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Evaluation of Students' Participation in the 5E-Based Flipped Classroom Approach

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Abstract

This study aims to evaluate the participation of students levels in the 5E-based flipped classroom approach. The participants of the study consist of 12 students in the 7th grade at a public school. Case study, one of the qualitative research methods, was adopted in the study. In this study, how student participation occurred at each stage of the 5E-based flipped classroom approach was evaluated based on the students' subjective experiences. The data evaluated in the study were obtained through video recordings taken during classroom lessons, student worksheets, student documents uploaded in Google Classroom, semi-structured interview questions, audio recordings, field notes of the researcher teacher, and observation forms. Observation forms were created by the researcher to analyze in-class and out-of-class processes. Observation forms were prepared in line with the principles specified in the stages of the 5E-based classroom approach, which is the basis of the study. In the analysis of the data, deductive-inductive qualitative content analysis was used. In the coding process, a preliminary coding list was created using elements of both deductive and inductive approaches, and deductive categories were employed based on the 5E-based flipped classroom approach, which serves as the theoretical background of the study. According to the results of this study, it has been observed that in the use of the 5E-based flipped classroom approach, students' participation in out-of-class processes prepares students for in-class processes, and thus students actively participate in in-class processes. This study provides a framework for teachers to develop effective teaching strategies in terms of increasing student participation in in-class and out-of-class processes using the 5E-based flipped classroom approach. It also offers suggestions regarding the 5E-based flipped classroom approach to ensure student participation in mathematics lessons and emphasizes the importance of student participation in the learning process.

Keywords: 5E-Based Learning Model, Flipped Classroom, Inquiry-Based Learning, Maths, Student Participation

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5E Tabanlı Ters Yüz Edilmiş Sınıf Yaklaşımında Öğrencilerin Katılım Durumlarının Değerlendirilmesi

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Öz

Bu çalışma 5E tabanlı ters yüz edilmiş sınıf yaklaşımında öğrencilerin katılım durumlarını değerlendirmeyi amaçlamaktadır. Çalışmanın katılımcılarını bir devlet okulunda 7. sınıfa giden 12 öğrenci oluşturmaktadır. Çalışmada nitel araştırma yöntemlerinden durum çalışması benimsenmiştir. Bu çalışmada 5E tabanlı ters yüz edilmiş sınıf yaklaşımının her bir aşamasında öğrenci katılımlarının nasıl gerçekleştiği öğrencilerin sübjektif deneyimlerine dayanarak değerlendirilmiştir. Değerlendirmeye tabi tutulan veriler için sınıf içinde dersler işlenirken çekilen video kayıtları, öğrenci çalışma kağıtları, Google Classroom'da yüklü olan öğrenci dokümanları, yarı yapılandırılmış görüşme soruları, ses kayıtları, araştırmacı öğretmenin alan notları ve gözlem formları kullanılmıştır. Sınıf içi ve sınıf dışı süreçlerin analizi için araştırmacı tarafından gözlem formları oluşturulmuştur. Gözlem formları çalışmanın dayanağı olan 5E tabanlı sınıf yaklaşımının aşamalarında belirtilen ilkeler doğrultusunda hazırlanmıştır. Verilerin analizinde tümdengelim-tümevarım nitel içerik analizi kullanılmıştır. Kodlama sürecinde tümdengelim ve tümevarım yaklaşım unsurlarını kullanarak bir ön kodlama listesi oluşturulmuş, çalışmanın teorik arka planı olan 5E tabanlı ters yüz edilmiş sınıf yaklaşımına dayalı olarak tümdengelim kategorileri kullanılmıştır. Bu çalışmanın sonuçlarına göre 5E tabanlı ters yüz edilmiş sınıf yaklaşımının kullanımında öğrencilerin sınıf dışı süreçlere katılımının, öğrencileri sınıf içi süreçlere hazırladığı ve öğrencilerin böylelikle sınıf içi süreçlerde aktif katılım sağladığı görülmüştür. Sınıf dışı süreçlere katılmayan öğrencilerin sınıf içi süreçlerde etkinlikleri yaparken zorlandıkları ve tartışmalara katılamadıkları belirlenmiştir. Bu çalışma, 5E tabanlı ters yüz edilmiş sınıf yaklaşımının kullanımında sınıf içi ve sınıf dışı süreçlerde öğrenci katılımlarını arttırmak açısından öğretmenlere etkili öğretim stratejileri geliştirmeleri konusunda bir çerçeve sunmaktadır. Ayrıca matematik dersinde öğrenci katılımını sağlamak için 5E tabanlı ters yüz edilmiş sınıf yaklaşımıyla ilgili öneriler sunmakta ve öğrenci katılımının öğrenme sürecindeki önemini vurgulamaktadır.

Anahtar Kelimeler: 5E Tabanlı Öğrenme, Ters Yüz Edilmiş Sınıf, Sorgulamaya Dayalı Öğrenme, Matematik, Öğrenci Katılımı

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Introduction

Participation refers to the level of active participation of the student in a learning activity (Welborn, 1992). The multifaceted nature of participation is also reflected in the studies in the literature. Behavioral engagement includes participation in academic, social, or extracurricular activities. Emotional involvement includes students' positive and negative reactions to their teachers, classmates, and school. Cognitive participation, on the other hand, is based on the idea of understanding complex ideas and trying to learn difficult skills (Fredricks et al., 2004, p.60). The active, conscious, and constructive contribution of students to the teaching process explains how students benefit from classroom learning opportunities (Reeve, 2012, p.165). Henrie et al. (2015, p.49) assert that assessing the success of student participation in achieving desired academic and social outcomes is a useful indicator.

Technological innovations and changing learning environments affect student engagement more than ever before. As these changing learning environments affect students' behavioral participation patterns in the online environment, an investigation is needed to determine how to better achieve student learning outcomes (Al Mamun & Lawrie 2023). Attard and Holmes (2019) emphasized the usage of technology can increase students' participation in the subject as it changes the way mathematics education is presented and evaluated. In the flipped classroom approach where technology is used, Hwang, Lai and Wang (2015, p.8) emphasized that the learning flow is continuously ensured and students can actively participate in the learning process. Abeysekera and Dawson (2015) defined the flipped classroom approach as an approach where information is transferred outside the classroom, reinforcement is applied after the lesson, and student-centered activities are used in the classroom. In Abeysekera and Dawson's (2015) flipped classroom approach, they mentioned that students must complete both pre-class and post-class activities in order to participate in in-class activities. Bond (2020, p.4) emphasized that further examination of the effects of the flipped classroom approach on student participation will help educators make more informed decisions and better understand student participation when applying this approach. Schallert et al. (2022a, 2022b) developed the 5E-based flipped classroom approach by combining the stages of the 5E learning model (Bybee et al., 2006) with Abeysekera and Dawson's (2015) flipped classroom approach. The 5E model is an inquiry-based model that enables students to wonder, make discoveries, and explain their discoveries (Bybee vd., 2006). There are studies in the literature that conclude that inquiry-based learning can increase student participation (Buchanan et al. 2016, p.34; Fielding and Makar 2009, p.9). In the 5E model, the questioning process is initiated by attracting students' attention and motivating them. Students must then explore new phenomena based on their experiences. Students should provide explanations based on their experiences during the exploration. The explanation phase is followed by the elaborate phase. During the elaborate phase, additional activities should be offered to make it easier to transfer concepts and processes to new situations for generalization purposes. During the evaluation phase, students should be given the opportunity to evaluate the skills they have acquired (Bybee et al., 2006). In the inquiry-based 5E learning model, it is noteworthy that students construct their knowledge by actively participating.

In the 5E-based flipped classroom approach, students are prepared for in-class activities in the pre-lesson stages, and are also given the opportunity to reinforce what has been

learned in the course or correct their deficiencies. In this approach, since students have the opportunity to examine the course materials in advance, they can allocate more time to processes such as discovery, practice, and group work under the guidance of teachers in classroom processes. It allows students who prepare for the lesson outside the classroom to actively participate in in-class activities (Schallert et al. 2022b). Schallert et al. (2022b, p.283) have specified the points that teachers and students should consider in planning what needs to be done in each stage of the 5E-based flipped classroom approach (Table 1):

Table 1. *Design Heuristic for 5E-based Flipped Classroom Scenarios*

Stages	Out of Class	In Classroom
Engagement	Students' prior knowledge is activated with questioning videos aimed at the objectives. The teacher introduces the training scenarios to arouse the curiosity of the students. Students review the provided material at their own pace and jot down any questions that come to mind.	Under the guidance of the teacher, the questions that students take notes outside the classroom are opened for discussion. Students actively participate in class discussion.
Exploration	Teachers provide inquisitive videos for exploration. In the inquisitive video, a problem is discussed in detail without foreshadowing the final solutions. Students prepare for the lesson by watching these videos.	The teacher is the guide in the discovery process. It gives instant feedback to the students during the implementation process of the activities. Students explore and explain the concept in the learning environment. Informal assessments are included.
Explanation	The teacher re-introduces the concepts and theories in case the student has overlooked them, and gives the students the opportunity to explain the concepts and theories learned. Students review the presented material and compare it with their own explanations.	Students explain the concepts and theories they discovered under the guidance of the teacher. Classroom discussion and activity allows the teacher to evaluate student's understanding of concepts and/or skill acquisition.
Elaboration	The teacher presents new but closely related interrogative videos or materials related to the concept being learned. Activities include real-life contexts. Students are given tasks to apply what they have learned to different situations.	The teacher encourages students to apply what they have learned to different situations. Taking into account that students may have different levels of success, tasks with different situations are given. Students apply what they have learned to new but closely related situations.
Evaluation	The teacher provides the opportunity for students to self-assess. Students participate in self-assessments to reflect on their learning process.	The teacher evaluates the learning process of the students. Formative assessment techniques are used.

Lesson planning principles presented by Schallert et al. (2022b, p.291) that will assist educators in the lesson planning process in the 5E-based flipped classroom approach are given in Table 2:

Table 2. *Design Principles for Setting up 5E-based Flipped Classroom Scenarios*

Principle 1	The out-of-class process is used to reveal the preliminary information about the subject to be learned.
Principle 2	Students are motivated to complete the activities in and out of the classroom. Online activities are used to provide immediate feedback for formative assessments.
Principle 3	Students are encouraged to participate in activities with questioning questions in and out of the classroom.
Principle 4	Instant feedback is provided to students by applying discovery activities in the classroom process.
Principle 5	The out-of-class process is used to reinforce the learned information.
Principle 6	In the classroom process, activities are applied that enable students to explain what they have learned by justifying them.
Principle 7	In the classroom process, activities involving different situations related to daily life are applied to the students in order to make sense of the learned information, where they can apply the knowledge and skills they have acquired.
Principle 8	In order to strengthen cooperative learning environments, activities involving small group work are applied in the classroom process.

There are many studies examining student participation in the literature (Cummins, 2016; Coufal, 2014; Clark, 2015). Reeve (2012, p.21) argued that changes in student participation cause changes in the learning environment, and further research is needed in the future to fully understand and evaluate this. In our study, 5E-based flipped classroom approach, that is, an integrated model, was used.

In this context, it was necessary to conduct a study that draws attention to the potential of student participation in the 5E-based flipped classroom approach. In this study, student participations were not evaluated behavioral (Fredricks 2013; Li et al. 2014; Lai et al. 2021; Ponitz et al. 2009), emotional (Sagayadevan and Jeyaraj 2012; Ulmanen et al. 2016) and cognitive (Greene et al. 2004; Helme and Clarke 2001). In this study, student participation was evaluated in line with the stages of the 5E-based flipped classroom approach. In addition, considering the scarcity of studies on the 5E-based flipped classroom approach, this study also enables us to understand the general validity of the approach.

In this study, we aim to evaluate how student participation occurs in the 5E-based flipped classroom approach, in order to fill the gap in the literature. The purpose of the study is also to analyze student participation in a more comprehensive, taking into account the subjective experiences of students. Thus, by filling the gap in the literature, it is aimed to make suggestions for the educators to better understand the 5E-based flipped classroom approach, which is a new approach in the field of education, and to ensure student participation.

Methodology

In the research, case which is one of the qualitative research approaches was chosen to apply; as it was aimed to evaluate student participation in the 5E-based flipped classroom approach. The case study is a research method based on "how" and "why" questions to examine a phenomenon or event in depth (Yıldırım & Şimşek, 2016, p.289).

Participants

The researcher carried out the application in her own school and in a class of students she directly taught. Easily accessible sampling was used in choosing the school where the study was conducted. The easily accessible sample is the researcher choosing the situation that is easy to access (Yıldırım & Şimşek, 2016, p.123). The participants of the study are 7th grade students in the 12-13 age group attending a public school. The study was carried out on a voluntary basis with 35 students from the selected 7th grade students. For the study group, 12 students were selected from 35 students who participated in the application. These participants are students who can cooperate effectively in a group, participate in in-class and out-of-class processes, actively participate in in-class discussions, and use computers, GeoGebra dynamic software, and Google Classroom.

Environment of the Research

The refurbishment works to be carried out in the school building selected for implementation forced our school to temporarily move to another building. In this temporary settlement, the education process continued in a building used by high school students. However, since our students left late in the evening, the duration of the lessons was determined as 35 minutes. The activities were applied to the curriculum in the mathematics lesson. Since the school does not have internet and a computer room, the researcher was able to carry out the application with the facilities of himself and his students. Students brought their own devices such as laptop, phones, tablets that they used while doing the activities.

Data Collection Tools

This study is based on the pilot implementation data of the ongoing doctoral thesis of the first author. Video and audio recordings, semi-structured interview questions, student worksheets and student works uploaded to Google Classroom were used to collect data. Video recordings were used to determine participant behaviors, reactions, and interactions in the classroom process. Audio recordings were employed to analyze students' responses to interview questions. Answers extracted from student worksheets were utilized to elaborate on student participation status in detail. Additionally, student studies uploaded on Google Classroom were employed to analyze students' participation status in out-of-class stages. Semi-structured interview questions were used to expand the findings obtained from other data collection tools and add more information. Student worksheets used as data collection tools were prepared in accordance with mathematical activities. For these worksheets, the opinions of a faculty member who was an associate professor in mathematics education at a state university and a primary school mathematics teacher who was writing her master's thesis in this field at the time were taken. In order to get the opinions of the experts, rubrics were prepared by the researcher and sent to the experts. The working papers were revised in line with the feedback from experts. Observation forms were created by the researcher for the analysis of in-class and

out-of-class processes. Observation forms were prepared in line with the principles stated in the stages of the 5E-based flipped classroom approach, which is the basis of the study. Observation forms were submitted to expert opinion and revised. In addition, a semi-structured interview form was prepared. The semi-structured interview form was asked to be examined by two experts in Curriculum and Instruction, an expert in Measurement and Evaluation, an expert in mathematics education, and also a doctoral specialist in Curriculum and Instruction. The final form of the semi-structured interview form was created by taking their opinions.

Task Preparation Process

In the study, out-of-class activities and in-class activities based on 5E-based flipped classroom approach were prepared for the following objective in the 2018 Mathematics Curriculum:

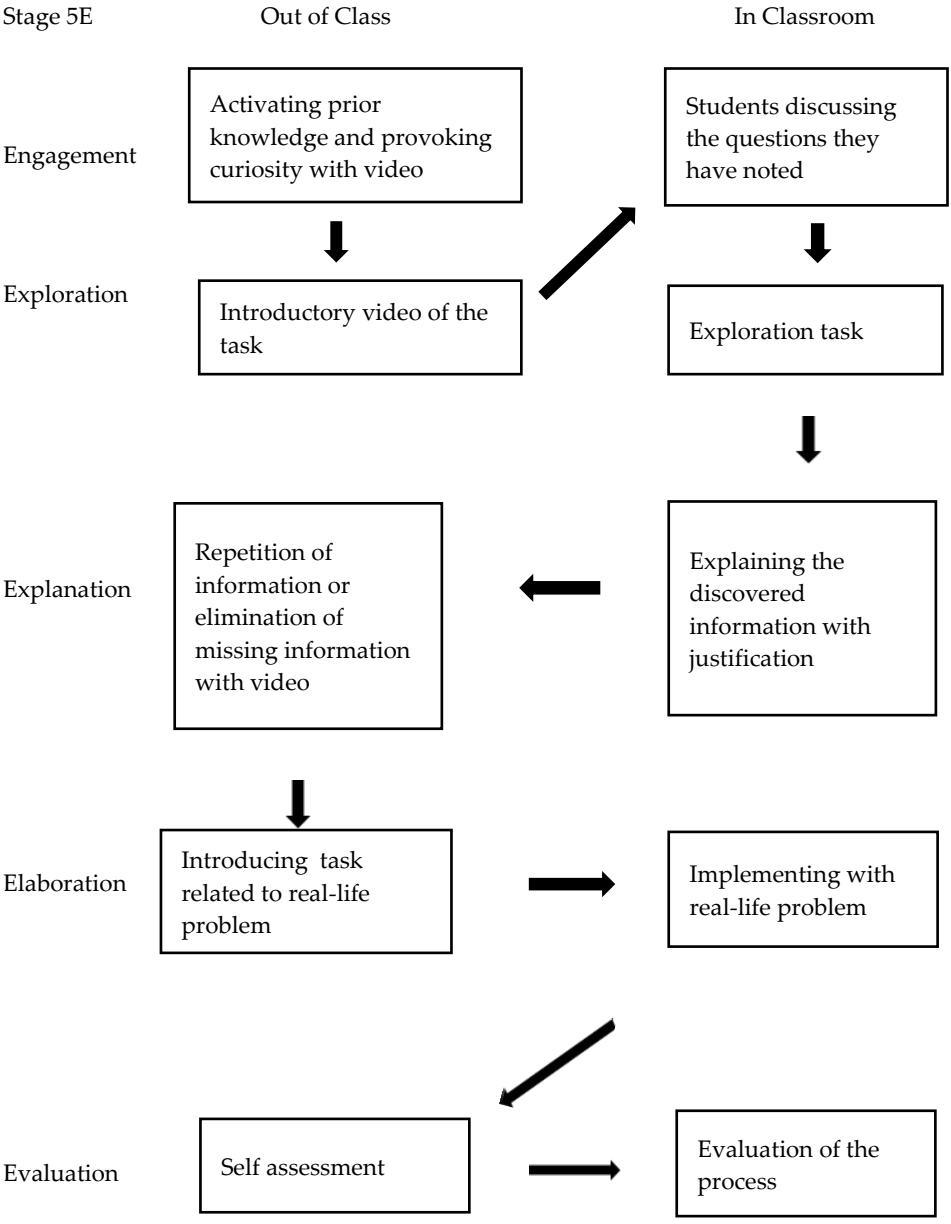
> "Determines the diagonals, interior and exterior angles of polygons; calculates the sum of the measures of the interior and exterior angles.
>
> Studies to explore the sum of interior angles are included" (MEB, 2018, p.69).

All the contents used in the study were prepared by the researcher. The out-of-class stages of the activities are discussed in two parts as pre-class out-of-class stages and after-class stages. Video recordings were made by the researcher using the Zoom program for the out-of-class stages. After the expert opinions, the video footage was revised and the videos were shot again. Video editing applications were not used while the videos were being prepared, and when there was an error in the video, the videos were taken from the beginning. The questions in the videos and the evaluation questions in the out-of-class phase were sent to the students as a word file document. Content in the out-of-class stages was sent to students via Google Classroom. The exploration activity in the classroom phase was done with the GeoGebra dynamic geometry software. Before starting the study, both a guide for GeoGebra dynamic geometry software and a practical demonstration of how to use the software were prepared by the researcher. In addition, the researcher teacher informed the students about how they can use Google Classroom. In the design of the activities, Schallert et al. (2022b) 5E-based flipped classroom approach design (Table 1) and lesson planning principles (Table 2), and Smith and Stein's (1998) activity framework were adopted. After the activities were completed, a mathematics teacher who practiced using the inquiry-based flipped classroom approach and was writing a thesis on this subject, and an expert in the field of mathematics education were consulted. In line with the feedback received, corrections were made in the activities.

Implementation Process

Students worked individually on out-of-class stages and in groups in the classroom process during the stages of exploring, explaining, and deepening. They made the in-class evaluation stage individually. The implementation stages of the 5E-based flipped classroom approach in this study is provided in Figure 1. Arrows indicate the sequence of implementation stages.

Figure 1. The Process Using the 5E-based Flipped Classroom Approach



Inquiry videos were used to activate students' prior knowledge and to draw their attention to the subject during the engagement (out-of-class) phase. In the exploration (out-of-class) stage, a video was sent to the students to introduce the activity that they would be doing in the classroom. During the in-class engagement phase, in-class discussions were opened by asking the questions that were on their minds. During the in-class exploration stage, the students were given worksheets and guided by the researcher to complete the activities with group work. During the in-class exploration

stage, the students were enabled to explain the information they acquired by justifying. Explanation in the classroom process, students were asked to do the activity distributed as a group in which they could explain the information they discovered. At this stage, students were asked to make explanations and justifications. During the explanation out-of-class stage, videos which have students question the information they learned and allow them to make reinforcement and they were asked to answer the questions. During the out-of-class elaboration phase, a video was sent to the students to introduce the activities they would do in the lesson. During the in-class elaboration phase, students were provided with activities related to daily life to transfer what they learned to new situations. During the out-of-class evaluation phase, students were sent questions about the subject and asked to answer them. Thus, students were provided with self-assessment. During the in-class evaluation phase, the students were given questions about the subject and the application was ended by asking them to answer.

Analysis of Data

The following steps were carried out in the analysis of the obtained data: first, the recorded videos were watched; then all dialogues in the videos were transcribed. By looking at the video recordings, the data in Google Classroom and the student handouts, the observation forms were filled several times by the researcher at different times and the consistency among them was checked. Some questions in the semi-structured interview form prepared in the study were focused on. Some questions suitable for the purpose of the study were selected and analyzed. The semi-structured interview form was personally applied by the researcher teacher. Expression errors in the answers given by the students were corrected with their permission. The answers given by the students directly to the question were written in support of the coding obtained from the observation form. 12 students were selected for the stage of presenting the analysis results. The analysis results of these students are given in detail in the findings section. In the presentation of the data analysis, instead of the real names of the students, students were presented as A, B, C ….

Schreier (2012) qualitative content analysis approach was used in the study. In the coding process, a preliminary coding list was created by using deductive and inductive approaches. In the coding process, deductive categories were used based on the 5E-based flipped classroom approach, which is the theoretical background of the study. As coding progressed, the initial coding list was modified and developed, codes were added, and categories were reviewed so that they did not conflict with each other (Miles & Huberman, 1994). The coding list is given in Table 3:

Table 3. Encoding List

	Out of Class	**In Classroom**
Engagement	Students reviewing the materials provided at their own pace and taking notes of any questions that come up	Students sharing questions and notes in class discussion The effect of students' sharing their ideas on discussions Students ınteracting with other students in classroom discussions

Exploration	Students preparing for the lesson by watching the ınquiry video	Students ınteracting with teacher and one another during activities Expressing students' answers explanatorily
Explanation	Students can use repetitive concepts in their answers to questions	Students' explanation of the concepts they discovered with their reasons Classroom discussions and activities helping evaluate students' levels of understanding concepts and acquiring skills
Elaboration	Preparing the student for the lesson by watching the ıntroductory video of the activity	Students applying what they learn to new situations
Evaluation	Students' use of the evaluation opportunity	Students explaining solution steps while solving questions

Findings

At this stage, the analysis of the videos and student worksheets for the in-class stages, and the analysis results of the data obtained from the Google Classroom for the out-of-class stages are included. Teacher-student dialogues, students' worksheets and students' answers to interview questions will be included. First of all, the application about what is done at which stage is introduced, then the observation chart is presented and interpreted.

Student Participation in the Out-of-Class Engagement Phase

Students Reviewing the Materials Provided at Their Own Pace and Taking Notes of Any Questions That Come Up:

The video and the questions in the video were written in word files and sent to the students via Google Classroom in order to increase the students' interest in the subject, attract their attention and remind them of their prior knowledge. In the video, a quadrilateral and a triangle were drawn to remind students of their prior knowledge and they were asked to answer how many sides, corners, interior and exterior angles they had. The teacher gave feedback to the answers from the students. It was seen that the answers sent by many students were correct. The teacher noticed that there were no correct answers from the answers sent by a student and decided to open this up for discussion during the in-class engagement phase. In addition, students H and B opened the questions that came to their minds for discussion during the in-class engagement stage.

Student Participation in the Out-of-Class Exploration Phase

Students Preparing for the Lesson by Watching the Inquiry Video:

Except for three students, other students participated in the out-of-class exploration phase, watched the video and sent answers to questions about the video. The answers sent by the students were given feedback by the teacher. Thus, it was ensured that the

students were prepared for the in-class exploration phase. It was observed that the students could not answer some questions, answered some incorrectly, and did not understand some of them. It can be understood that this situation does not fully prepare the students for the in-class activity. For example, student C's answer for question one is given below:

He replied, "I couldn't find a connection with the outer inverse superposition on the right". It is understood that he did not fully understand the question. He answered the second question as follows:

> "Parallel because they run equally".

He has given his answer. However, the type of angle was asked in the question.

Student H gave correct answers to all questions. Student A answered the other questions correctly, except for the 2nd question. Student A's answer to question 2:

> Student A: "Contralateral angle comes to my mind"

Since he came prepared for the activities, it was determined that student H participated actively while doing the activity in the classroom.

At the same time, student A was asked whether the videos sent outside of the classroom prepared him/her for the lesson or not.

> Student A: "Those videos were very helpful to me, I was watching them before I came to the class. You were mostly asking questions from those videos anyway. You were asking similar questions. Knowing their answers beforehand helped me a lot in the lesson. Sometimes I already knew the answer on the activity sheet, so I could finish it faster".

Student Participation in the Class Engagement Stage

During the introductory stage, the students asked questions that came to their minds, and class discussions were opened. Thus, a participatory learning environment was provided and the students were allowed to share their thought processes.

Students Sharing Questions and Notes in Class Discussion:

At the stage of engagement the classroom, Student D repeated the answer she gave outside the classroom with the guidance of the teacher and a class discussion was opened.

Student D the student watched the inquisitive video but gave wrong answers to some questions. He answered the 1st question as:

> "Infinite exterior angles" and "Four interior angles or unknown".

> He answered the second question as: "unknown interior angle" and "unknown exterior angle"

The Effect of Students' Sharing Their Ideas on Discussions:

Student B opened the class discussion by asking the question that stuck in his mind about the interior and exterior angles discussed in the video.

> Student B: "Why do we call the exterior angles of the rectangle and square four but not eight?" asked the question.

Student F gave the following answer to Student B's question:

> Student F: "He drew two when he was drawing the exterior angle, but he was going to draw one".

Student B clearly expressed his opinion by asking the above-mentioned question. Student F contributed to the discussion by explaining where his friend made a mistake in this question.

Students were given the opportunity to express their thoughts. The students' sharing of different ideas contributed to the enrichment of the class discussion.

Students Interacting with Other Students in Classroom Discussions:

Student H presented a different point of view earlier and started a class discussion to confirm this.

> Student H: “You drew a square, you asked how many triangles are formed. After that, I drew such a drawing and said that there would be 2 of them. Then it came to my mind, we can do it like this” and draws on the board.
>
> Teacher: “And two or four?”
>
> Student J: “Four. Because when we draw non-adjacent diagonals, there are four of them”.
>
> Student H: “Maybe they shouldn't overlap”.

When Student B answered "eight", the teacher tried to guide the students by asking the question "How many times did you count the same triangle?"

Thus, students were able to benefit from the perspectives of their friends while improving their own understanding.

At the same time, Student A and K's answers to the interview question:

> Student A: “It worked very well for you to be a group in the class. We were learning different ideas and it allowed us to learn ideas from different groups, which was very good as we all told the solutions. Also, some friends did not attend the class. Student M was normally someone who didn't attend a lot of lectures. But in our practice, it is better than normal, now he exchanged ideas with us and this was very good for us”.

> Student K: "It improved our communication even more. He also became a better grasper. It developed our thinking. There was different of opinion. We tried to find a common idea".

In addition, it was observed that students' interaction with one another increased their communication, and they were able to express their thoughts by exchanging ideas.

Student Participation in the Classroom Exploration Phase

In the classroom exploration stage, the teacher acts as a guide. Students are expected to discover what is intended to be given and to explain the concepts they have discovered. The teacher gives instant feedback to the students when the activities are done.

Students Interacting with the Teacher and One Other During the Activities:

Student E asks questions about the activity. The teacher guides by showing it on the student's computer. At that time, one of student E's bandmates goes to listen to what the teacher has to say. All of the other students in the group also listen carefully to their teacher. This allowed students to focus.

Since rounding must be done in GeoGebra while doing the activity, the teacher makes a reminder on the GeoGebra program on the smart board. Student B explains to his friends how to do it for those who use GeoGebra on tablet and phone.

> Student B: "Tablet and phone have a setting at the top. When you press the setting, three options will appear: graph, general, and algebra. You choose the general. There is rounding. You click on rounding."

In the interview, Student C stated that it was very productive for the teacher to guide the classroom activities.

It has been observed that students' interaction with their teacher and each other helps them understand the subjects better by providing a better understanding of what they will do in the activities.

Expressing Students' Answers Explanatorily:

> Teacher: "Which of the relative positions of the three lines in the plane can we see here?" to answer the question

> Student H: "There is a Z rule"

and shows it on the smart board.

> Teacher: "Is there a relationship between the sums of the interior angles of the quadrilateral and the sums of A and C?"

> Student H: "Z rule because it has interior reverse angles."

> Teacher: "What is the sum of the interior angle measures of the hexagon? he asks. Student B and C raise their fingers".

Student C: "720°"

Teacher: "Why?"

Student C: "Because of the triangles drawn in it".

Teacher: "Is there a pattern between the number of sides of the polygon and the number of diagonals?"

Student B: "He already has one and two around him. We can subtract the total vertices and find each vertex".

Student B: "It could be n-3".

Teacher: "Can we create a pattern about the measure of an interior angle of a polygon by using the number of sides of the polygon and the sum of the interior angles of the triangle? Explain".

Student H: "Sir, we showed the formula in that formula [on the board (n-2).180°] and said divide by (n)".

Teacher: "Why did you say divide by (n)?"

Student H: "Because it gave the sum of the interior angles of the polygon. For example, we were dividing it by how many corners it had".

Thus, it was seen that student B, C, and H were able to discover and explain where the formulas came from.

At the same time, Student B's response to the relevant interview question:

Student B: "Besides, our expression skills were improving. The fact that we explained those questions to each other in the group and exchanged ideas increased our knowledge of mathematics and increased our ability to explain".

Students were given the opportunity to express their thoughts. It has been observed that in this case, where students can explain the concepts they have discovered, much more active participation in the learning process is achieved.

Student Participation in the Classroom Explanation Stage

Students explain what they have discovered with justification.

Students' Explanation of the Concepts They Discovered with Their Reasons:

Teacher: "With what formula do we find the sum of the interior angles of a polygon?"

Most of the students give the answer (n-2).180°.

Teacher: "Why am I multiplying (n-2) by 180°".

Student H: "Because (n-2) is to find how many triangles there are and the sum of the interior angles of all triangles is 180°".

Teacher: "How do I find the measure of an angle in a regular polygon?"

Student E: "(n-2)180°/n"

Teacher: "Why did you divide by n?"

Student E: "We use (n-2).180° to find the sum of all interior angles. To find an angle, we divide by n".

Thus, it was seen that the students explained why the formulas were written in this way by justifying them.

In addition, student B's response to the relevant interview question:

Student B: "Student J's attendance has increased considerably now. He began to stand up like a spokesman. He started to tell. So this project we did has not only improved our math but also our explanation".

Student E gave the following answer to the interview question:

Student E: "For example, if there is a formula or something else, you can understand where they come from. For example, I read the formula n-2, this n-2 does not stay in my head. I understand where that n-2 comes from".

Their explanations were provided by justifying the formulas they discovered. In this way, it has been observed that students can have a deep understanding of where the formulas come from.

Classroom Discussions and Activities Helping Evaluate Students' Levels of Understanding Concepts and Acquiring Skills:

Teacher: "(n-2) What is 180°?"

Student L: "Interior angles".

Teacher: "What are interior angles?"

Student L: "Total".

Teacher: "The sum of the interior angles. Can you tell me again the sum

formula?"

Student L: "Teacher (n-2) 180°"

Teacher: "So where does the -2 in the formula come from?"

Student L: "I think it has one side".

Teacher: "Where does the -2 in the formula come from?"

Student L cannot answer

Student L answered question 1 correctly. However, when the justification was requested, he called the whole formula as interior angles and could not explain exactly where (-2) in the formula came from. With the guidance of the teacher, the level of understanding the concept and gaining skills was determined. Student B was able to explain where (-2) in the formula came from, along with his justification. Thus, it was seen that the approach used allowed students to identify their strengths and weak areas that needed improvement.

Student Participation in the Out-of-Class Explanation Stage

The teacher explains the subject again; Students are given the opportunity to explain what has been learned. Students examine the presented explanations and compare them with their own. Except for two students, the other students answered the questions in the out-of-class explanation document.

Students Can Use Repetitive Concepts in Their Answers to Questions:

Students interpreted question 1 in different ways. For example;

Student A: "Since the triangle is isosceles, both are 45°. Since one side of the quadrilateral is 90°, one triangle becomes 180° and two triangles 360°".

Student B: "From the Z rule (USA), we find that the angle ˆ is 45°. Since the diagonals are bisectors, they are 45×2=90° degrees. Since 90×4=360°, the sum of the interior angles of the square is 360°".

Student C: "Yes, we can find it because the triangle is 180° degrees, there are two triangles inside a quadrilateral and the result is 360° degrees".

Student L: "Yes, since the interior angles of a triangle are 180°, 180° + 180° equals 360°".

The students who answered the 2nd and 8th questions answered without explanation. No different comments were made from the students who answered the other questions correctly, either only answered or answered the question with its justification.

In the interview, students J and G mentioned that they reinforced the documents sent during the out-of-class phase.

It was observed that this situation enabled students to reinforce the concepts they discovered**.**

Student Participation in the Elaboration Stage Outside the Classroom

The teacher sends the activity that includes real-life contexts to the students and aims to make the students come prepared to the lesson.

Preparing the Student for the Lesson by Watching the Introductory Video of the Activity:

Most of the students answered the questions about the activities. As an example, student F mentioned that he will design a spacecraft, use regular polygons for this, and use the sum of interior angles to find the angle of view.

It has been seen that the students who come prepared get more efficiency from the activities.

Student Participation in the Elaboration Stage of the Classroom

Students participate in the teacher's activities involving different situations associated with daily life.

Students Applying What They Learn to New Situations:

Student C: "Our formula is (n-2).180°"

Teacher: "Where does this formula come from?"

Student C: "This shows how many sides n has. -2 adjacent angles".

Teacher: "Correct. Neighboring corners".

When student C cannot explain where (n-2) in the formula comes from, another student answers as the number of triangles formed.

Teacher: "What is 180?"

Student C: "Sum of interior angles. Of the octagon (8-2)180°, this equals 6.180°= 1080°. In hexagon (6-2).180° = 4.180°. We subtract 1080°-720°".

Thus, it was seen that the student found the sum of the interior angles of the octagon and the hexagon from the formula for the sum of the interior angles of the polygon.

Transferring what has been learned to new situations shows that learning is actually carried out. It can contribute to the permanent learning process.

Student Participation in the Out-of-Class Evaluation Phase

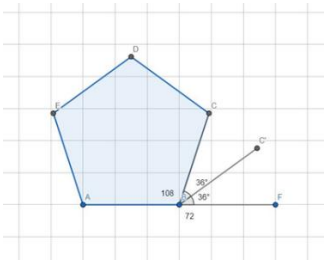
Students' Use of Evaluation Opportunity:

Less than half of the students answered the assessment questions. If we give an example from student B, who answered all the questions correctly; he found the angle x in between by utilizing an interior angle of many polygons and subtracting it from the sum of the

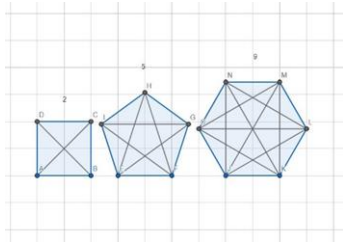
interior angles of the triangle. And while solving it, he made the necessary explanations. He drew the answers to the 2nd and 3rd questions over the GeoGebra dynamic software and showed them on the figure 2.

Figure 2. Student B's Answers

question 2



question 3



2+5+9=16

He also interpreted the 4th question without taking any action.

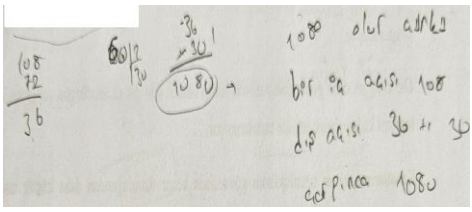
This stage can show the level of what students have learned. It has shown that students can have a more effective learning experience as feedback is provided.

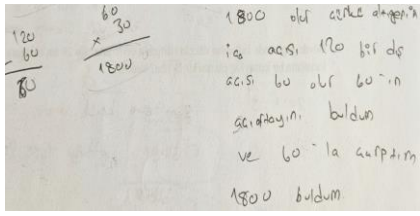
Student Participation in the Classroom Evaluation Phase

In the classroom assessment phase, the teacher evaluates the learning process of the students.

Students Explain Solution Steps While Solving Questions

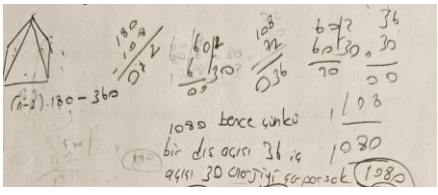
Figure 3. Student A's Answers:

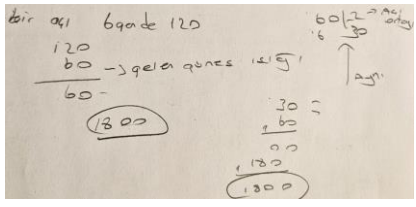




Most of the students answered by drawing a figure 4. For example: Student K's answers:

Figure 4. Student K's Answers





The students' thinking processes were followed by examining their solution stages, and it was concluded that this method could help them develop their missing parts.

Conclusion

Student participation was evaluated in line with the principles of the 5E-based flipped classroom approach. The stages of the approach are categorized and the focus is on evaluating student participation in the in-class and out-of-class stages.

Lo and Hew (2021, p.13) stated in their studies that classroom observation should be made to monitor student behaviors. In this study, in which a qualitative approach was followed in accordance with this recommendation, it was concluded that the 5E-based flipped classroom approach increased the participation of students in in- class processes when they attended the out-of-the clasroom processes. Likewise, according to Demir et al. (2022), although the 5E-based flipped classroom approach increased student participation, it was understood that it had negative effects on student participation if students did not participate in out-of-class stages. Some students emphasized that they did not have the necessary technological equipment to participate in online learning platforms, and others emphasized that their motivation to communicate and discuss on online learning platforms was low, and that this may have prevented students from creating a productive discussion process because they wanted to communicate face to face in the learning environments they were accustomed to. Cevikbas and Kaiser (2021, p.1455) also stated that when students could not complete the pre-lesson tasks, participation was negatively affected. They mentioned that the flipped classroom approach positively affects student participation, but it should not be forgotten that some students may experience difficulties in the adaptation process.

With the 5E-based flipped classroom approach, different materials and strategies can be used to ensure student participation in out-of-class and in-class processes. Çevikbaş (2018, p.204) emphasized that students' participating in discussions, participating in group work, solving problems with different difficulties, receiving developer support and monitoring and evaluating their progress increased their participation in the course. All these applications, which are claimed to increase class participation, were easily applied in the stages of the 5E-based flipped classroom approach in this study. As a result, it was seen that students increased their participation in classroom stages. It has been observed that students increase their participation in in-class stages.

In the flipped classroom approach, students have more opportunities to participate in the activity and have a discussion about the topic. However, for this, teachers should carefully plan the activities, videos and study notes they offer outside of the classroom (Zengin, 2017, p.89). It is thought that this may help to make the learning process more meaningful. As a solution to this, it can be said that teachers should diversify materials for students with different learning styles. Additionally, students and educators need to be supported in order to successfully implement the 5E-based flipped classroom approach.

The results of this study show that students should be given the opportunity to review the provided material at their own pace and direct their own learning process. Likewise, Tütüncü and Aksu (2018, p.211) mentioned that in the flipped classroom approach, students can watch videos at their own pace, teachers can provide immediate feedback

to students about their learning processes as a guide, and teachers can differentiate their teaching and materials in accordance with students' needs and pace.

One of our conclusions is that watching questioning videos provided outside the classroom helps students prepare for the lesson to have preliminary information about the activity to be covered in the lesson, encourages them to think before the lesson, and that using questioning videos to prepare students for the lesson can be an effective method of increasing student participation. Bredow et al. (2021, p.4) likewise argued that in the flipped classroom approach, sending course materials to students in advance allows them to understand the information more deeply by encouraging active participation in in-class activities. Likewise, Çevikbaş (2018, p.183) stated in his study that it would be useful to watch lecture videos to ensure student participation.

It can be thought that it is important for students to give explanatory answers to the questions in terms of exhibiting their skills in the learning process, as it provides the opportunity to understand the thinking processes of the students and determine their needs. Likewise, Özcan et al. (2022, p.129) suggested to mathematics teachers that in order to deepen the conceptual understanding of the inquiry-based flipped classroom approach, classroom discussions should be supported with guiding questions. Demir et al. (2022, p.21) observed in his study that the teacher's use of guiding questions was effective in helping students enter the justification process, and in some cases, when the teacher did not participate in the discussion processes, the students abandoned the discussion. In this study, it was concluded that the students' sharing the questions in their minds in the class allows the discussions to deepen and strengthens the interaction of the students with each other and student-centered learning.

Bredow et al. (2021, p.6) stated that in the flipped approach, students can draw conclusions and make connections by reinforcing what has been learned. Likewise, Clark (2015) emphasizes that watching the videos sent in the flipped classroom model multiple times contributes to the students' better understanding of the relevant subject. In addition to these, as Schallert et al. (2022b) stated, it is argued that out-of-class practices are beneficial in terms of reinforcing students' knowledge and eliminating their deficiencies when applied after in-class activities. In this study, it was clearly determined that by using the 5E-based flipped classroom approach, students reinforced the subjects they learned and understood the relevant subject better.

As a result, it is understood that the 5E-based flipped classroom approach supports student participation in different aspects. It has been observed that participation in out-of-class processes increases students' interest and motivation, and also by coming prepared to class, active participation in in-class processes increases. It has been determined that students who do not participate in out-of-class processes have difficulty performing activities in the classroom and cannot participate in discussions. It has been observed that participation in discussions and group studies in the classroom processes and the monitoring and evaluation activities carried out by the teacher throughout this process increase the participation of the students. It has been determined that students' ability to express their ideas and interact with the teacher and each other during classroom processes enables them to develop a deep understanding of their knowledge.

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