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Research Article

Development of a mobile learning application for pattern teaching in fashion design[1]

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Abstract

This study was conducted to develop a mobile learning application for the instruction of the Pattern Making Course, a skill-based fundamental course in the field of fashion design. Utilizing the Flipped Learning Method, which supports active student participation, the mobile learning application was used by students in the course for a duration of two weeks. In the study, the Multi-Stage Mixed Design Method, one of the mixed-method designs, was employed. During the development phase of the mobile learning application, the ADDIE instructional design model was utilized. In the analysis phase of ADDIE, a survey was conducted with instructors teaching the course to determine the topics to be included in the mobile application. The survey aimed to identify the most challenging topics for students in the Pattern Making Course. During the design phase, the content of the application, instructional materials to be used in the course, pre-test and post-test questions, and evaluation forms for instructors and students at the end of the application were prepared. In the development phase, the mobile learning application was programmed to be compatible with Android and iOS operating systems. In the implementation phase, the mobile learning application was utilized for two weeks in the "Introduction to Pattern Making" course in a flipped learning environment with 51 students and instructors in the sample. In the evaluation phase, data collected from instructors and students were analyzed by calculating arithmetic mean, standard deviation, percentage, and frequency values. Additionally, the responses to the semi-structured questions were evaluated through descriptive analysis. As a result of the study, students' evaluations of the developed mobile learning application, PaMa, yielded positive outcomes. Students expressed that having access to information via their mobile devices without time and space constraints provided great convenience and freedom. This study is considered significant as it introduces a technology-based instructional design for the Introduction to Pattern Making Course, a crucial subject in the field.

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Introduction

In traditional teaching models, instruction is delivered within the classroom during a limited timeframe. However, with the evolving requirements and innovations of the modern era, education has taken a different direction. The opportunities provided by technology have expanded the horizons of both educators and students in teaching and learning activities. Among these opportunities, mobile learning applications have increasingly emerged as instructional tools in contemporary education.

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Mobile Learning

Mobile learning emerged as a new paradigm in education at the end of the 20th century and has attracted the attention of scholars since the early 2000s with the widespread adoption of mobile devices (Sharples, 2000). It is defined as a form of learning that enables students to learn independently of time and place by utilizing wireless technology. Traxler (2020) defines mobile learning as "a type of learning that helps learners acquire knowledge, attitudes, skills, and processes through connectivity and portability." Similarly, Saran (2016) describes it as "a process in which individuals are mobile, utilizing high-capacity mobile devices and broadband internet connections to access information resources at any time."

Portability, proximity, individuality, connectivity, and accessibility, which lie at the core of mobile learning, are among the key features of mobile devices (Ally, 2009:1). Mobile technologies and applications serve as promising tools for creating collaborative learning environments, as they facilitate the easy sharing of materials and provide new communication channels, thereby enhancing student engagement (Hsu & Ching, 2013). Fundamental advantages of mobile devices—such as unlimited mobility, flexibility, and compact size—offer new opportunities to improve learning environments in different settings, particularly given that students are assumed to be constantly on the move. These devices enable continuous interaction with educational content across various contexts (Oyelere, Suhonen, Wajiga & Sutinen, 2017). Examining the advantages of mobile learning, students can access course materials anytime and anywhere while tracking their own progress. Additionally, mobile learning supports individual learning, collaborative learning, informal learning, and situated learning (Gimenez Lopez, Magal Royo, Laborda & Garde Calvo, 2009; Cheon, Lee, Crooks & Song, 2012). Students can engage with mobile applications in a highly personalized manner, which ultimately fosters greater participation and enhances learning outcomes (Diacopoulos, Crompton & Education, 2020; Oliveira, Pedro & Santos, 2021). These advantages not only allow students to learn at their own pace but also provide diverse and inclusive learning experiences through multimedia content within applications. The intensive use of mobile devices and technologies is increasingly transforming the nature of knowledge and discourse, leading to changes in both formal and informal learning processes as well as in the ways information is distributed and accessed (Traxler, 2007).

Özsarı and Saykılı (2020: 121) conducted a content analysis of postgraduate academic studies on trends, potentials, and challenges in mobile learning in Türkiye between 2010 and 2019. The findings of the study revealed that mobile learning positively impacts academic achievement, that students develop a favorable attitude toward mobile learning, and that mobile learning enhances students' motivation toward the course. Additionally, the results indicated that mobile learning is beneficial for providing flexibility in terms of time and space, is easy to use, enjoyable, and effective in enhancing interaction. However, the study also identified several challenges associated with mobile learning, including infrastructure issues, software and hardware limitations, and content deficiencies.

In Algabsi's (2021) comprehensive analysis of mobile learning applications, it was found that the majority of studies in this field have been conducted within computer sciences. However, when examining research in higher education, mobile learning applications have been widely integrated into courses across various disciplines, including medical education, nursing education, language learning, and sciences such as chemistry, biology, and mathematics. Findings from academic studies in these fields indicate that educational content and videos delivered via mobile devices facilitate student learning, enhance engagement, and provide an enjoyable and stimulating experience. In anatomy courses, students who used mobile learning applications demonstrated lower anxiety levels and higher success rates compared to those receiving traditional instruction. Similarly, research has shown that mobile-supported e-books are effective in language learning, and that students using mobile applications in classroom activities achieved higher success rates than those who did not. The study results further revealed that mobile learning applications positively impact students' learning outcomes (Willemse, Jooste & Bozalek, 2019; Bolatlı & Kızıl, 2021; Xodabande & Hashemi, 2023; Arain, Hussain, Rizvi & Vighi, 2018; Madang, Tibrani & Santoso, 2019).

As evidenced by studies in different disciplines, the integration of mobile learning applications in higher education leads to increased student achievement and motivation. Fashion Design Education in higher education consists of a curriculum that includes both theoretical courses and skill-based practical courses. Research findings from various fields suggest that mobile learning applications—one of today's increasingly popular and even demanded educational

technologies—enable students to engage more effectively in learning activities. This highlights the significance of developing mobile application content and software specifically tailored for the field of fashion design. Furthermore, given the focus on skill-based learning, this study is among the first to develop mobile application designs for skill training, further emphasizing its importance.

Pattern Making in Fashion Design

The Pattern Making Course is one of the fundamental courses included in both associate and undergraduate degree programs in the field of Fashion Design. Çeğindir (2017) defines pattern making as a two-dimensional or three-dimensional template of a garment, primarily in applied industrial production fields that combine both art and science, such as clothing design. In its simplest form, pattern making refers to the process of creating a garment based on specific proportions in either two or three dimensions.

The Pattern Making Course is one of the key subjects in skill-based instruction within the fashion design field. Skill is defined as "a person's ability to successfully complete a task and achieve an intended outcome based on aptitude and learning, demonstrating proficiency and mastery" (tdk.gov.tr). Today, the primary responsibility for educating fashion designers—who are knowledgeable about scientific research processes, capable of designing innovative, creative, aesthetic, and original garments that meet the needs of their target audience, and possess the necessary skills to produce their designs (Çınar, 2021: 16)—lies largely with Fashion Design undergraduate programs at universities. Fashion design curricula consist of courses that provide students with professional competencies, covering both design and the technical infrastructure of design. Competency can be defined as an individual's capacity to perform professional tasks according to a specific standard (Çelik & Kılınç, 2022: 265). Competency-based education, on the other hand, refers to the entirety of processes that prioritize what an individual can accomplish as a result of education (outcome-based), focusing on the development of the necessary skills, knowledge, and attitudes required to meet competency standards (Guthrie, 2009: 18). When designing a garment, a fashion designer must have a thorough understanding of the socio-economic structure of the target group, the ergonomic suitability of the design for the human body, the feasibility of the production process, the materials intended for use, and a sufficient level of pattern-making knowledge.

When examining undergraduate curricula in Fashion Design, it is observed that the Pattern Making Course is typically allocated 3 to 4 hours per program. Pattern-making education begins with fundamental pattern knowledge, where students are introduced to basic pattern techniques for garments such as skirts, trousers, blouses, and jackets through demonstration methods. Additionally, students engage in hands-on applications to learn how to create patterns for garments with diverse design features. The ultimate goal of pattern-making education is for students to transform their drafted patterns into three-dimensional garments and observe the final outcomes.

In large-scale production companies, the accuracy and quality of pattern-making processes performed by qualified professionals are of critical importance. In the fashion industry, the demand for skilled pattern makers—who possess extensive knowledge of pattern preparation—is continuously increasing. This highlights the necessity of improving both pattern-making expertise and its practical application. Given the significance of pattern-making education for the industry, it is essential to identify the learning challenges students encounter during pattern-making training and develop appropriate solutions to enhance their learning experience.

In the garment design process, which involves numerous stages, computer technologies play a significant role (Vural & Çoruh, 2012). With advancements in software, computer-aided pattern-making (CAD) systems have become increasingly prevalent in pattern-making processes, leading to faster product development, enhanced production efficiency, and shortened time-to-market for fashion products (Liu & Geng, 2003; Meng, Mok & Jin, 2010; Ural, 2019). The use of digital technologies in the fashion design industry has notably improved production efficiency, cost management, time management, model diversity, and, consequently, the support for creativity. The textile and fashion industry ranks among the top sectors in terms of natural resource consumption in raw materials and production processes. In this regard, 3D technologies offer promising innovations for reducing costs and waste generation. To effectively utilize these technologies, users must have a strong foundation in pattern-making, supported by high-quality training and the integration of technology into the learning process.

Importance of Study

In traditional teaching methods, learners remain passive as the instructor plans and delivers the lesson. As stated by Ataş and Delialioğlu (2016), shortcomings in instructional approaches encourage researchers and educators to integrate technology into learning environments. This need became even more evident during the COVID-19 pandemic, when remote education was mandated across all educational levels during lockdown periods. The importance of distance learning materials that enhance the quality of instruction became increasingly apparent during this time. The mobile learning application developed for the Introduction to Pattern Making Course is expected to positively contribute to the field by allowing students to engage with course-related applications independently of classroom hours and physical learning spaces. This would enable them to gain more hands-on experience and actively participate in their learning process outside of class, thereby internalizing the instruction. This study is considered significant because it introduces an innovative approach to the Pattern Making Course, both by employing a different instructional method and by integrating a curriculum-aligned mobile learning application into the course structure. Thus, it has the potential to enhance fashion design education by providing a technology-supported learning model.

Aim of the Study

This study aims to develop a mobile learning application for the instruction of the Pattern Making Course, which is one of the skill-based fundamental courses in the field of Fashion Design. In line with this objective, the following research questions were explored:

- What should be the content structure of the mobile learning application?
- How should the interface design, process sequence, and workflow of the mobile learning application be structured?
- What are the perceptions of instructors and students regarding the developed mobile learning application and flipped learning supported by mobile learning?
- How does student achievement change in flipped learning supported by a mobile learning application?

Method

The method of this study was systematically planned in stages based on the study's aim, the methods followed to achieve this aim, and the data to be collected. Accordingly, a Mixed-Methods Approach was employed. Mixed-Methods Research is defined as an approach in which the researcher collects and analyzes data, incorporates findings, and draws inferences by using both qualitative and quantitative approaches or methods within a single study or research program (Tashakkori & Creswell, 2007: 4). In conducting the study, one of the six different designs of Mixed-Methods Research, as defined by Creswell and Clark (2015), was adopted: the Multi-Stage Mixed Design Method. This design is described as "a cyclical approach in which one or a group of researchers examines a central program objective through sequentially connected quantitative and qualitative research phases, where each new approach builds upon previous findings". The Multi-Stage Mixed Design Method provides a comprehensive methodological framework for developing a general research or evaluation program, particularly for long-term, multi-phase projects (Creswell & Clark, 2015: 108).

In this study, the ADDIE instructional design model was utilized during the development of the mobile application and the design of the instructional environment for the Introduction to Pattern Making Course. Branch (2016) describes ADDIE as one of the most effective product development models, particularly for guiding complex situations and developing various learning resources. The ADDIE model consists of five phases:

- Analysis,
- Design,
- Development,
- Implementation, and
- Evaluation.

The ADDIE model, which follows a systematic instructional design approach, is widely used in processes such as distance education, educational website design, and interactive material development (Li, 2003; Branch, 2016; Shibley, Amaral, Shank & Shibley, 2020).

Analyze

In the analysis phase, the Introduction to Pattern Making course curricula in undergraduate Fashion Design programs were examined. This review included course semesters, weekly course topics, course duration, and ECTS (European Credit Transfer and Accumulation System) information. The analysis revealed that the course content is largely standardized across most universities. Based on this common content, a survey was developed to gather instructor opinions, with the aim of identifying the topics students find most challenging in learning and preparing content accordingly. The target population of the study consisted of instructors teaching pattern-making courses in Fashion Design undergraduate programs in Türkiye during the 2021-2022 academic year. Within this population, the sample group was composed of 22 instructors teaching the Introduction to Pattern Making course. The survey was sent online to all 22 instructors, and responses were received from 17 of them. An analysis of the demographic characteristics of the participating instructors showed that they held a range of academic titles, and more than 70% had over ten years of professional and teaching experience in the field. According to the frequency analysis, the topics that students struggled with the most were identified as "dart manipulation in skirts" and "pleat construction in skirts". Since dart manipulation serves as a fundamental topic for other aspects of pattern-making and is essential for knowledge transfer, it was selected—based on expert opinions—as the primary content focus for the mobile application design. The survey findings indicated that 82.35% of the instructors identified "pleat construction in skirts" as a difficult topic for students, while 76.47% pointed to "dart manipulation in skirts" as another major challenge (Çileroğlu & İnci, 2023)[4].

Design

During the design phase, the implementation of the flipped classroom system was planned. A two-week period was allocated for teaching dart manipulation content. Additionally, the detailed content structure for dart manipulations in skirts—covering the fundamental applications of the Introduction to Pattern Making Course—was determined. Based on the learning objectives and expected competencies, decisions were made regarding the information notes, audio narrations, video demonstrations, and interactive exercises to be included in the mobile application. The survey results guided the selection of specific subtopics related to dart manipulation, ensuring a structured and comprehensive content flow.

Given the practice-oriented nature of the course, a procedural instructional approach was employed in designing the content. In this approach, the instructor sequences the procedural steps for a task, allowing students to follow the steps systematically and complete the process. Smith and Ragan (2005) emphasize that subsequent procedural steps should build upon previous ones, enabling students to apply the learned procedure in unfamiliar and varied situations. They further state that procedural knowledge must be both demonstrated and practiced in real-life scenarios. Following a simple-to-complex progression, each topic was structured accordingly. After learning the content through the mobile application, students were required to share their completed activities via a social media-based interaction platform to facilitate a more interactive learning experience. WhatsApp was chosen as the preferred sharing platform due to the moderate sample size and the fact that students were already accustomed to using it in coursework. Additionally, a short end-of-topic assessment was designed within the mobile application, featuring multiple-choice and true/false questions.

The mobile application aimed to help students acquire basic concepts and techniques related to dart manipulation. More complex skirt pattern-making tasks were planned to be completed in face-to-face sessions under instructor supervision. At this stage, evaluation forms for both the flipped classroom model and the mobile application were developed. The mobile application evaluation form was structured under three categories: content, design, and usability. The questions within each category were prepared using a five-point Likert scale, drawing upon existing research

[4] Çileroğlu and İnci (2023) presented the research data in the paper titled "Topics Challenging for Students in Pattern Making-I Course in Fashion Design" at the 10th Akdeniz International Social Sciences Congress.

instruments for mobile application evaluation (Kalınkara, 2017; Demir & Akpınar, 2016). Additionally, instructor and student interview forms were designed to assess:

- The instructional flow in the flipped classroom model,
- The adequacy of mobile learning content,
- The number and scope of examples and exercises,
- The effectiveness of reinforcement activities,
- The overall contribution of the mobile application and flipped classroom to skill development.
- The final version of the evaluation forms was developed based on both literature review and expert opinions obtained within the scope of the study.

Development

In the development phase, the mobile application was programmed to be compatible with smartphones and tablets, ensuring alignment with the pre-designed content. Due to the financial support required for software development, a TÜBİTAK 1002-A project application was submitted and approved. To ensure full participation of students, the software was designed to be compatible with both iOS and Android-based smartphones. For the development of interactive features and gamified elements, the Unity game engine was utilized. Additionally, the flipped classroom model was implemented during this phase to integrate the developed material into the instructional process. Branch (2016:82) defines the key steps of the development phase as follows: Content production, Selection and development of supporting media, Preparation of a student guide, Preparation of an instructor guide, Process revisions, and Pilot testing. During this phase of the study, the content determined in the design stage was fully developed. The mobile application content was structured to break down information into smaller segments, following the step-by-step instructional approach (Bradly, Haynes, Cook, Boyle & Smith, 2009). The mobile application was designed to allow students to: Select measurements, Observe pattern alterations, and Engage in interactive activities to visualize and practice changes in patterns dynamically.

During the development phase, the mobile application was fully completed, and activities for both in-class and out-of-class use within the flipped classroom environment were planned. These activities included: Instructional materials for face-to-face lessons, Analysis tasks for students in the classroom, including the first-week and second-week skirt models, and Other in-class activities to reinforce learning. Additionally, the pilot testing of the mobile application was conducted in this phase. The pilot study was carried out with 42 students at Istanbul Arel University, all of whom had previously taken the Introduction to Pattern Making Course. Students were asked to use the mobile application for one week, after which their feedback was collected online using the mobile application evaluation form. The evaluation form included Likert-scale questions assessing: The content of the application, The design of the application and The usability of the application. The pilot test data collected from students indicated that they strongly agreed with the statements regarding content, design, and usability, with average scores ranging between 4.20 and 5.00 ($\bar{x}$=4.20-5.00). Based on the frequency, percentage, and standard deviation analyses, it was determined that the content was sufficient. Consequently, the same content was implemented in the classroom setting for further testing and evaluation.

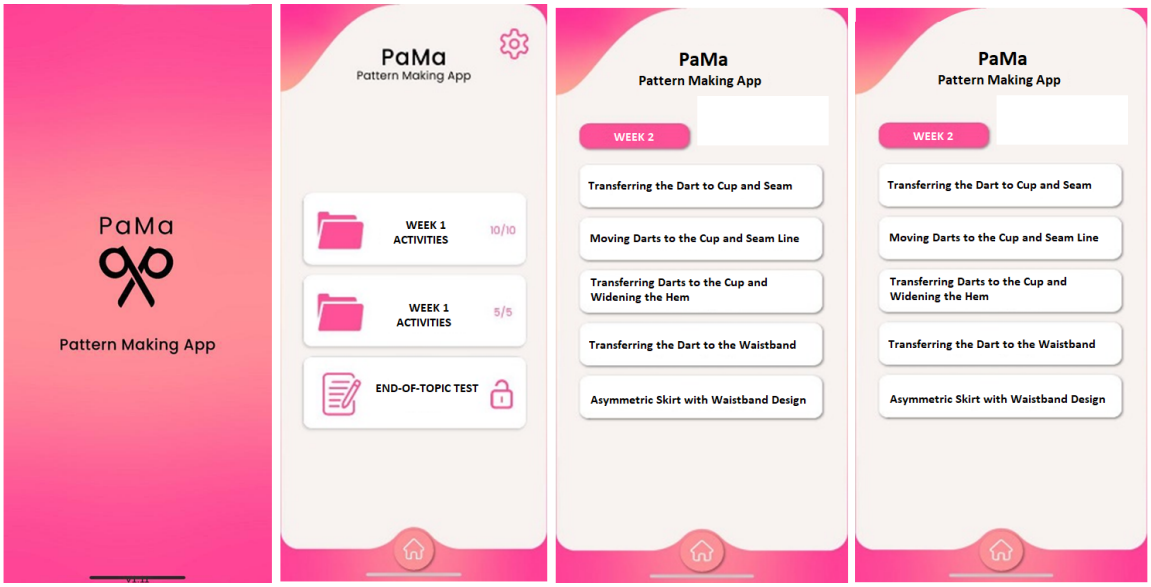

Figure 1. Logo design, application launch screen, and main menu

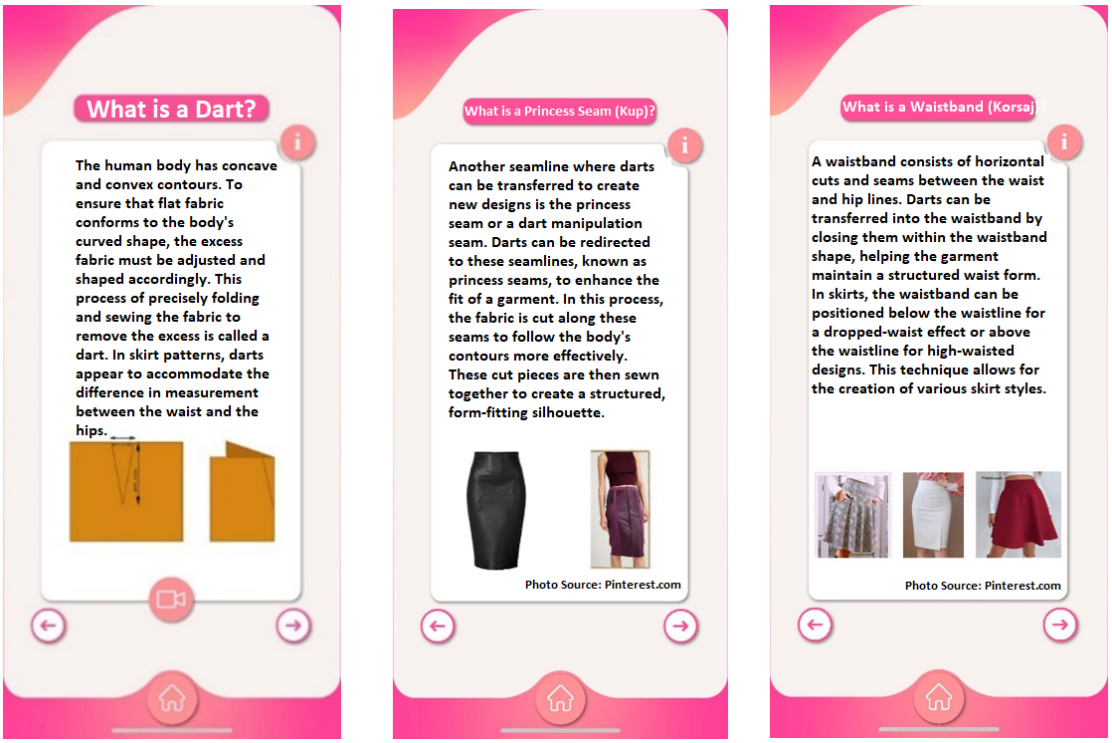

Figure 2. Examples of information notes in the application

When users click on each heading, they can access the corresponding content. The topic contents include: Information notes, Audio narration (represented by a speech bubble icon), Videos (indicated by a camera icon), A skirt visual representation (activated by clicking the eye icon), and An interactive feature that allows students to perform hands-on exercises (activated by the scissors icon). In the information notes, key concepts are defined and briefly explained, supported by visual illustrations.

When a student clicks the scissors icon, they can perform cutting operations on the screen, simulating the manual cutting process of traditional methods. The icons are color-coded: if an audio or video recording is available for a topic, the icon appears in a darker shade; if not, it is displayed in a lighter shade. Clicking the eye icon enlarges the skirt drawing on the screen. This function is designed to help students visualize the final skirt model by demonstrating how the pattern pieces come together after assembly.

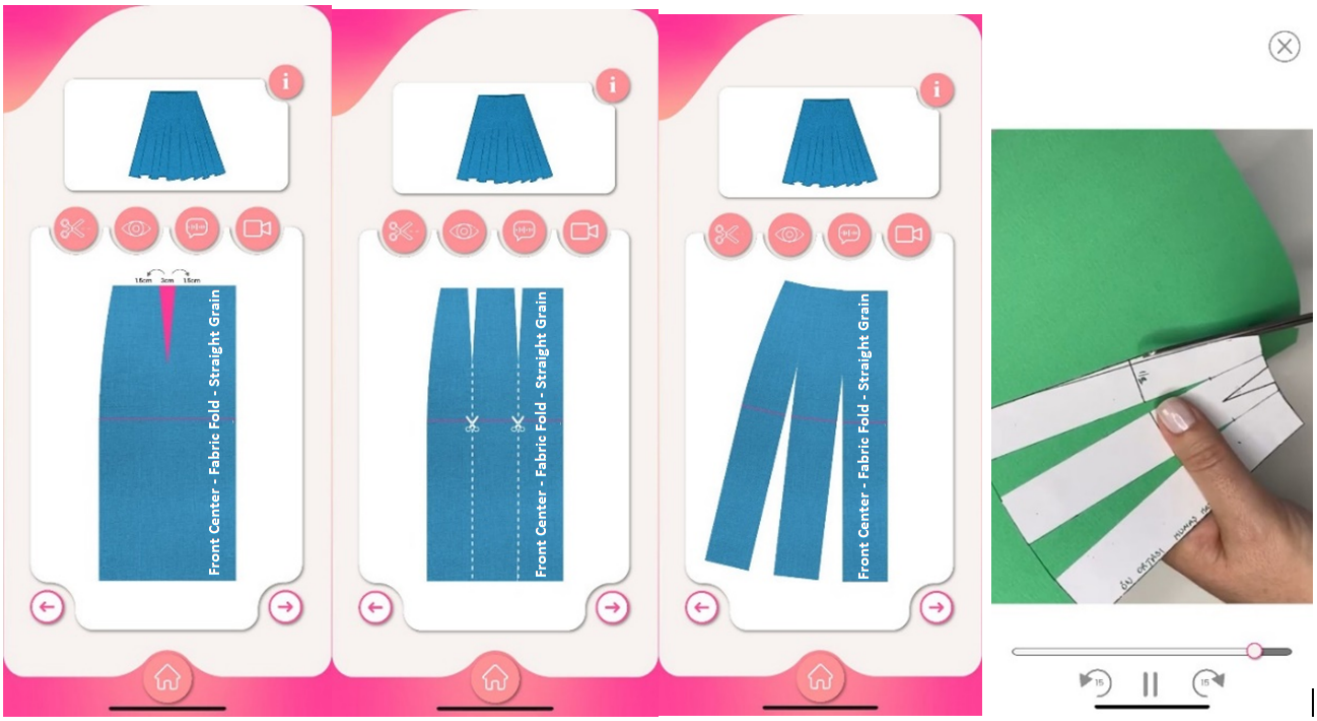

Figure 3. Interactive application and video of the two-point dart manipulation process

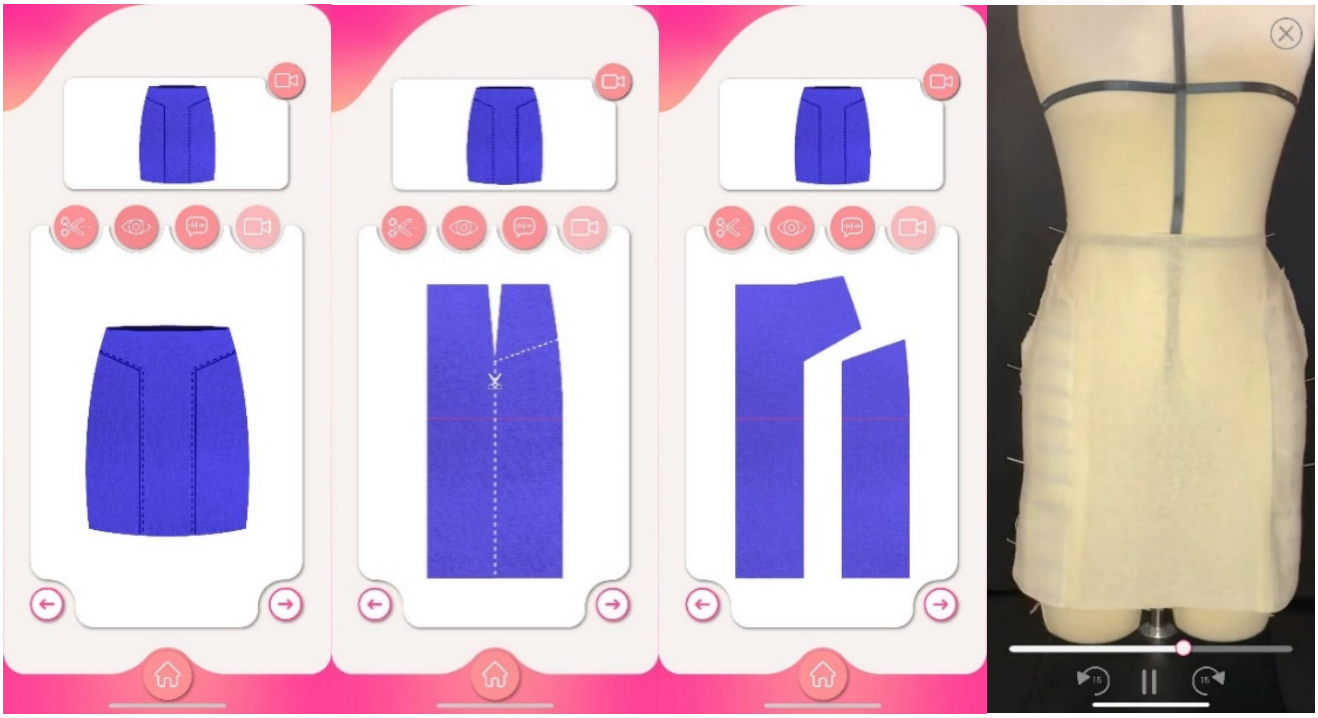

Figure 4. Princess-seamed skirt study screen and assignment video

When the camera icon on the screen is clicked, students can watch instructional videos that demonstrate the step-by-step process of the topic. The video player interface includes functions that allow students to: Fast-forward or rewind the video, and Pause the video at any desired point for better comprehension.

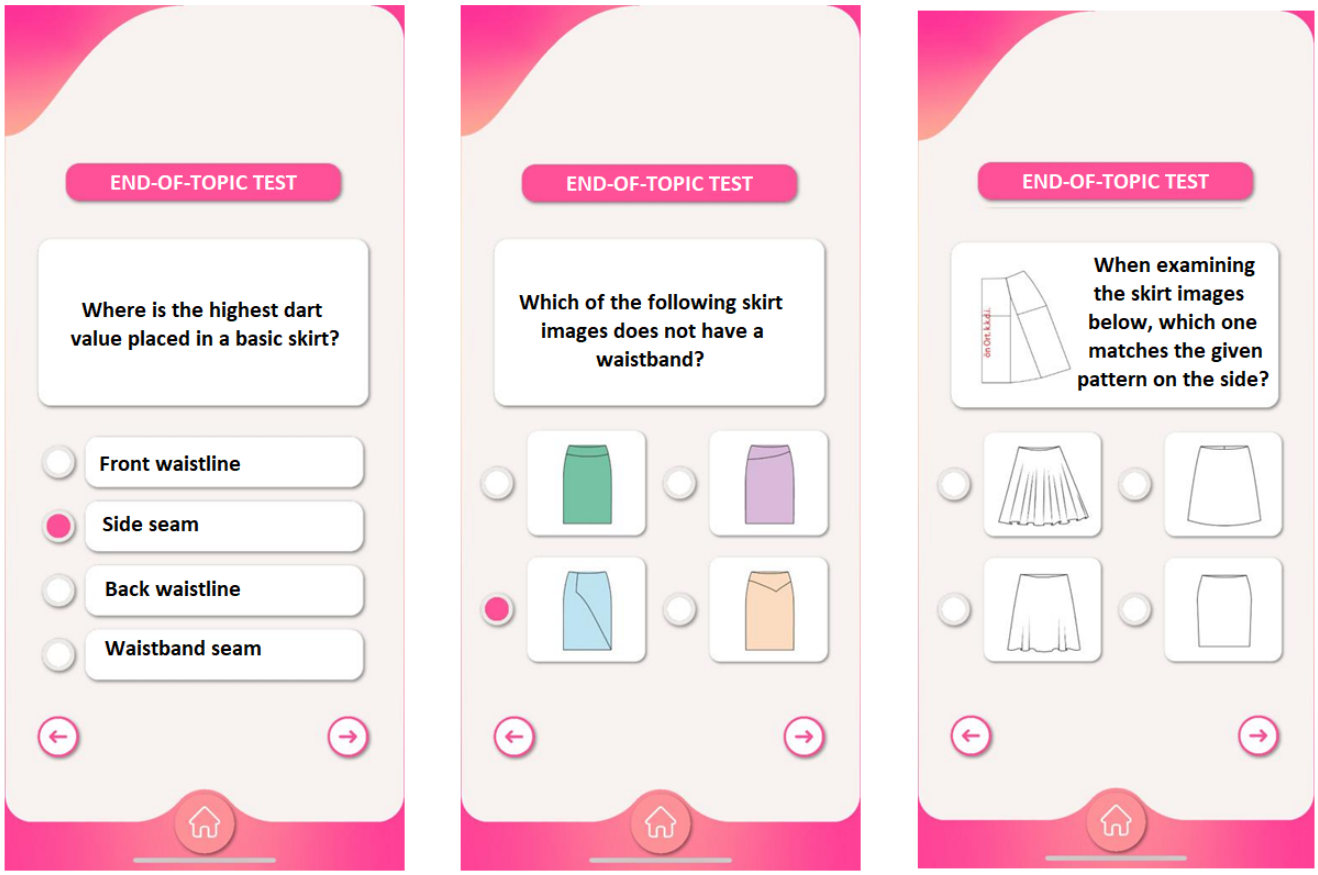

Figure 5. Examples of end-of-topic tests

The final test in the application is designed to allow students to review their correct and incorrect answers. Additionally, students receive a score out of 100 based on their performance.

Implementation

After the mobile application was developed, the students taking the Pattern Making Course in undergraduate Textile and Fashion Design Department in Turkey constituted the population of the research. From this population, 51 students who took the Pattern Preparation course for the first time in the Model Technical Drawing and Pattern Making Course in the Textile and Fashion Design Department of the Faculty of Fine Arts of Istanbul Haliç University in the Fall 2023-24 semester were determined as the sample of the research with the purposeful sampling method. While selecting the sample, the large number of students, the fact that the topics of skirt and trousers are given in the Model Technical Drawing and Pattern Making Course and the researcher's easy access to the university were taken into consideration.

During the implementation phase, the PaMa mobile learning application was used by students in a flipped learning environment for a two-week period as part of the Introduction to Pattern Making Course (offered under the course title Model Technical Drawing and Pattern Making) in the Textile and Fashion Design Department at Haliç University. The course consisted of two sections, both taught by the same instructor. Before the implementation, a preliminary briefing was provided by the researcher to the participating instructor and students, explaining: How the flipped classroom environment would be structured, How the mobile application would be integrated into the instructional design, and How the application should be used effectively within the course. This informational session on mobile application usage was conducted one week before the in-class implementation. For each student group, a WhatsApp group was created, including the instructor and the researcher, where students could share their work, ask questions, and engage in discussions about their assignments. During the implementation phase, students were required to complete mobile application activities related to each week's topic before attending class and to share their completed exercises in the WhatsApp group. Students used the mobile application for one week prior to the class session, allowing them to:

Practice pattern-making activities, Share their pattern exercises in the WhatsApp group, Ask questions to the instructor and Engage in discussions on alternative pattern solutions.

A meeting was held with the course instructor to plan the face-to-face component of the course. During the in-class instruction, the instructor was tasked with: Assessing students' prior knowledge through question-and-answer sessions at the beginning of the lesson, Answering students' questions related to the topic, and Evaluating students' understanding by assigning a skirt model analysis task that incorporated the knowledge and skills acquired through the mobile application. At this stage, the researcher provided the instructor with a model-based skirt visual, specifically designed to align with the mobile application content and activities. During the activity, the instructor: Distributed the visual to students, Asked students to write down the key characteristics of the model in the designated section on the worksheet and Posed questions about the pattern analysis and how the pattern should be structured. The instructor's role in the face-to-face sessions was designed as a facilitator, guiding students and supporting their progress throughout the learning process.

Evaluation

In the evaluation phase, the pre-test and post-test data collected from students who used the application for two weeks were analyzed. Additionally, semi-structured interview forms were administered to both instructors and students to assess their experiences with the mobile learning application and the flipped classroom model. The collected data were examined to evaluate perceptions of mobile learning and the flipped learning approach, as well as to determine the effectiveness of integrating mobile learning into the instructional process.

Findings

Below are the findings regarding instructor and student opinions on the flipped learning environment supported by the mobile application.

Instructor Opinions on the Flipped Learning Environment Supported by the Mobile Application

The instructor fully agreed with all statements related to the conceptual information provided in the mobile application. Regarding the design of the mobile learning application, the instructor expressed entirely positive opinions. Similarly, responses to questions about the usability of the application were generally positive. However, when asked about the ease of downloading the application, the functionality of animations and videos, and the application's stability during activities, the instructor partially agreed with these statements. The instructor noted that their mobile device was relatively old and had limited storage capacity, which was likely the cause of the technical issues experienced.

Regarding the flipped classroom environment supported by mobile learning, the instructor stated that it was their first time implementing an alternative teaching method in the course. The instructor observed that students engaged more actively in class since they completed the applications before attending the lesson and arrived better prepared for in-class model analysis tasks. One of the instructor's key observations was that the combination of conceptual explanations with visual support, followed by reinforcement through instructional videos, was one of the most beneficial aspects of the mobile learning application. Additionally, the instructor emphasized that the integration of mobile learning with the flipped classroom model significantly enhanced student motivation.

Student Opinions on the Flipped Learning Environment Supported by the Mobile Application

Below are the data collected from 51 students who participated in the study and used the mobile application in class for two weeks, along with the findings derived from these data.

Table 1. Student opinions on the ınformation provided in the application

Information Provided in the Application	N=51		SD		D		N		A		SA	
	M	SD	%	f	%	f	%	f	%	f	%	f
The information is clear and precise.	4,00	0,77			1,96	1	21,5	11	50,8	26	25,4	13
The information notes are sufficient.	3,98	0,75			3,92	2	19,6	10	54,9	28	21,5	11
The content of the example models is complete.	3,90	0,76			7,84	4	19,6	10	47,0	24	25,4	13
The reinforcement activities for the topics are comprehensive.	3,72	0,89	1,96	1	3,92	2	29,4	15	49,0	25	15,6	8
The video content is sufficient.	3,80	0,85	5,88	3	3,92	2	21,5	11	41,1	21	27,4	14
The video content is understandable.	3,98	1,09	3,92	2	1,96	1	13,7	7	52,9	27	27,4	14
The audio narrations are sufficient.	3,90	0,92	1,96	1	3,92	2	15,6	8	54,9	28	29,4	12
The audio narrations are clear.	4,86	0,86	1,96	1			15,6	8	52,9	27	29,4	15
The short quizzes are clear and understandable.	4,03	0,79	1,96	1	1,96	1	11,76	6	58,8	30	25,4	13

Note: 1.00–1.79 → **SD**: Strongly Disagree. 1.80–2.59 → **D**:Disagree, 2.60–3.39 →**N**: Notral, 3.40–4.19 → **A**:Agree, 4.20–5.00 → **SA**: Strongly Agree, **Sd**: Standard Deviation, **M**: Mean

Examining student opinions on the information provided in the application, the most notable findings are as follows: For the statement "The information notes are sufficient," 54.90% of students responded "Agree," while 21.56% selected "Strongly Agree." Meanwhile, 3.92% of students disagreed with this statement. The overall mean score for this item was $\bar{x} = 3.98$, indicating that students generally agreed with the sufficiency of the information notes.

For the statement "The video content is understandable," 52.94% of students responded "Agree," while 27.45% selected "Strongly Agree." Meanwhile, 1.96% of students disagreed with this statement. The mean score for this item was $\bar{x} = 3.98$, indicating that students generally agreed with the clarity of the video content.

For the statement "The audio narrations are sufficient," 52.94% of students responded "Agree," while 29.41% selected "Strongly Agree." In contrast, 1.96% of students strongly disagreed with this statement. The mean score for this item was $\bar{x} = 3.90$, showing that students agreed with the sufficiency of the audio narrations.

For the statement "The audio narrations are clear," 54% of students responded "Agree," while 24% selected "Strongly Agree." Meanwhile, 2% of students strongly disagreed with this statement. Since this question was answered by 50 students, the results were calculated based on n = 50. The mean score for this item was $\bar{x} = 4.86$, indicating that students strongly agreed with the clarity of the audio narrations.

For the statement "The short quizzes are clear and understandable," 58.82% of students responded "Agree," while 25.49% selected "Strongly Agree." Meanwhile, 1.96% of students strongly disagreed with this statement. The mean score for this item was $\bar{x} = 4.03$, indicating that students generally agreed with the clarity and understandability of the quizzes

In Table 1, which presents student opinions on the information provided in the application, the combined percentage of "Agree" and "Strongly Agree" responses for the short quizzes item reached 84%, demonstrating a predominantly positive perception.

The arithmetic mean values in Table 1 range from 3.40 to 4.19, indicating that most responses were concentrated in the "Agree" category. The only exception was the "The audio narrations are clear" item, where the arithmetic mean was 4.86, aligning with the "Strongly Agree" category.

Considering these findings, it can be concluded that the information provided in the application is adequate and appropriate.

Table 2. Student opinions on the design of the mobile application

Application Design	N=51		SD		D		N		A		SA	
	M	SD	%	f	%	f	%	f	%	f	%	f
The colors used in the mobile application interface are visually appealing.	3,88	0,69	1,96	1	1,96	1	21,5	11	54,9	28	19,6	10
The colors are harmoniously integrated.	3,94	0,81			1,96	1	19,6	10	60,7	31	17,6	9
The font type and size used in the application are appropriate.	4,03	0,68	1,96	1			13,7	7	60,7	31	23,5	12
The selection of visuals in the application is suitable.	4,07	0,74			1,96	1	13,7	7	58,8	30	25,4	13
The placement of animations and videos within the interface is appropriate.	4,05	0,68			1,96	1	13,7	7	60,7	31	23,5	12
The design of the drawing activities is well-structured.	3,90	0,69			3,92	2	19,6	10	58,8	30	17,6	9
The drawing activities are clear and understandable.	4,00	0,73			1,96	1	15,6	8	62,7	32	19,6	10
The placement of buttons required to complete tasks in the application is suitable.	3,84	0,68	1,96	1	1,96	1	21,5	11	58,8	30	15,6	8
The language used in the application interface is clear and comprehensible.	4,15	0,84					17,6	9	49,0	25	33,3	17

Note: 1.00–1.79 → **SD**: Strongly Disagree. 1.80–2.59 → **D**:Disagree, 2.60–3.39 →**N**: Notral, 3.40–4.19 → **A**:Agree, 4.20–5.00 → **SA**: Strongly Agree, **Sd**: Standard Deviation, **M**: Mean

Examining student opinions on the design of the mobile application, the most notable findings are as follows:

For the statement "The colors are harmoniously integrated," 60.78% of students responded "Agree," while 17.64% selected "Strongly Agree." Meanwhile, 1.96% of students disagreed with this statement. The mean score for this item was $\bar{x} = 3.94$, indicating that students generally agreed with the harmonious use of colors in the application.

For the statement "The font type and size used in the application are appropriate," 60.78% of students responded "Agree," while 23.52% selected "Strongly Agree." Meanwhile, 1.96% of students strongly disagreed with this statement. The mean score for this item was $\bar{x} = 4.03$, indicating that students generally agreed with the appropriateness of the font type and size used in the application.

For the statement "The placement of animations and videos within the interface is appropriate," 60.78% of students responded "Agree," while 23.58% selected "Strongly Agree." Meanwhile, 1.96% of students somewhat agreed with this statement. The mean score for this item was $\bar{x} = 4.05$, indicating that students generally agreed with the placement of animations and videos in the interface.

For the statement "The drawing activities are clear and understandable," 62.74% of students responded "Agree," while 19.60% selected "Strongly Agree." Meanwhile, 1.96% of students disagreed with this statement. The mean score for this item was $\bar{x} = 4.00$, indicating that students generally agreed with the clarity and understandability of the drawing activities.

Looking at Table 2, which presents student opinions on the design of the mobile application, it can be observed that the total percentage of "Agree" and "Strongly Agree" responses exceeded 75%, indicating a highly positive perception of the application's design.

The arithmetic mean values in Table 2 ranged between 3.40 and 4.19, showing that most responses were concentrated in the "Agree" category. Based on these findings, it can be concluded that students found the design of the application satisfactory and well-structured.

Table 3. Student opinions on the usability of the mobile application

Usability of the Application	N=51		SD		D		N		A		SA	
	M	SD	%	f	%	f	%	f	%	f	%	f
The application can be easily downloaded to a mobile device	4,45	0,80					9,8	5	35,2	18	54,9	28
The application pages load quickly	4,37	0,67					7,8	4	47,0	24	45,0	23
Animations and videos in the application open without issues	4,20	0,65	3,92	2			11,7	6	41,1	21	43,1	22
The forward, rewind, and pause functions in videos work smoothly	3,88	0,99	5,88	3	5,88	3	11,7	6	47,0	24	29,4	15
Audio narrations in the application play without difficulty	4,07	1,10	1,96	1			21,5	11	43,1	22	33,3	17
The forward, rewind, and pause functions in audio narrations work properly	3,90	0,87	3,92	2	3,92	2	17,6	9	47,0	24	27,4	14
Drawing activities can be performed without any issues	4,21	1,05					11,7	6	54,9	28	33,3	17
The forward and backward navigation between pages works smoothly	4,17	0,64	1,96	1			13,7	7	47,0	24	37,2	19
The application runs without errors during activities	4,05	0,82	3,92	2			15,6	8	47,0	24	33,3	17
The steps required to access content within the application are sufficiently clear	4,21	0,93			1,96	1	11,7	6	40,0	25	37,2	19
Accessing the desired content is easy	4,21	0,73	1,96	1			7,8	4	54,9	28	35,2	18

Note: 1.00–1.79 → **SD**: Strongly Disagree. 1.80–2.59 → **D**:Disagree, 2.60–3.39 →**N**: Notral, 3.40–4.19 → **A**:Agree, 4.20–5.00 → **SA**: Strongly Agree, **Sd**: Standard Deviation, **M**: Mean

Examining student opinions on the usability of the mobile application, the most notable findings are as follows:

For the statement "The application can be easily downloaded to a mobile device," 54.90% of students responded "Strongly Agree," while 35.29% selected "Agree." The combined percentage of these responses indicates that 90% of students expressed a positive opinion, suggesting that the majority of students did not encounter issues while downloading the application. The mean score for this item was $\bar{x} = 4.45$, indicating strong agreement.

For the statement "The application pages load quickly," 47.09% of students responded "Agree," while 45.08% selected "Strongly Agree." The mean score for this item was $\bar{x} = 4.37$, indicating strong agreement with the ease of page loading.

For the statement "Drawing activities can be performed without issues," 54.90% of students responded "Agree," while 33.33% selected "Strongly Agree." The mean score for this item was $\bar{x} = 4.21$, indicating strong agreement that the drawing activities functioned smoothly.

For the statement "Accessing the desired content is easy," 54.90% of students responded "Agree," while 35.29% selected "Strongly Agree," and 1.96% responded "Strongly Disagree." The mean score for this item was $\bar{x} = 4.21$, indicating strong agreement that students found it easy to access the desired content.

Examining the table data on application usability, the arithmetic mean values for six items ranged between 3.40 and 4.19, corresponding to the "Agree" category. Meanwhile, the arithmetic means for five other items ranged between 4.20 and 5.00, falling within the "Strongly Agree" category.

Based on these findings, it can be concluded that the usability features of the application align with user expectations and are effectively designed for instructional purposes.

Additionally, students were asked open-ended questions regarding their experiences with flipped learning supported by mobile learning. Responses to the first four questions were analyzed, and frequent similar expressions were identified to perform a frequency analysis for clearer data interpretation.

Table 4. Student opinions on whether the mobile application helped them understand the subject better

Student Opinions:	**f**	**%**
Clear, precise, and understandable	13	27
Helped reinforce the topic	15	31,25
Facilitated learning and enabled more effective learning	25	52
Provided visual learning support	7	14,58
Accessible at any time	6	12,5

**Students expressed multiple opinions. (n = 48)*

For the question *"Did the developed mobile application help you understand the topic better?",* 52% of students who responded "Yes, it helped" stated that the application made learning easier and enabled more effective learning. Additionally, 31.25% of students indicated that the application helped reinforce the topic. The feature of being accessible at any time was mentioned last, with 12.5% of students highlighting this aspect.

Table 5. Student opinions on which features of the mobile application were most beneficial for learning

Student Opinions	**f**	**%**
Video and audio narration	26	51
Interactive applications	18	35,29
Accessibility	5	9,80
Clarity of in-app activities	17	33,33

**Students expressed multiple opinions. (n = 51)*

For the question *"Which features of the mobile application do you find most beneficial for learning?"*, 51% of students identified video and audio narration as the most helpful feature, while 35.29% stated that the interactive student applications within the app were the most beneficial. Accessibility was mentioned the least, with 9.80% of students highlighting it as a key feature.

Table 6. Student opinions on the positive aspects of flipped learning supported by the mobile application

Student Opinions	**f**	**%**
Facilitates learning	16	47
Helps in coming to class prepared	7	20,58
Accessibility	12	35,29
Supports individual learning	17	50

**Students expressed multiple opinions. (n = 34)*

For the question *"What do you think are the positive aspects of flipped learning supported by the mobile application?"*, 50% of students stated that flipped learning supports individual learning, while 47% indicated that it facilitates learning.

Students were also asked, *"What additional features would you like to see in the mobile application?"*. Their suggestions included: Increasing the number of videos, introducing small rewards upon completing a topic, adding forums within the app for real-time support, incorporating adjustable playback speed for audio and video content, expanding topics to include different pattern-making techniques, enhancing existing features and adding measurement markings directly onto the patterns.

Table 7. Contribution of the mobile application to course motivation

Student Opinions:	**f**	**%**
Increased my interest in the course	32	62,74
Made learning easier	45	88,23
Increased my curiosity about the course	25	49,01
Provided easy access to course-related information anytime and anywhere	51	100
Made learning activities and the course more enjoyable	28	54,90
Allowed me to engage in learning activities at my own pace	28	54,90
Stimulated my motivation to learn the topic	31	60,78
Encouraged my sense of discovery about the topic	23	45,09

**Participants selected multiple options. (n = 51)*

For the question *"How did the mobile application contribute to your motivation for the course?"*, 100% of students stated that it provided easy access to course-related information anytime and anywhere. Additionally, 88.23% reported that it made learning easier, 62.74% stated that it increased their interest in the course, and 60.78% indicated that it stimulated their motivation to learn the topic.

The percentage distribution of responses demonstrates that the mobile application positively influenced students' motivation for the course.

Below are the average scores and *t-Test* results of the 47 students who completed both the pre-test and post-test.

Table 8. Comparison of participants' pre-test and post-test scores

Measurement	Mean	S	Difference	95% Confidence Interval		t	p
				Lower Bound	Upper Bound		
Pre-Test	9.49	2.68	-4.66	-5.45	-3.85	-11.54	.000
Post-Tet	14.15	2.12					

In the study, a paired-samples *t-Test* was conducted to examine whether there was a significant difference between the pre-test and post-test responses of the study group regarding the 19 questions on dart manipulation processes. The results indicated that the post-test scores were significantly higher, demonstrating a meaningful improvement in students' understanding after using the mobile application.

Conclusion and Discussion

The study aimed to propose a new instructional approach for the Pattern Making Course. The findings from student feedback collected during the implementation phase of the ADDIE model regarding the mobile application revealed the following:

- Students agreed with the information provided in the application ($\bar{x}$ = 3.40–4.19).
- Students agreed with the design of the application ($\bar{x}$ = 3.40–4.19).
- For the usability of the application, students agreed with six items ($\bar{x}$ = 3.40–4.19) and strongly agreed with five items ($\bar{x}$ = 4.20–5.00).

These results indicate that students had a positive perception of the content, design, and usability of the mobile application.

Evaluation results from the implementation phase of the ADDIE model showed that the instructor found the most beneficial aspects of the mobile learning application to be the use of visuals to explain key concepts, followed by the reinforcement of topics through videos. Similarly, Shalhap and Daher (2023) state that mobile learning supports cognitive engagement, particularly through videos, by integrating different tools in a modular format. The course instructor also emphasized that flipped learning supported by mobile learning enhanced student motivation.

Student evaluations of the PaMa mobile learning application were found to be highly positive. Students expressed that having access to information on their mobile devices without time and space constraints provided significant convenience and freedom. Existing research indicates that instructors can foster cognitive curiosity and engagement by recognizing the function of specific mobile activities, such as gamification tools (Shalhap & Daher, 2023). Students reported a high level of satisfaction with the visual representations of skirt patterns in the application, as well as with its interactive features. They stated that the mobile learning application significantly increased their motivation to learn in the Pattern Making Course, facilitated their learning process, and made the class more enjoyable. Studies conducted in various fields also suggest that videos and educational content facilitate learning, are cognitively stimulating and engaging, reduce anxiety levels, and enhance both academic success and course satisfaction (Willemse, Jooste & Bozalek, 2019; Ailoon & Delialioğlu, 2019; Bolatlı & Kızıl, 2021). Some students mentioned that the application occupied too much storage space on their phones, while others suggested adding a variable speed function for the videos. Although this feature was tested during the design phase, it was found that increasing playback speed caused students to miss critical details. Additionally, considering individual differences in learning styles, it was determined that excluding this function would be more appropriate for the application.

A significant difference was found between the pre-test and post-test scores of the study group before and after the implementation of flipped learning supported by mobile learning, indicating an increase in student achievement. Based on this result, it can be concluded that the mobile learning application had a positive impact on students' academic success. Similar studies support these findings. Ercan and Sönmez (2021) reported positive outcomes from their mobile learning application for Chemistry courses, while Nuanmeesri (2019) found similar results in undergraduate theoretical course modules. Likewise, Syahidi et al. (2020) developed a mobile learning application for engineering courses in vocational colleges, Oyelere et al. (2018) for computer technology system analysis and design courses, and Klimova (2019) for English language instruction, all of which demonstrated the effectiveness of mobile learning in improving academic performance.

Some students expressed that they did not find it suitable for flipped learning supported by mobile learning to be used throughout the entire course. When working on problems in class and teaching each other, students must engage in a different type of cognitive processing, which may enhance their learning. However, some students may initially find the flipped approach unsettling and may not fully embrace the shift from traditional methods, despite its learning benefits (Missildine et al., 2013; Strayer, 2012). Additionally, it is suggested that students in undergraduate education do not find a single method and content delivery approach sufficient, as they have expectations for a more varied learning experienceş.

Recommendations

Mobile learning provides students with individualized and self-paced learning opportunities, thereby promoting equal access to education. To ensure that students can fully benefit from this learning model, it is essential to expand internet access and improve connectivity.

This study focused on development and implementation-oriented data collection regarding mobile learning. Future research should consider expanding studies related to the Pattern Making Course in the field of Fashion Design by incorporating web-based online instructional methods. Researchers are encouraged to explore online teaching models alongside mobile learning applications to broaden the scope of instructional design in this area. Due to budget constraints, certain features such as forums or chat functions, which were initially intended to be integrated into the application, could not be included. Future studies should aim to develop more extensive in-app functions, such as animations and chat features, using low-memory-consuming methods to enhance the learning experience.

Additionally, for future research, it is recommended to include a wider variety of model visuals and patterns to help students better understand the relationship between skirt visuals and pattern structures. Furthermore, reinforcement assignments for extracurricular student activities should be planned to further support learning and skill development.

Given the individual differences among students, the workload planning for tasks they need to complete independently outside of class could be challenging. Additionally, instructors using this teaching method must actively respond to students' questions outside of class. Considering the course load in undergraduate Fashion Design programs for both students and instructors, it is suggested that flipped learning supported by mobile learning should be applied selectively to the topics students struggle with the most rather than the entire curriculum.

The developed mobile application is specifically designed for the Introduction to Pattern Making course in undergraduate Fashion Design programs and is limited to skirt dart manipulation, the most challenging topic for students in this course. Future research should explore similar applications for other topics and processes in pattern making.

The study focused on developing a mobile application for the Pattern Making Course. It is recommended that a similar study be conducted with a sufficient number of students by forming experimental and control groups to measure the application's impact on course success.

Considering the significance of developing high-value brands in our country's textile and ready-to-wear industry and competing with global brands, training skilled individuals capable of effectively transferring knowledge is crucial. Utilizing technological advancements to address instructional challenges in teaching Pattern Making, a fundamental

course in undergraduate Fashion Design programs, is considered essential for improving the learning process. In this context, considering that the Introduction to Pattern Making course is given at high school, associate and undergraduate levels, it is recommended that the developed application be included in the course as a teaching tool that will support students' individual learning and provide them with the opportunity to access basic information independently of the classroom.

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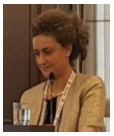

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