching model in the Greek curriculum for chemistry from 8th to 12th grade students. Specifically, this involves designing and creating suitable educational material according to the flipped classroom methodology for targeted chemistry course units, which include laboratory exercises as well. The flipped classroom is a blended learning model, where students prepare by watching video lectures or other educational material at home, while homework is conducted in the classroom with the assistance of the teacher and students discussing and resolving questions. The teacher supports students exactly where they encounter difficulties, thus shifting their role from traditional lecturing to guiding, supporting, and individualizing.
Keywords
Learning science, flipped classroom, laboratory teaching

Introduction

The flipped classroom belongs to learning models, which focus on the student. In these models, the student actively and consciously participates in all stages of learning[1]. Additionally, it serves as a powerful catalyst, transforming the teacher into a guide in teaching rather than authority of knowledge and simultaneously transforming students into active learners who take on a more collective and self-directed role in the learning process[2].
Another advantage of the specific learning model allows the redistribution of time in class, facilitating the advancement of skills through collaborative work schemes and discussions. This, in turn, encourages students to teach and learn concepts from each other, always guided by teachers. Additionally, it enables students to actively participate in their own learning and to be proficient in mastering the knowledge they acquire[3]. It should also be emphasized that the flipped classroom is a blended learning model because it utilizes both face-to-face and distance learning methods[4].
In this study, a series of teaching interventions will be presented, which have been implemented by the undersigned during the academic years 2022-23 and 2023-24 at a specific Gymnasium and Lyceum school of Patras-Greece. These teaching interventions represent yet another way to share teaching tools that educators can use to enhance their instruction and strengthen their interaction with students in each area of study.

Theoretical Framework

Keypoints

21st-century students are often referred to as digital natives due to their familiarity with new technologies. According to McMahon and Pospisil (2005)[4], these students prefer learning environments that facilitate multitasking, collaborative activities, and social aspects of learning[5].

The flipped classroom represents an educational process where instruction shifts from group learning to individual, and the group space transforms into a dynamic, interactive learning environment where the educator guides students as they explore concepts and engage creatively with the subject matter. Therefore, education, especially in the field of Physical Sciences, plays a significant role as it follows the social constructivist approach, serving as a process of knowledge construction by students through individual and social processes[7]. The emphasis in teaching Physical Sciences should shift from one-way delivery of information through lectures to the construction of knowledge by the students themselves through collaborative activities in the classroom, with the teacher acting as a collaborator alongside the students[8].

In conventional teaching, classroom time is primarily devoted to the teacher presenting new knowledge, while students use their time at home to absorb and apply it through assigned tasks. Conversely, in the flipped classroom, students are tasked with studying and interacting with the content prior to class. Subsequently, during class, they are tasked with applying the knowledge through active approaches, with the teacher serving as a guide in their efforts. The flipped classroom allows students to focus on higher levels of thinking during class time, in accordance with Bloom's cognitive taxonomy (e.g., apply, analyze, evaluate, create), as lower levels (remember, understand) have already been addressed before class[9].

Literature Review

The flipped classroom model gained worldwide recognition through the efforts of Bergmann and Sams[10]. In their attempt to assist students who were unable to attend their classes, they recorded PowerPoint presentations and uploaded them as videos on YouTube, making them accessible to absent students. Tucker[11] states that the flipped classroom model is based on the idea that students can study and prepare at home by watching interactive videos related to the lesson. Then, during class time, students can solve problems, advance concepts, and actively participate in the educational process through collaborative learning (see figure 1).

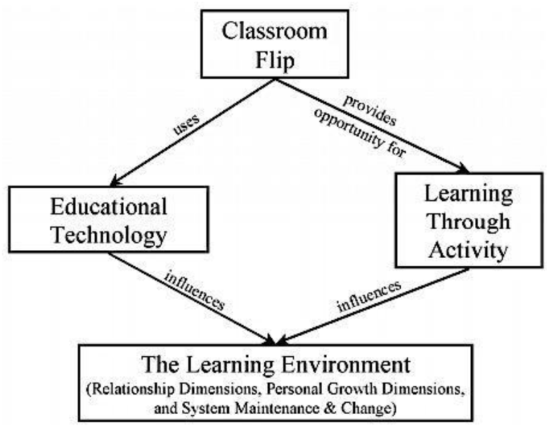

Figure 1: Theoretical framework of flipped classroom (taken from Strayer, 2007[30]).

The flipped classroom model appeared to empower students to interact with educational content at their own pace, place, and time, taking responsibility for their learning and gaining greater autonomy and self-confidence[12]. Additionally, the implementation of active learning educational techniques such as discussions, problem-solving, case studies, etc., during classroom sessions allowed students to achieve deeper understanding, cultivate critical thinking, and attain higher academic performance. Furthermore, active student engagement in the learning process was observed[13], while collaborative approaches provided opportunities for students to interact, fostering communication and collaboration skills[14].The role of the teacher also appeared to change, transitioning to that of a facilitator helping students overcome challenges encountered during the knowledge-building process[15].

Methodology

Today, flipped classroom is implemented worldwide, across all levels of education and in various academic subjects (such as Physical Sciences, Mathematics, Humanities, and Social Sciences, etc.). Technology has enabled students to have easy access to digital media, particularly videos, through the internet. This has facilitated the online teaching of educational material in a remote setting, thereby enabling more interactive student participation during in class sessions. Moreover, especially in Greek educational community several educational videos that are been created for in class use usually replace the laboratory process. With the specific procedure that is been described below the provided video are being processed (with the website administrator's permission) in such a way that students interact with the provided material rather than being passive recipients of information[2].
Although the implementation of the flipped classroom model may vary under different circumstances, it always relies on the following four pillars: a flexible environment, a learning culture, intentional content, and the professionalism of educators[16].

In the flipped classroom methodology, we can identify three main stages: the pre-class stage, the in-class stage and a third stage, after the class, which help students benefit more from the activities conducted in class as they can reflect on and consolidate their knowledge[17]. During the pre-class stage, students engage with the content through video lectures, podcasts, and other digital materials prepared by the educator and made available on a digital learning platform. This allows each student to interact with the content according to their own learning style, pace, and preferred time and place[18]. Additionally, educators can use online assessments to identify students' prior knowledge and conduct an initial assessment of their understanding of the content, thus planning their next steps for the in-class stage accordingly[19]. It's worth noting that this initial engagement of students with the content focuses more on the lower levels of Bloom's taxonomy of cognitive objectives (remembering, understanding)[20]. Sharing content, aside from equipment (computers, tablets, etc.), requires a digital learning platform (Learning Management System) where course content is posted, access to the internet for students, and digital skills for interaction[21].

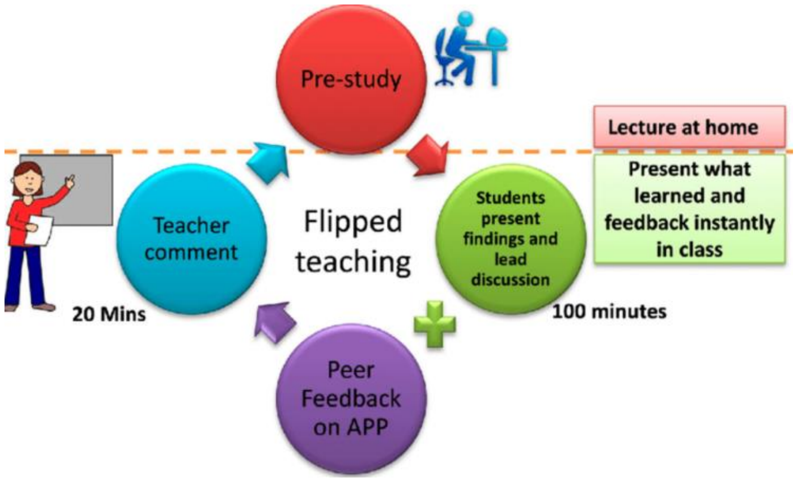

Figure 2: Stages of flipped classroom methodology (taken from Hsu, Ting, 2017[31])

Learning management Systems (L.M.S)

Learning Management Systems (LMS) play a crucial role in facilitating the implementation of the flipped classroom model. An LMS enables the seamless sharing of educational content, including instructional videos, assessment quizzes, documents, and more. It provides educators with the means to upload materials and interact with students, while also allowing learners to access and engage with the content. Key features of an LMS include:

1. Content Sharing: Educators can upload multimedia resources, documents, and assignments for students to access.
2. Communication: LMS platforms facilitate communication between educators and students through direct messaging, email, and discussion forums.
3. Collaboration: Students can collaborate on projects, share ideas, and co-create content through features like wikis and group discussions.
4. Assessment: LMS systems support both formative and summative assessment methods, allowing educators to track student progress and evaluate learning outcomes.
5. Grading and Feedback: Educators can grade assignments, provide feedback, and monitor student performance using the built-in grading tools.
6. Organization: LMS platforms offer organizational tools for structuring content into units or modules, making it easy for students to navigate.

Overall, Learning Management Systems provide a comprehensive environment for teaching and learning, facilitating interaction, collaboration, assessment, and monitoring of student progress. They offer a range of features to support educators in delivering content and engaging students effectively in both traditional and flipped classroom settings.
In this study, some of the available Learning Management Systems were utilized, such as LAMS AI, e-me, and e-platform (exclusively for the students of the specific schools). These systems assist educators worldwide in designing and implementing online educational activities.

Purpose and Research

While an extensive body of research exists regarding theoretical framework in Greek literature[22] as well as several flipped based approaches in primary education[23] research highlighted the necessity of a series of teaching interventions in the educational field of Chemistry for the secondary education in Greece that will be used in future research as a guide to the impact of a teaching intervention that is based on the flipped classroom. Thus, the learning outcomes of these teaching interventions can be contrasted with the learning outcomes of teaching interventions that are based on the school science textbook used by Greek schools (traditional teacher-centered approach to flipped science learning).

Educational Material Implementation

For the needs of the teaching interventions that follow, planning and creation of educational material were carried out for 8th to 12th grade students in the conceptual areas of Chemistry that follow.

Example for 8th grade students

Conceptual Area: Preparation of a Solution with a specific %w/w concentration
Learning Management System: “e-platform”[28]
Number of participated students: Twenty-two (22)
Teaching Procedure:
Before Class: Students access the digital classroom on the e-platform from their homes using their login credentials, where specific materials and videos from the internet are posted. Then, they complete the provided worksheet questions and submit their answers.
During Class: Students work in groups to conduct the experiment proposed in their school textbook, under the guidance and supervision of the educator. In this case, the experiment titled "Preparation of a solution with a specific % w/w concentration" was implemented.
After Class: After completing the experiment at home, students return to the e-platform. They answer two additional exercises for reinforcement and then respond to a questionnaire or survey.

Example for 9th grade students

Conceptual Area: Neutralization – Salts
Learning Management System: "e- platform"
Number of participated students: Twenty-three (23)
Teaching Procedure:
Before Class: Students access the digital classroom on the e-platform from their homes using their login credentials, where specific materials and videos from the internet are posted. Specifically, they watch a video titled "Successive neutralizations of acid solution with base using indicator." Then, they complete the provided worksheet questions and submit their answers. For the purpose of the specific paper a screenshot of the procedure is being presented on figure 3.

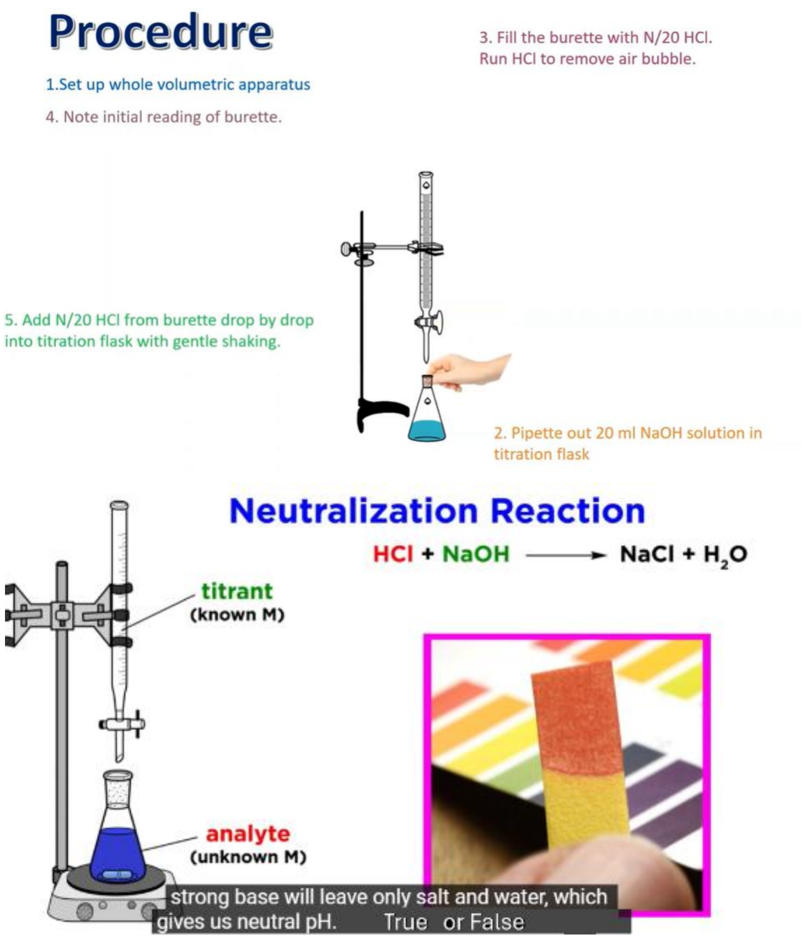

Figure 3: Attachment from the material distributed to students before class

During Class: Students work in groups to conduct the experiment proposed in their school textbook, under the guidance and supervision of the educator. In this case, the experiment titled "Neutralization of hydrochloric solution from sodium hydroxide solution and preparation of sodium chloride" was implemented. In this particular case, students worked without the usual time pressure (due to the analytical Greek curriculum, chemistry is taught only for 1 hour per week), while the educator has the opportunity to delve into ion equations for salt formation.

After Class: After completing the experiment at home, students return to the e-platform. They answer two additional exercises for reinforcement and then respond to a questionnaire or survey.

Example for 10th grade students

Conceptual Area: Preparation of a Solution of Defined Concentration
Learning Management System: “e-me” electronic platform[27]
Number of participated students: Sixteen (16)
Teaching Procedure:
Before Class: Students access their private cell on the e-me platform from their homes using their login credentials, where specific materials and videos from the internet are posted. Specifically, they watch a video titled "Preparation of copper sulfate solution of defined concentration." Then, they complete the provided worksheet questions and submit their answers. For the purpose of the specific paper a screenshot of the procedure is being presented on figure 4.

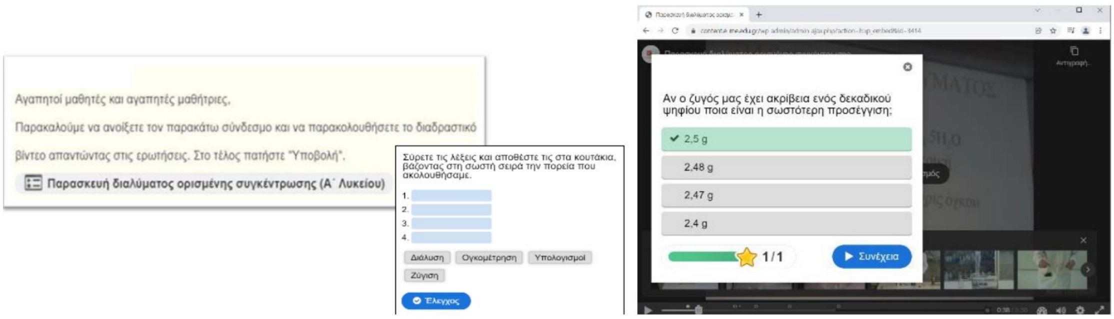

Figure 4: Attachment from the material distributed to students before class[24]

Firstly, the administrator explains the purpose of the educational material and asks from the students to view carefully the provided video and answer questions concerning the experiment like the one on figure 1 and translated below:
“If the scale has an accuracy of one decimal place, which of the following options is the most correct based on the video you watched”
During Class: Students work in groups to perform the experiment suggested in their laboratory guide under the guidance and supervision of the educator. In this case, the experiment titled "Preparation of a Solution of Defined Concentration" was implemented. The students worked more autonomously, with ample time, solving questions, remaining alert, and confident about what they were doing. They had time to discuss alternative ideas on how to conduct the experiment differently. They had time to improvise with successive dilutions, while the educator had the opportunity to delve deeper into the concepts of dilution and mixing solutions of the same substance.
After Class: The third part is digital, adapted for distance learning and includes a survey for evaluating the learning process and self-assessment activities. For the specific paper a screenshot of the procedure is being presented on figure 5.

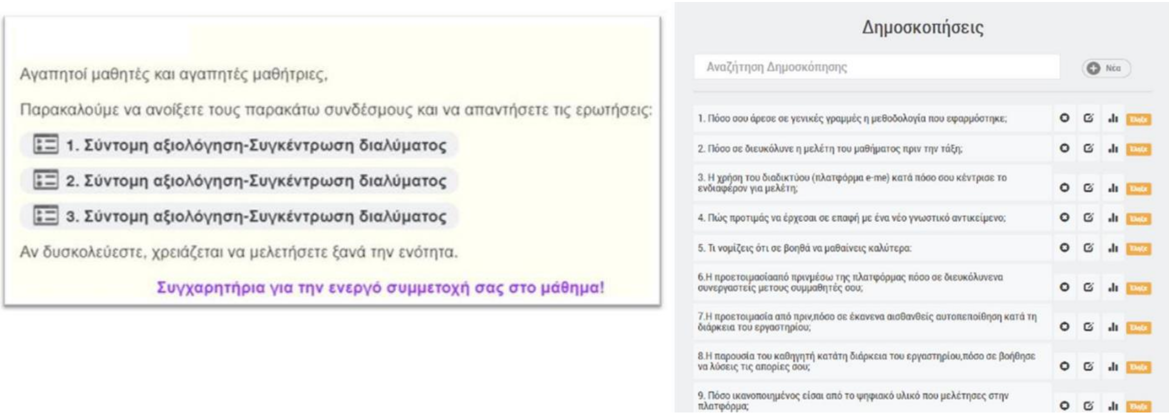

Figure 5: Attachment from the material distributed to students after class

More specific the administrator asks the students to open the provided links and complete the questions on a scale from 1 (Not at all) to 4 (Very much).
A few of the questions are been translated below:
"1. How much did you like the methodology that was followed?
6.How much did the prior preparation through the platform help you collaborate with your classmates?
9. How satisfied are you with the digital material you studied on the platform?"

Example for 11th grade students

Conceptual Area: Catalytic converters
Learning Management System: "e- platform"[28]
Number of participated students: Eighteen (18)
Teaching Procedure:
Before Class: Students, before the lesson, either from home or in the school computer lab (in-class flip scenario), log in with their personal codes to the digital classroom of the e-platform, where specific material and a video from the internet titled "How does a catalyst work?" are posted. They then complete the questions on the provided worksheet and submit their answers. For the specific paper a screenshot of the procedure is being presented on figure 6.

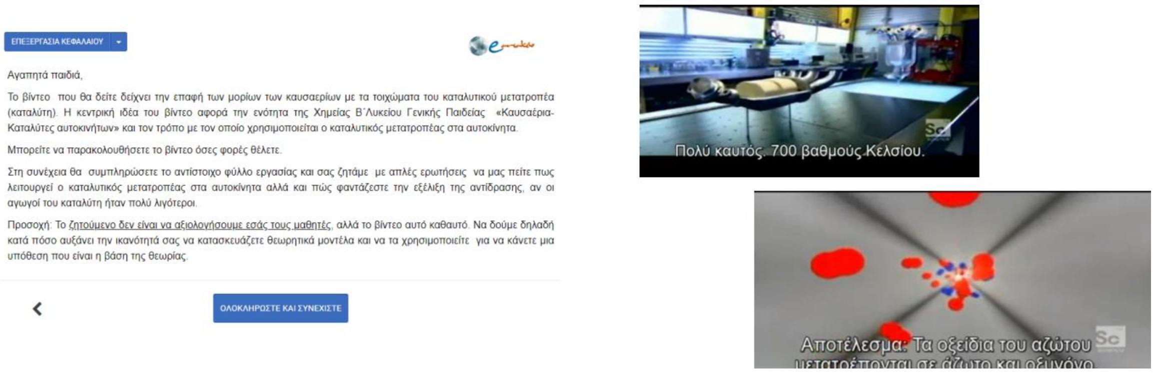

Figure 6: Attachment from the material distributed to students before class[25]

Firstly, the administrator explains the purpose of the educational material and asks from the students to view carefully the provided video on figure 3. A part of the provided paragraph is being translated below:
"The aim is not to be evaluated, but to understand the use of a catalytic converter in cars"
Then students answer questions concerning the experiment like the one translated below (from the original Greek version) on figure 7:

Catalytic Converters
Part 1

A. Try to answer the following questions:

1. Which of the gases emitted by cars are toxic?

   ....
   ....
   ....

2. Where is the car's catalytic converter located?

   ....

3. Inside the catalytic converter, there is a porous material divided into two blocks. In the first one, there are the chemical elements .... and .... while in the second one .... and ....

Figure 7: Attachment from the material distributed to students before class[25]

In-Class: The second part takes place in the classroom and involves printed material supporting active student participation within the class structure and efficient use of teaching time according to the Chemistry II High School teaching guidelines for the school year 2022-23[29].

After Class: The third part is also digital, adapted for distance learning and includes practice and self-assessment activities, where students are informed of the results of the learning process. The teacher supports students precisely where they face difficulties, shifting their role from traditional lecturing to guiding, supporting, and personalizing. For the specific paper a screenshot of the procedure is being presented on figure 8.

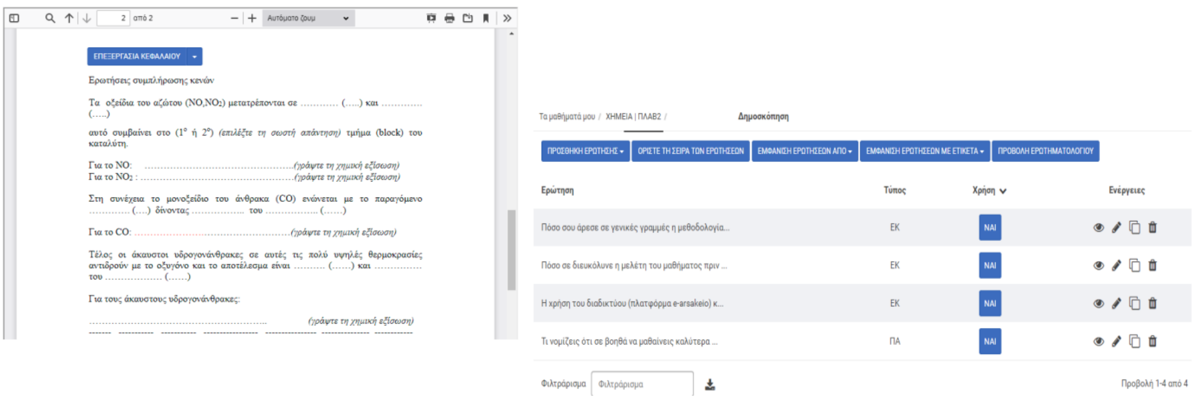

Figure 8: Attachment from the material distributed to students after class

More specific the administrator provides to students a digital working sheet showed on figure 5 (left side) for having feedback concerning the knowledge that students gained for the specific conceptual area and then asks the students to open the provided link and complete the survey on a scale from 1 (Not at all) to 4 (Very much).

A few of the questions showed on figure 5 (right side) are been translated below:
"1. How much did you like the methodology that was followed?
6.How much did the prior preparation through the platform help you collaborate with your classmates?
9. How satisfied are you with the digital material you studied on the platform?"

Example for 12th grade students

Conceptual Area: Acid-Base Titration (Acidimetry-Alkalimetry)
Learning Management System: e-platform – LAMS AI
It's a user-friendly and visually appealing environment for designing, managing delivery, and executing sequences of learning activities, essentially an electronic teaching and learning environment. The new generation of LAMS systems utilizes artificial intelligence and is called LAMS AI[26] (similarly to CHAT GpT).
Number of participated students: Fourteen (14)
Teaching Procedure:
Following the diagram below (figure 9) the lams procedure is been presented as a graph. Then the full procedure is been described.

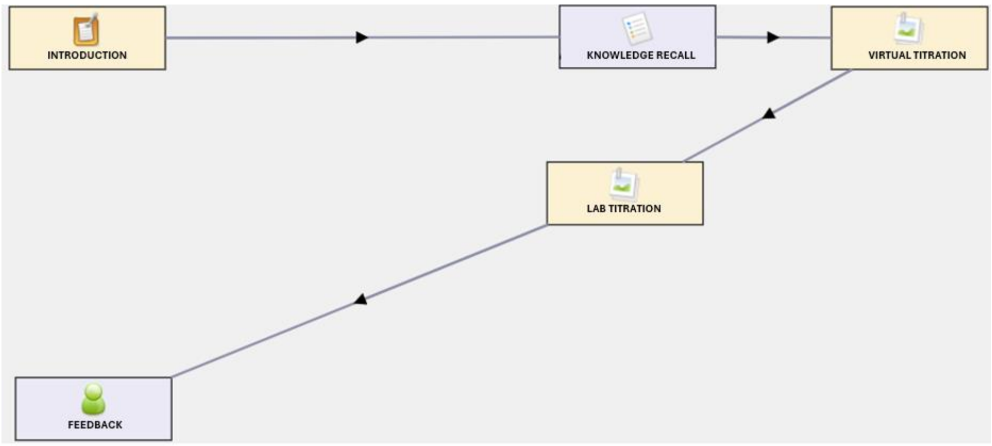

Figure 9: LAMS Diagram of Titration

Before Class: Students, prior to conducting the laboratory exercise, either from home or in the school computer lab (in-class flip scenario), log in with their codes to the digital classroom of the e-platform, where specific material and a video from the internet titled "Determination of the acetic acid content in vinegar" are posted (Alkalimetry). They then complete the questions on the provided worksheet and submit their answers (see figure 10 below).

Figure 10: In class flip scenario for 11th or 12th grade students

In-Class: The second part takes place in the laboratory and involves determining the %w/w concentration of sodium hydroxide from a standard hydrochloric acid solution (Acidimetry). The teacher supports students precisely where they face difficulties. The teacher's role shifts from traditional lecturing to guiding, supporting, and personalizing (see figure 11 below).

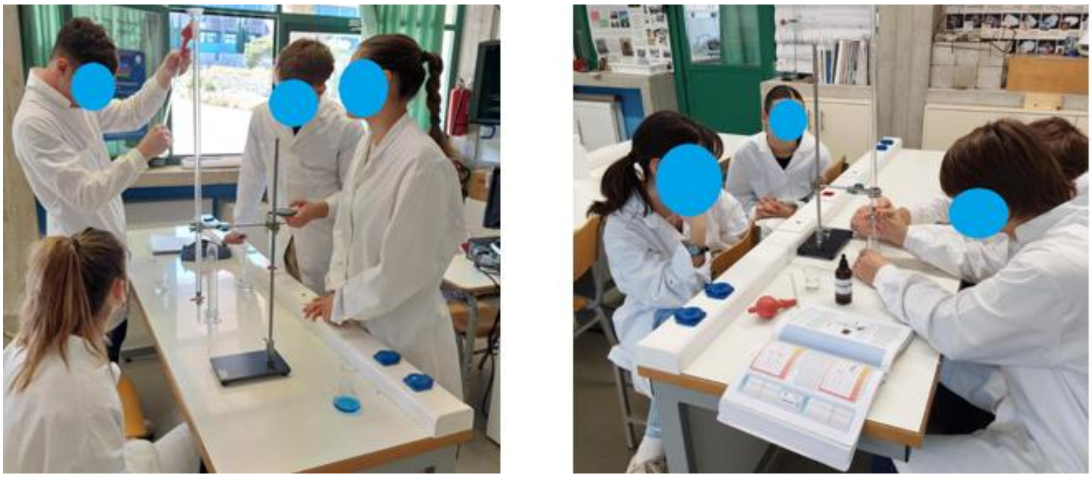

Figure 11: In class laboratory scenario for 12th grade students

After Class: The third part is also digital, adapted for in-class study, and includes practice and self-assessment activities, where students are informed of the results of the learning process.

Discussion and conclusions

From the analysis of the questionnaires for the assessment of the entire process, it was found that there are advantages as well as disadvantages mentioned in the sentences below:
Among the advantages of the method, standout are better time management and greater acceptance and engagement of students during the implementation of the laboratory exercise within the classroom. The teacher supports students precisely where they face difficulty (Teacher's role shifts from traditional lecturing to guidance, support, and personalization) Students are encouraged to invest their study time from

their own space, at their desired pace and rhythm, autonomously, away from the classroom to some extent achieving lower levels of knowledge and understanding on their own.
There are also points highlight significant aspects of the digital learning landscape. Unequal access to technology underscores disparities in educational opportunities, potentially widening the gap between students with and without access to digital resources. Increased study time at home reflects a shift in learning dynamics, where students are expected to engage more independently outside traditional classroom settings. Similarly, educators face the challenge of allocating additional time to prepare digital materials, adapting teaching strategies to online platforms. Ensuring the quality and reliability of digital materials becomes paramount, as their effectiveness directly influences the learning experience. Addressing these concerns is crucial for fostering equitable access to education and optimizing digital learning environments for all students.

Suggestions for future research

After recording the educational material and teaching interventions of this study, the suggestions for conducting future research in the specific conceptual areas follow:
α) The learning outcomes of this teaching intervention should be contrasted with the learning outcomes of a teaching intervention based on the instructional material of the school textbook that is used in all Greek middle schools.
b) In order to investigate whether the learning outcomes remain unchanged over time, it is proposed to implement a research study using the same teaching material and assessing the learning outcomes not only before and immediately after the teaching intervention, but also several months afterwards.
c) Carry out the same research on a larger sample of students of similar age and in General High Schools from different regions of Greece, to explore whether the learning outcomes can be generalized.

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References

1. Kiriazis, A. & Bakoyiannis, S. (2003). New Technologies in Education. Coexistence of Teaching Practice and Technology, Athens: Self edition, [In Greek].
2. Mascolo, M. F. (2009). Beyond student-centered and teacher-centered pedagogy: Teaching and learning as guided participation. Pedagogy and the human sciences, 1(1), 3-27.
3.Acedo, M. (2013) 10 Pros And Cons Of A Flipped Classroom. Link: http://www.teachthought.com/trends/10-proscons-flipped-classroom, Accessed [15th June 2024], [In Greek].
4.Young, A. H., Gallagher, P., & Porter, R. J. (2002). Elevation of the cortisol-dehydroepiandrosterone ratio in drug-free depressed patients. *American Journal of Psychiatry*, *159*(7), 1237-1239.
5. McMahon, M., & Pospisil, R. (2005). Laptops for a digital lifestyle: Millennial students and wireless mobile technologies. *Proceedings of the Australasian Society for Computers in Learning in Tertiary Education*, *2*, 421-431.
6. Roehl, A., Reddy, S. L., & Shannon, G. J. (2013). The flipped classroom: An opportunity to engage millennial students through active learning strategies. *Journal of Family and Consumer Sciences*, *105*(2), 44.
7. Driver, R., Asoko, H., Leach, J., Scott, P., & Mortimer, E. (1994). Constructing scientific knowledge in the classroom. *Educational researcher*, *23*(7), 5-12.
8. King, A. (1993). From sage on the stage to guide on the side. *College teaching*, *41*(1), 30-35.
9. Gilboy, M. B., Heinerichs, S., & Pazzaglia, G. (2015). Enhancing student engagement using the flipped classroom. *Journal of nutrition education and behavior*, *47*(1), 109-114.
10. Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. International society for technology in education.
11. Tucker, B. (2012). The flipped classroom: Online instruction at home frees class time for learning. *Education next*, *12*(1), 82-84.
12,22. Gariou, A. (2015). Investigation of the application of the "flipped classroom" model as a supplementary method of distance education in secondary education - Action Research. Diploma thesis, HOU. [Online] Available at: https://apothesis.eap.gr/handle/repo/29904, Accessed [15th June 2024], [In Greek].
13. Gariou, A., Makrodimos, N., Papadakis, S. (2021). Flipped Classroom: A blended learning model for all levels of education. Patras 2021, Gotsis. [Online] Available at: http://www.gotsis.net.gr/book.php?id=60dce8cf3a5d2 , Accessed [15th June 2024], [In Greek].
14. Pange, J. (2022). Online Student-to-Student Interaction: Is It Feasible? In *Innovations in Learning and Technology for the Workplace and Higher Education: Proceedings of 'The Learning Ideas Conference'2021* (pp. 250-256). Springer International Publishing. [In Greek]
15,18,19. Bishop, J., & Verleger, M. A. (2013, June). The flipped classroom: A survey of the research. In *2013 ASEE annual conference & exposition* (pp. 23-1200).
16, 23. Makrodimos, N., Papadakis, S., & Koutsouba, M. “Flipped classroom” in primary schools: a Greek case «Α α η η» η ό η ό ί, [In Greek].

17. Abeysekera, L., & Dawson, P. (2015). Motivation and cognitive load in the flipped classroom: definition, rationale and a call for research. *Higher education research & development*, *34*(1), 1-14.
20,21. Gilboy, M. B., Heinerichs, S., & Pazzaglia, G. (2015). Enhancing student engagement using the flipped classroom. *Journal of nutrition education and behavior*, *47*(1), 109-114.
24. Giannakopoulos, N., Gariou, A. (2019). Production and evaluation of educational material for "Solution Concentration" using the e-me platform of the Digital School. [Online] Available at: https://www.researchgate.net/publication/332781941_Paragoge_kai_axiologese_ekpaideutikou_ylikou_gia_te_Synkentrose_dialymatos_me_axiopoiese_tes_platphormas_e-me_tou_Psephiakou_scholeiou , Accessed [15th June, 2024]. [In Greek]
25. PEKES Western Greece. (2022). Scientific Symposium on Flipped Classroom. [Online] Available at: https://blogs.sch.gr/pekesde/archives/2683#prettyPhoto Accessed [15th June, 2024], [In Greek].
26. Papadakis, S. (2022). Webinar Innovation in Education: "Flipped Classroom" [Online] Available at: https://blogs.sch.gr/pekesde/archives/3280, Accessed [15th June, 2024].
27. e-me User Manual: https://e-me.edu.gr/s/eme/main/manual.html#e-me-hives Accessed [15th June, 2024], [In Greek].
28. e-arsakeio User Manual: https://www.e-arsakeio.gr/start [Online] Available at: http://events.di.ionio.gr/cie/imaes/documents21/CIE2021_OnLineProceedings/31CIE2021_Lampo_Final_P%20361-376.pdf, Accessed [15th June, 2024], [In Greek].
29. Chemistry teaching instructions for second grade of General High School for the school year 2023-24 https://iep.edu.gr/el/graf-b-yliko-2023-2024/geniko-lykeio-2023-2024 , Accessed [16th June, 2024], [In Greek].
30. Strayer, J. F. (2007). The effect of the classroom flip on the learning environment: A comparison of learning activity in a traditional classroom and a flip classroom that used an intelligent tutoring system. Ph.D. Thesis, Columbus, OH: Ohio State University.
31. Hsu, Ting. (2017). Behavioral sequential analysis of using an instant response application to enhance peer interactions in a flipped classroom. Interactive Learning Environments. 26. 1-15. 10.1080/10494820.2017.1283332.