FLIPPED CLASSROOM AND TRADITIONAL METHOD IN TEACHING MATHEMATICS IN BULGARIAN SCHOOL

Assoc. Prof. Dr. Evgeniya Nikolova
Burgas Free University (Bulgaria)
Institute of Mathematics and Informatics – Bulgarian Academy of Sciences

Abstract. Flipped learning is an educational technique in which students engage with instructional materials outside of class (such as films, texts, or interactive tutorials) while using class time for active learning tasks such as problem-solving, group work, and discussions. Flipped learning can be a particularly effective strategy in the context of school-based mathematics education. By allowing for greater differentiation, engagement, and interactivity, it can help to support the learning needs of all students and promote deeper understanding of mathematical concepts. This article looks at some key aspects of the implementation of the flipped classroom in mathematics education and suggests a possibility for its combination with the traditional model of mathematics education in Bulgarian schools to achieve more efficient and effective learning.

Keywords: flipped classroom; traditional classroom learning; blended learning; mathematics education

1. Introduction

A flipped classroom, first proposed in 2007, was the first to be employed by two teachers, Jonathan Bergmann and Aaron Sams (Bergmann & Sams 2009). They used this method in their math classrooms, providing students with video lectures in advance and using class time for problem solving and individual study. The flipped classroom concept aims to change the traditional model of learning in which the teacher introduces new content to students in class and students complete work at home. Instead, students can access and study pre-recorded lectures or materials before class. The teacher becomes more involved in the classroom, supporting students in comprehending and applying knowledge, facilitating group discussions, problem solving, and providing individual assistance. The pre-lesson video assisted students in better understanding the content with sample tasks and provided additional opportunities for interaction with their teacher in class. Because of the flipped classroom format, students who need more time to grasp key ideas can catch up on learning when and where they want. This learning model aims to change students from passive listeners to active participants in the educational process and provide

greater individualization and support. Since then, the idea of a flipped classroom has been developed and implemented in many schools and educational institutions around the world.

In many studies, the value of technology in education and, more particularly, how technological programs should be used to help pupils grasp mathematics have been determined. Students that participated in flipped learning were shown to be more productive (Birgili & Demir 2022); (Sablan & Prudente 2022). This training improves student engagement (Cevikbas et al. 2022), motivation (Rodriguez et al. 2018), and self-control (Sun et al. 2017), while also delivering a more individualized learning experience (Toivola et al. 2022). It promotes improved student autonomy (Alajlan 2022) and course satisfaction (Kim et al. 2021). Teachers frequently use flipped learning to promote student collaboration (Trust et al. 2018), creative thinking (Hsia et al. 2021); (Sya'Roni et al. 2020), problem-solving (Rachmawati et al. 2018), and soft skills. In addition to the advantages outlined above, flipped learning has been shown to reduce students' anxiety about mathematics (Marshall et al. 2017). According to various studies (Haavold 2019), students in flipped classrooms improve in math knowledge and change in math ideas more than students in traditional classes. Although the flipped classroom approach significantly improves students' mathematics learning outcomes, an experiment conducted in 2020 by Xuefeng Wei and his colleagues (Wei et al. 2020) revealed that it was more beneficial to students at an intermediate level of math than those at a high or low level. In 2021, in (Fornons et al. 2021) was shown how students perceive the flipped classroom based on their learning style. According to their findings, students with a theoretical learning style rated the use of this technique more positively, whereas students with a reflective learning style rated it the least positively. The idea that the flipped classroom can improve student learning results when compared to traditional classrooms is still being explored.

The flipped classroom can be particularly useful in mathematics education, where understanding concepts and mastering skills require hands-on work and application. Although the application of this approach is not yet widespread in all schools and classes in Bulgaria, there are teachers who actively use it and prove its positive results. As an example, the implementation of a mirror classroom and formative assessment through the use of programs from the Google G Suite educational package in a Plovdiv school can be cited (Garov & Tzarev 2020).

Based on previous research on the concept of the flipped classroom, this article seeks to spark the interest of mathematics teachers in this concept and its implementation. In Section 2, attention is focused on the problem of how flipped learning can be applied in mathematics classes, and several recommendations and tools for its implementation are given. In Section 3, a hybrid strategy (flipped classroom and traditional model) is presented.

2. The flipped classroom in school mathematics learning

The key to implementing flipped learning in mathematics education is to discover an approach that works best for the individual needs and goals of the students and the learning environment. Here's an example of a flipped class for Probability. *Pre-class instruction*: Assign pupils to watch a pre-recorded film that introduces probability, its ideas, and applications. Other teaching elements, such as texts or interactive simulations, can be included. *Group work in class:* Divide students into groups and assign them to work on probability problems in class. You can assign a range of problems with varied levels of complexity to each group. In a math flipped classroom, *post-class activities* are crucial for reinforcing learning and ensuring that students can master the concepts covered in class. *Peer-to-peer learning*: Encourage students to learn from one another by having them share their problem-solving strategies and work together to find solutions. You can provide guidance and feedback as needed and help students who are struggling. *Interactive discussions*: Facilitate an interactive discussion on probability topics, such as sample space, events, and the rules of probability. Use this opportunity to clarify any misunderstandings or misconceptions that students may have. *Assessment:* Formative assessments, quizzes, and projects can be used to assess student learning and ensure that they have a thorough comprehension of the ideas. Although the fundamental approach for designing a flipped classroom for different topics may be similar, the precise instructions and exercises for each topic may differ depending on the nature of the topic, the level of the students, and the learning goals.

When compared to traditional instruction, the flipped classroom could improve understanding of mathematical subject matter and motivation to study this topic in a variety of ways. *Active learning*: The flipped classroom emphasizes active learning by having students engage with the material before going to class. This can lead to a deeper comprehension of mathematical ideas because students can take more time to assimilate the content and ask questions when they don't understand. *Personalized learning*: The flipped classroom paradigm provides for more individualized learning because students can work through the subject at their own pace and have access to supplementary resources as needed. *Engagement*: Math can be made more entertaining for students by incorporating technology and interactive in-class activities. Students may be more motivated to learn and engaged in the subject matter if they have opportunities for hands-on learning, teamwork, and problem-solving. *Feedback and support*: The flipped classroom concept frequently includes more regular feedback and support for students, namely: individual feedback from the instructor, group feedback and peer assessment, and self-assessment. Additionally, online platforms, portfolios, and class discussions are utilized to offer timely feedback and support students' learning journey. Students may be more motivated to enhance their comprehension of the subject matter if they receive quick feedback on their work and have access to extra resources.

However, the success of the flipped classroom depends on effective implementation and the use of appropriate resources and activities. Flipped mathematics class-

room practice related to design features and elements suggests (Fung et al. 2021): maintaining the same level of course load when converting a traditional lecture course to a flipped one; reviewing in class to ensure students are ready to tackle more complex tasks; engaging students in solving a number of tasks with peer support; allowing students to evaluate the usefulness of course materials by using real-world mathematical problems; and using class time to review.

In addition to the advantages of using the flipped classroom method in mathematics education, potential disadvantages must also be considered. *Lack of access to technology*: To participate in flipped classroom-based learning, students must have access to technology such as computers, tablets, or mobile phones, which can lead to a digital divide. *Self-directed learning*: Flipped learning necessitates students being self-disciplined and self-organized, which may be challenging for some. *Limited face-to-face instruction*: Flipped learning may reduce the amount of face-to-face instruction time, which can be a disadvantage for students who benefit from in-person interaction with their teachers and peers. *Teacher workload*: Flipped learning requires teachers to create and curate instructional materials, which can be time-consuming and require a significant amount of planning and preparation. *Lack of engagement*: Flipped learning may not be effective for all students, as some may struggle with the self-paced and independent nature of the approach or may not find the instructional materials engaging or interactive enough to hold their interest. *Dependence on technology*: Flipped learning relies heavily on technology, which can be subject to technical issues, such as slow internet connections or website outages, that can disrupt the learning experience.

A blended learning approach that blends flipped classroom and traditional classroom approaches can be an effective way to provide students with a choice of learning experiences that cater to varied learning styles and preferences. Here are a few ideas for combining flipped and traditional classroom methods: *use flipped learning for pre-class instruction; incorporate technology into traditional classroom activities; combine flipped and traditional approaches in a single class session; use traditional teaching methods to enhance flipped learning; incorporate evaluations to assess student learning*. This method can provide students with a variety of learning experiences that are tailored to their individual learning styles and preferences, while also promoting greater understanding and retention of the information. You may build a more flexible and individualized learning environment that suits the requirements of all students by combining flipped and traditional teaching approaches. As a result, some of the flipped classroom's potential drawbacks are alleviated, as it gives a more balanced approach to teaching and learning that incorporates the benefits of both online and face-to-face instruction.

Blended learning and flipped classroom models can be effectively used in the teaching of mathematics in Bulgarian schools and this can be realized in several ways: *developing a library of online resources*, *using flipped learning for pre-class instruction*, *introducing interactive technology*, *encouraging peer collaboration*,

personalizing learning, and *using assessments to measure learning*. By incorporating online resources, interactive technology, and personalized learning tools, teachers can provide students with a more flexible and tailored learning experience that meets their individual needs and preferences. Some examples of educational sites and online tools that can be used in math education in schools are: Ucha.se[1], Khan Academy[2], Mathletics[3], IXL[4], GeoGebra[5], and Desmos[6].

Preparing math topics for blended learning, including flipping and traditional methods, requires careful planning and preparation. The basic steps that teachers can take to prepare on their own are: 1. By *defining clear learning objectives*, you can design your lesson plans around specific outcomes and ensure that your students are making progress toward their goals. 2. *Identify instructional materials* might include textbooks, online resources, videos, or other materials that you have created or found. By identifying the instructional materials that you will use, you can ensure that you have everything you need to teach your lesson effectively. 3. *Design activities and assessments* might include problem sets, quizzes, group projects, or other activities that engage your students and encourage them to apply what they have learned. 4. Depending on your teaching style and your students' needs, you may choose to deliver your lessons through *a combination of flipped and traditional methods*. Plan out how you will deliver each part of the lesson, whether it be through pre-recorded videos or in-class lectures and discussions. Be sure to consider how you will engage students who may be absent or have different learning needs. 5. Finally, it is important to *test your approach and adjust* as needed. This might involve gathering feedback from your students, reviewing assessment results, or reflecting on your own teaching practice.

When preparing video lessons, mathematics teachers would do well to follow some recommendations, such as: *Keep the video length appropriate; Use visual aids and examples; Use a conversational tone; Provide clear and concise explanations; Provide practice problems; Make the video visually appealing; Use appropriate technology and tools*. As a rule, aim for videos that are no longer than 10 – 15 minutes. Visual aids such as diagrams, graphs, and animations can help to illustrate mathematical concepts and make them easier to understand. Speaking in a conversational tone can help to make the video feel more engaging and accessible to students. Use simple language and provide step-by-step explanations that are easy to follow. At the end of the video, provide students with practice problems that allow them to apply the concepts they have learned. A visually appealing video can help to hold students' attention and increase their motivation to learn. There are many tools available that can help to create engaging and interactive videos, such as screen-casting software, video editing software, and interactive whiteboards. A few popular options you might consider are: ScreenPal[7], Camtasia[8], OBS Studio[9], and Loom[10].

3. Blended learning, including flipping and traditional methods, in math education in Bulgaria

Bulgarian mathematics teachers face several difficulties in their work, such as the diversity of the knowledge levels of the students in the class, large classes, and limited teaching time. In most cases, there are students in the classes with different levels of mathematical knowledge and skills. This can make it difficult for teachers to meet the needs of all students and support their development within the traditional classroom format. Class sizes that are excessively large may limit the individual attention that teachers can provide to each student. As a result, students with greater difficulties may fall behind. Teachers struggle with limited time to teach the material and reach all students. In the traditional classroom format, they often lack time for revision and in-depth discussion of difficult issues.

Blended learning, combining elements of a flipped classroom and the traditional method, can be recommended for mathematics education in Bulgaria for several reasons: individualized learning, development of digital skills, support for teachers, and optimal use of time. Depending on the nature of the topic and the learning objectives, certain topics may be more suitable for a flipped classroom than others. Tables 1–5 provide one blended learning option for each grade level from 8 to 12. The meaning of abbreviation is as follow: MCGET – Mathematics Curriculum, GET – General Education Training, EM – Educational Model, FC – flipped classroom, TC – traditional classroom.

Table 1. Blended learning for math education in 8th grade

MC for 8th grade (GET)	EM	Reasoning
1. Basic combinatorial concepts	FC	It can be taught through interactive tasks and exercises in a computer environment where students can solve problems at their own pace. In class, the teacher may teach the subject in a more structured way, starting with the basic concepts and theories.
2. Vectors	TL	It is important that students have a clear understanding of the concepts and properties of vectors. Interactive exercises can be used to facilitate the learning of the material.
3. Triangle and trapezoid	FC	The exercises can be interactive, and the theory can be presented through video material or online discussions. In class, the teacher may start with theory and use tasks to reinforce knowledge.
4. Square root	TL	The material can be presented in a more structured way. Interactive exercises can help make the material easier to digest.
5. Quadratic equations	FC	The presentation can build on knowledge that students have had since 7th grade, and the activities can be interactive and help make the content easier to learn.

6. Circle	TL	It requires a clear exposition of the theory and basic concepts. Interactive examples and animations can be helpful for a better understanding of the material.
7. Rational expressions	FC	The exercises can be presented in the form of interactive tasks that help students understand concepts and processes. In class, confirm the knowledge through tasks.
8. Inscribed and circumscribed polygons	TL	It requires the exposition of basic concepts and theories. Interactive examples can also be used to achieve a better understanding of the material.
9. Equalities in the plane	FC	As this topic builds on knowledge acquired in 7th grade, the exercises can be interactive and help students understand concepts. In class, confirm the knowledge through tasks.

Table 2. Blended learning for math education in 9th grade

MC for 9th grade (GET)	EM	Reasoning
1. Classical probability	FC	Students can explore and apply probability principles to real-world situations. Examples from everyday life as well as interactive exercises and scenarios can be used to understand the concepts of classical probability.
2. Functions	FC	Students can explore graphs, properties, and the application of functions in real-world contexts. Virtual environments and educational applications can be used to visualize graphs and interactive exercises.
3. Systems of linear equations with two unknowns	FC and TL	This topic can be partially presented in a flipped classroom. Students can consider theoretical aspects and basic principles of systems of linear equations. Exercise problems and their solutions can be provided online, allowing students to work individually or in groups.
4. Systems of equations of the second degree with two unknowns	TL	The subject is more appropriately taught through traditional learning, although certain aspects can also be incorporated in a flipped classroom format. The flipped classroom format can include interactive tasks and scenarios to guide students in solving systems of equations using computer programs.
5. Similar triangles	FC	The concept requires visual understanding and working with geometric shapes. Students can explore the properties and relationships of similar triangles using interactive resources and virtual tools. They can create and manipulate geometric figures, measure sides and angles, discover patterns.
6. Rational inequalities	TL	The topic requires systematic mathematical analysis and solving inequalities with rational expressions. Exercises and examples can be presented in the classroom, targeting specific methods and techniques.

7. Metric dependencies between sections	FC	Students can use various online resources to explore different metric dependencies and solve problems.
8. Trigonometric functions of an acute angle	TL and FC	Traditional teaching can be used initially for a detailed explanation of trigonometric functions and their properties. Because they are abstract concepts that require deeper understanding and lots of hands-on practice to be understood and mastered by students, a flipped classroom provides them with the opportunity to explore and experiment with different angles and their trigonometric values using interactive resources and web-based tools.

Table 3. Blended learning for math education in 10th grade

MC for 10th grade (GET)	EM	Reasoning
1. Irrational expressions. Irrational equations.	TL	The topic involves theory and mathematical principles that can be presented through lectures and assignments. It can be difficult for some students to understand, and it requires a lot of practice.
2. Progressions	FC	It is based on many practical examples. Students can work in groups to solve problems related to progressions and share their solutions with others.
3. Statistics and Data Processing	FC	Students can explore statistics, collect, and analyze information using technologies and software tools for data processing.
4. Solving a triangle.	TL and FC	The teacher can present the main theorems and formulas for solving triangles, give interactive examples to achieve a better understanding of the material, and explain their application in different situations. Students can use online visualization tools to solve problems as well.
5. Elements of stereometry.	TL and FC	As the previous topic.

Table 4. Blended learning for math education in 11th grade

MC for 11th grade (GET)	EM	Reasoning
1.Powers and logarithms	FC	Students already have some knowledge of powers and can cope with memorizing the basic concepts and properties of powers and logarithms using video tutorials, exploring their properties and applications, and solving problems using online math calculation tools.

2. Solving plane figures.	TL and FC	Analogous to topic 4 of 10th grade.
3. Trigonometry.	TL and FC	Analogous to topic 8 of 9th grade.
4. Probabilities.	FC	Analogous to the similar topics from the previous classes.

Table 5. Blended learning for math education in 12th grade

MC for 12th grade (GET)	EM	Reasoning
1. Statistics.	FC	Analogous to the similar topics from the previous classes.
2. Equations.	FC	Students can explore different types of equations and solve problems using online algebra tools.
3. Inequalities.	FC	Students can explore and solve different types of inequalities, create graphs, and explore their solutions using computer programs. This will help them develop graphical and numerical representations of inequalities and solve practical problems.
4. E x t r e m a l problems	TL and FC	The teacher can introduce the basic concepts and methods for solving extremal problems, use software tools and applications to visualize mathematical concepts, give examples, and explain techniques for finding the largest and smallest value. Students can solve various extremal problems using computer programs and virtual environments. This will help them visualize and analyse graphs, explore functions, and solve practical problems.

Mathematical concepts are presented gradually and, in an age-appropriate manner, with students building new knowledge upon their existing understanding. The sequential development of concepts allows students to gradually and interconnectedly grasp mathematical ideas. When introducing new concepts, the flipped classroom can be useful in cases where visualization can facilitate easier comprehension of new ideas. This allows students to grasp the fundamental concepts before coming to the classroom, while in the classroom, practical exercises and examples can be conducted to reinforce understanding and application of the new concepts. For example, in Bulgaria, according to the national curriculum, combinatorics is taught in the eighth grade. This includes basic combinatorial concepts such as permutations, variations, and combinations. These are mathematical concepts that are difficult for many students. In this case, the flipped classroom can be a better approach, as it allows for greater individualization and adaptation to different students. The

pre-class video lessons that students watch can provide visual demonstrations and illustrations of combinatorial concepts. This helps them visualize and understand the abstract concepts through diagrams, animations, or real-world examples. The video format can facilitate learning by providing visual images that are easier to remember and comprehend. Students can revisit and rewatch the video lesson based on their understanding and needs. Additionally, depending on the platform or tool used for video lessons, interactive features such as quizzes, problem-solving tasks, and embedded exercises can be provided. In the classroom, students can be organized into groups and given tasks to solve together, applying the combinatorial concepts they have learned beforehand. This allows them to support each other and learn from each other.

When introducing concepts based on prior knowledge, the flipped classroom can also be beneficial. For example, in Bulgarian schools, logarithms are taught in the eleventh grade. Since the concept of logarithm is introduced based on students' prior knowledge of exponentiation, students can independently watch pre-class video lessons that present the fundamental ideas and definition of logarithms, demonstrate examples, and explain important properties. Such an approach stimulates the active participation of students and engages them in the process of discovering and understanding the relationship between logarithms and exponents. In the classroom, the teacher can address any questions that arise and highlight important aspects related to the concept of logarithm. They can also provide exercises that help students better grasp the material and practice their skills with logarithmic calculations.

However, in some cases, the traditional approach may be more suitable when introducing new concepts. For example, due to the conceptual complexity of the topic "Vectors," it is better for the teacher to teach it in class, where they can provide immediate feedback to students and address any difficulties that arise. This is harder to achieve when students are watching video lessons independently within the flipped classroom framework. Of course, technology provides opportunities for visualization and easier comprehension of the concept of vectors. Both in class and in post-class activities, interactive exercises can be provided to students. In post-class assignments, students can be tasked with preparing presentations on topics related to the applications of vectors in real-life situations or their applications in other areas of science and technology.

The decision between traditional and flipped classroom teaching methods is influenced by a number of factors, including the content of the learning material, student prerequisites, resource availability, and teacher preferences. However, the following can be highlighted as basic criteria for picking a strategy based on the type of topic: 1. Traditional teaching methods can be utilized for themes requiring clear presentation and explanation from the teacher; issues requiring systematic inquiry and a step-by-step approach; and topics including proofs or theoretical foundations.

2. The flipped classroom can be utilized for themes that demand active student engagement, topics that build on students' existing knowledge and experiences, group work and cooperation, topics that stimulate creative thinking, and topics that require the application of practical skills.

4. Conclusions

In conclusion, some recommendations can be made to educators who wish to use blended learning, combining elements of a flipped classroom and the traditional method. Provide students with a sufficient amount of learning materials with varied repetition, ensuring that this amount is not overwhelming for students. Allow students enough time to engage with the flipped learning materials so they can work on their own and take ownership of their learning. Between learning materials and problem-solving activities include a support step to keep students from falling behind. Include interactive activities. Depending on the learning content and your students, choose which topics and which stages of the flipped classroom will be done online. Identify ways to promote support and cooperation among students to reduce anxiety.

NOTES

1. https://ucha.se/
2. https://bg.khanacademy.org/math
3. https://login.mathletics.com
4. https://www.ixl.com/math
5. https://www.geogebra.org/
6. https://www.desmos.com/
7. https://screenpal.com/
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✉ **Dr. Evgeniya Nikolova, Assoc. Prof.**
ORCID iD: 0000-0001-8313-1572
Institute of Mathematics and Informatics
Bulgarian Academy of Sciences
Burgas Free University
62, San Stefano St.
8001 Burgas, Bulgaria
E-mail: evgeniyanikolova@gmail.com