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Video-based microlearning and the impact on programming skills and technology acceptance

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Abstract

Microlearning is a modern learning modality that has been adopted in recent years for student education. This study aimed to reveal the effect of video-based microlearning on the development of programming skills and technology acceptance among intermediate school students. The study used a quasi-experimental design for two groups. A technology acceptance scale and a performance observation card for programming skills were prepared in order to collect data for the study. A cluster random sample of intermediate school students participated in video-based micro learning. The students were divided into two groups: the experimental group (consisting of 31 students) and the control group (consisting of 32 students). The results of the study showed that there were statistically significant differences between the mean scores of both study groups in favor of the experimental group in the post-application of the performance observation card for programming skills. However, there were statistically significant differences between the mean scores of the students in the experimental group in the pre- and post-application of the technology acceptance scale in favor of the post application. The study suggested that computer teachers might benefit from employing video-based microlearning to teach students programming skills at different stages based on these results. Suggestions related to the research findings are also provided.

Keywords: Education technology, Design instructional, Microlearning, Programming skills, Technology acceptance, Video.

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Contents

Contribution of this paper to the literature
This study expands the existing frame of research on video-based microlearning, a key form of microlearning by demonstrating its effectiveness in enhancing students' programming skills. Additionally, it investigates student receptivity to this technology providing valuable insights that may encourage teachers to adopt video-based microlearning as a strategy for improving students' skills.

1. Introduction

One of the most important skills for students to have in the twenty-first century is programming which has resulted in an increase in interest in teaching (Hu, 2023). Programming is the way instructions are given to a computer in a language that it understands to perform a task. It consists of a set of skills such as identifying a suitable programming language, designing or formulating a problem-solving solution and coding (Yeom, Herbert, & Ryu, 2022).

Many studies have indicated that teaching programming skills goes beyond achieving educational objectives. Popat and Starkey (2019) explained that teaching programming leads to the acquisition of critical thinking and problem-solving skills and cultivates the ability to be creative. Pila, Aladé, Sheehan, Lauricella, and Wartella (2019) said that teaching programming contributes to promoting information and communication literacy. Teaching young children the basics of programming can develop their interest in programming concepts and related skills.

However, there are some challenges. When it comes to programming curriculum in schools, students may feel that learning programming is a difficult task that causes anxiety and stress. Learning programming abilities is not always simple (Terroso & Pinto, 2022). Alsuhaymi and Alotaibi (2023) agreed that learning programming skills is difficult because of the nature of the content and its complexity. They suggested using interactive technologies that arouse students' interest while they are learning and encourage them to acquire skills. Bers, González-González, and Armas–Torres (2019) encouraged providing the best opportunities for students to learn programming and its skills in kindergarten, elementary school and secondary school. Yahya and Jumaat (2023) suggested that using appropriate teaching methods and technologies help students learn programming skills given their importance and the influence of learning programming on career opportunities.

Some researchers have encouraged the use of educational technology materials in the education process. Microlearning environments have emerged as one of the most notable digital innovations in education that have attracted the interest of scientists and researchers (Al-Nasheri & Alhalafawy, 2023; Alshehri, 2021). Microlearning which is frequently offered in online learning settings is the splitting of instructional content into smaller more manageable pieces. This allows students to absorb, store and retrieve knowledge more readily than through traditional teaching methods (Heath & Shine, 2021). Khong and Kabilan (2022) defined microlearning as an approach in which educational content is presented briefly and at a specific time using text, images, infographics and videos. Similarly, Allela, Ogange, Junaid, and Charles (2020) defined it as providing instructional content in small, well-planned and well-divided learning units of short duration to enhance learning efficiency.

Microlearning's foundation is based on short, targeted interactions. It comprises presenting brief material extracts from longer course units. These self-contained units should be meticulously organized, media-rich and adaptable to diverse learning styles (Wang, Towey, Ng, & Gill, 2021).There are several forms and styles of microlearning that are specialized for specific media or technologies. These include useful infographics, entertaining instructional games, short audio clips, visually appealing art, interactive information that encourages engagement and videos (Allela, 2021; Alshehri, 2021; Wang et al., 2021). Indeed, video is the most time-efficient and easily accessible multimedia technology and is the cornerstone of microlearning delivery. It facilitates comprehension and long-term knowledge retention making it the most interactive learning modality for learners (Mali, Sonawane, & Jadhav, 2021). The literature has explored the factors driving the proliferation of microlearning and its emergence as a topic of discussion among certain specialists. The focus on condensing the main ideas that the teacher wants to get across and explain to the students is one of the main reasons behind this. Essentially, a teacher can summarize a long lecture on a certain topic into a brief presentation or video that reinforces the main learning goals (Scaglione, 2019). Some authors have demonstrated the significant role that microlearning plays in improving students' cognitive achievement and learning ability (Major & Calandrino, 2018; Sahin & Kırmızıgül, 2023). Major and Calandrino (2018) revealed that microlearning positively contributed to an improvement in the academic performance of students with both behavioral and cognitive issues. Similarly, Skalka and Drlík (2020) emphasized the effectiveness of microlearning in developing students' learning skills. Furthermore, Gün and Kırmızıgül emphasised the rise of microlearning as a modern, successful and perfect teaching strategy for students in the twenty-first century. As a result, studies on this topic are valuable and further research is required to explore deeper into the subject.

Recent studies have emphasised the significance of future research into video-based microlearning to assist develop an understanding of its contributions to the educational process (Al-Maliki, 2021; Al-Nasheri & Alhalafawy, 2023; Al-Shahrani, 2022). Therefore, there is a need for a study to explore the effect of video-based microlearning on the acquisition of programming skills for intermediate school students because of the difficulty of the educational content and to identify the acceptance of this technique by students during learning. Kaur and Raskirat (2020) emphasised the crucial importance of research on technology acceptance in educational contexts highlighting the ability to lead educated decisions about the use of technologies in a variety of educational contexts.

2. Study Problem

The researcher identified and formulated the study problem as follows:

2.1. *Students' Low Level of Programming Skills*

Several recent studies in Saudi Arabia have addressed programming skills and indicated that learner level is poor. A study by Alkhalifah, AL-Nssayan, and AL-Shargabi (2020) discovered that students in Saudi education struggled to learn programming and that additional study was required to understand this issue due to the traditional methods used in teaching programming lessons in computer courses. Similarly, Al-Othman and Almawash (2020) emphasized the need to develop computer curricula, methods and techniques especially programming skills and recommended that further studies be conducted in this field. This emphasises the importance of addressing intermediate school students' lack of programming skills.

Additionally, Al-Qarni and Omran (2021) demonstrated a weakness in programming skills among intermediate school students and the need to develop programming skills using an attractive and exciting method.

Alsuhaymi and Alotaibi (2023) identified the programming unit as a significant source of student difficulty characterized by difficulties in comprehension and assimilation based on their considerable teaching experience in computer science and technology in Saudi Arabia. They identified this gap after interviewing several computer supervisors and were able to confirm their perception that students' computer skills were declining with a focus on programming capability.

According to the opinions of the teachers and computer administrators, the researcher discussed programming-related topics. Programming is a complex subject that requires in-depth comprehension, reasoned actions and studies that enhance the educational process. The researcher conducted interviews with a few computer and information technology teachers.

2.2. Level of Technology Acceptance for Video-Based Microlearning

The growing integration of technology within the educational landscape poses a substantial challenge for teachers. This imperative to seamlessly blend skill development with technological application necessitates intensified dedication and meticulous time management strategies (Criollo-C, Guerrero-Arias, Jaramillo-Alcázar, & Luján-Mora, 2021). However, the vast potential of technology-driven learning and pedagogy cannot be overstated, for it demonstrably empowers students to cultivate their technical capabilities, hone their problem-solving acumen and refine their critical thinking proficiencies (To'raqulovich, 2021). Furthermore, Al-Shahrani (2022) underscores the amount of technology currently available in the field of education making it important to research the extent to which this technology is accepted by learners. Mazrur, Jennah, Mujib, and Jamalie (2023) and Nagy (2018) reviewed the literature and discovered that studies on technology acceptance in education have examined how learners behave with respect to various technologies and how willing they are to learn through them. This has led to expectations and self-perceptions about how willing people are to use a given technology. Hence, it is crucial for education researchers to analyse the adoption of technology among several users in order to better understand learners' satisfaction with technology and educational innovations to save time and money and enhance learning outcomes. Accordingly, the researcher recognizes the need to develop intermediate school students' programming skills through a computer and information technology course that uses video-based microlearning and measures the acceptance of this technology by intermediate school students.

2.3. Research Questions

What effect does video-based microlearning have on the following?

a) Practical programming skills in a computer and information technology course.
b) Technology acceptance among students of a computer and information technology course.

The following two hypotheses were formulated to find the answer to this question:

2.4 Research Hypotheses

H01: There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the students of the study groups in the post-application of the performance observation card for programming skills.

H02: There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the students in the experimental group in pre- and post-application of the technology acceptance scale.

2.5. Study Importance

- The literature study revealed a research gap concerning the use of video-based microlearning to foster programming skills and assessing intermediate school students' adoption of this technology.
- It highlights the value of using video-based microlearning in the development of different and diverse skills.
- It encourages similar experiments with different technologies to be performed and contributes to the improvement of learning environments.
- Furthermore, this research can draw educational supervisors' attention to the importance of providing professional development for teachers about video-based microlearning and how to employ it in teaching.

2.6. Study Objectives

This study aims to achieve the following objectives:

- To design video-based microlearning to develop programming skills for intermediate school students in the computer and information technology course.
- To measure the effect of using video-based microlearning on the development of intermediate school students' programming skills and their acceptance of technology.

2.7. Terms Used in the Study

Microlearning: The goal of this learning approach is to improve the programming abilities outlined in the computer and information technology course by reducing educational content into short, targeted digital videos that last no longer than three minutes.

Programming skills: The third-grade intermediate school in Saudi Arabia's computer and information technology course lists HTML programming abilities as one of the required competencies.

Technology acceptance: This is a measurement of the study sample's acceptance of learning through video-based microlearning based on a scale the researcher designed.

3. Literature Review

3.1. Video-Based Microlearning

The concept of microlearning emerged in 2005 with Research Studios Austria initially defining it as 'learning in small steps (Kossen & Ooi, 2021). According to Gutierrez (2018), microlearning is defined as an instructional strategy that divides knowledge into condensed and targeted units that provide learners with the exact knowledge they need to meet learning objectives. Al-Maliki (2021) further emphasizes that video-based microlearning is an increasingly popular learning method and one of the most widespread microlearning applications. Video-based microlearning relies on several components such as kinetic, auditory and visual effects including text, shapes, graphics and colors. Microlearning in the classroom and in an e-learning environment relies on the presentation of educational content using multimedia (e.g., text, sound, music, pictures, graphics and videos) that is organized and presented in short and attractive segments to facilitate the learning process. Microlearning has distinct characteristics (Al-Maliki, 2021; Sahin & Kırmızıgül, 2023) including the following:

- Small units that facilitate the reception of information and understanding of the relationships among them.
- Education units that each address a single learning objective and are presented quickly (usually 2–5 minutes).
- A variety of auditory and visual stimuli.

Additionally, the microlearning style is consistent with the theory of cognitive load which underscores the importance of the amount of information being presented to learners commensurate with the learners' mental capacity (Kossen & Ooi, 2021). The dual-coding theory suggests that the way in which information is presented and how learners encode it determine how easily information is retained and remembered. Information presented in both visual and verbal forms is more likely to be recalled than information presented in a single format. The microlearning approach aligns with these theories (Al-Maliki, 2021). Several researchers (e.g., (Friedler, 2018; Pappas, 2016; Sahin & Kırmızıgül, 2023)) have found that the most important advantages of using microlearning is for all student. It is usable for all courses. It helps with student motivation, recognizes individual differences among students and supports individual learning, easy retrieval of information and a perception of relations among information and concepts. Newgen Enterprise (2018) has stated that video-based microlearning is an important new trend in the education process and that they expect to see a significant increase in its use in education because it contributes significantly to the development of various types of knowledge and skills.

3.2. Programming Skills

Programming is an integral component of computer science (Ismail, Ngah, & Umar, 2010). The teaching of programming as an introductory course has gained momentum within educational institutions worldwide. This reflects the global understanding that programming proficiency is a fundamental skill that requires development (Alsuhaymi & Alotaibi, 2023). Programming skills encompass the technological process of instructing a computer to execute specific tasks for problem-solving. This collaborative endeavor involves humans' crafting instructions (code) in a language comprehensible to computers enabling them to carry out those instructions (Coursera, 2023). Programming can be extremely challenging for students due to its mostly abstract nature which frequently results in comprehension issues (Ismail et al., 2010; Tsai & Lai, 2022) .Biju (2018) advocated for a shift from traditional theoretical programming instruction to an approach that emphasizes the immediate application of concepts. He argued that this shift is crucial to bridge the gap between theoretical knowledge and practical application. Similarly, Xia and Liitiäinen (2017) stated that picking the appropriate teaching method is essential to improving students' programming skills.

3.3. Technology Acceptance

The rapid development of communication media, communication devices, software and applications and teaching and training methods has encouraged educational institutions to invest in the field of education. However, many technologies used in the field of education have ultimately failed to fulfill their intended role (Reich, 2020; Stallard & Cocker, 2014). Studying various technologies used in the educational process is important to help decision-makers adopt the tools most appropriate for students in economic, administrative and practical environments (Kaur & Raskirat, 2020).

Technology acceptance can be defined as a user's willingness to employ technology for the tasks it is designed to support (Teo, 2011). Xiong (2018) defined technology acceptance as the way in which students perceive, accept and adopt the use of technology. He noted that when acceptance is achieved, students become the users of the technology.

Murillo, Novoa-Hernández, and Rodriguez (2021) added that users' levels of satisfaction with technology are necessary and can be measured using the technology acceptance model (TAM). The TAM assesses a user's perception of a technology and evaluates the adoption of technology over time (Fauzi, Wandira, Sepri, & Hafid, 2021). The TAM can forecast a user's attitude towards technology, their behavioral intent to adopt it and ultimately their actual usage behavior (Al-Rahmi et al., 2021). The present study benefited from this model in designing a measure of technological acceptance of video-based microlearning technology.

4. Methodology

This study relied on the quantitative methodology as follows:

- The descriptive approach: This approach was used to describe and analyze previous research and studies, construct a list of criteria for video-based microlearning design and build the study's processing and measurement tools in addition to its contribution to the interpretation and discussion of the results.
- Experimental approach: This approach using a quasi-experimental design was used to measure the effect of video-based microlearning (see Figure 1).

Group	Pretest	Experimental treatment	Posttest
Control group	Performance observation card & technology acceptance scale	Traditional teaching	Performance observation card
Experimental group		Video-based microlearning	Performance observation card and technology acceptance scale

Figure 1. Experimental treatment procedures.

4.1. The Study Population and Sample
4.1.1. Study Population
It consisted of third- grade intermediate school students of public schools affiliated with the Hafr Al-Batin Education Directorate during the first semester of 2022 and it included a total of 2,914 students in 39 schools.

4.1.2. Study Sample
The study followed the cluster random sampling technique for the study sample. A number of considerations were taken into account when selecting students for the study groups: students who did not complete any of the pre- or post-measurements and any student from the study groups whose absences exceeded 25% of the total experimental treatment hours were excluded. Table 1 shows the distribution of the study sample members in the first experimental group, the second experimental group and the control group to which the research materials and tools were applied.

Table 1. The distribution of the study sample.

Group	Total students in the classroom	Research students
Control group	33	32
Experimental group	34	31
Total number of study samples	67 students	63 students

It is clear from Table 1 that the size of the study sample as a whole was 67 students and there has been a change in sample size during the pre- and post-measurement of the study tools due to the absence of some students from one of the two applications. Therefore, after adoption and statistical analysis, the study sample's true size was determined to be 63 students. 32 students were in the control group and 31 students were in the experimental group.

4.2. Study Treatment Materials
This study designed video-based microlearning by adopting the instructional design model Analysis, Design, Development, Implementation, and Evaluation (ADDIE) and taking into account general guidelines for multimedia design (Mayer, 2014) for the following reasons:

- The applicability of the ADDIE model in the current study is due to its compatibility with the data and objectives of the study.
- The flexibility of the proposed design model in terms of adding a subprocess or modifying a step.

4.2.1. ADDIE Model
The ADDIE model includes five main stages (see Figure 2): analysis, design, development, implementation and evaluation.

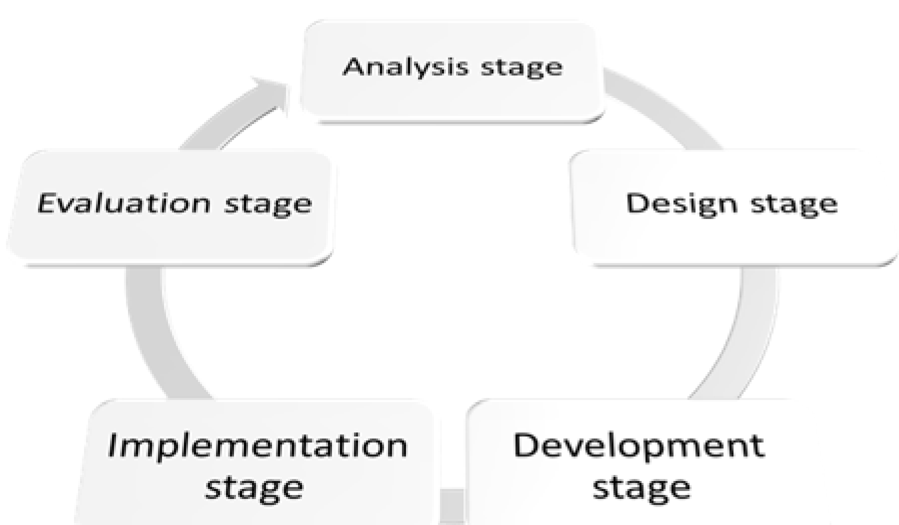

Figure 2. ADDIE model.

These stages were implemented as follows:

4.2.2. The Analysis Stage

This is the starting point for the design, development and evaluation processes and it aims to draw a detailed map of the subject as a whole. The analysis stage consists of several steps:

- Needs assessment: Develop intermediate school students' programming skills through the computer and information technology course that uses video-based microlearning and measure the acceptance of this technology by intermediate school students.
- Content analysis: Examine the educational content for programming skills in the computer and information technology course to identify the lesson objectives, concepts and skills to be achieved.
- Analysis of student characteristics: Identify the study sample's capabilities and possession of the basic skills for dealing with computers and using software through discussion with the course teacher and students.
- Analysis of resources and constraints in the learning environment: Provide a learning environment with a computer lab connected to the internet with a capacity of 35 students.

4.2.3. The Design Stage

A number of relevant studies by Al-Maliki (2021) and Al-Shahrani (2022) training courses were reviewed for guidance during the design stage which consisted of the following steps:

- Prepare a list of behavioral objectives: The computer and information technology course content included 10 behavioral objectives. Each objective was placed at the beginning of the video to help students understand the purpose of the content.
- Select media and digital elements: The output of this stage is the selection of digital media (e.g., still images, animations and educational illustrations) related to the educational content while considering the educational aspects associated with it.
- Organize content and sequencing its presentation: The educational content has been divided into 10 parts; each part addresses a specific goal and provides focused educational content that addresses a skill aimed at achieving the stated objective, designing scenarios for educational strategies and applying them to all the produced clips. This strategy starts by introducing concepts, then skills followed by practical application and finally a set of self-evaluation questions.
- Determine measurement tools: The researcher designed the following measurement tools to achieve the study objectives: The performance observation card for programming skills aims to identify the effect of video-based microlearning on intermediate school students' programming skills in the computer and information technology course. The technology acceptance scale measures the level of acceptance of learning technology through video-based microlearning technology to develop programming skills among intermediate school students.

4.2.4. The Development Stage

In this stage, the abovementioned descriptions were converted into instructional products using the website of the animated video creation tools platform to design video-based microlearning (https://www.vyond.com). Vyond is a platform dedicated to designing video clips and the researcher has previous skills and experience with Vyond. In addition, Adobe Photoshop was used to edit some images and graphics and10 video-based microlearning units were produced using the Vyond site.

4.2.5. The Application Stage

- The researcher performed the following procedures before applying the product to the study sample: The produced digital content was piloted on a sample of students from the study population and outside the selected sample to verify the validity of the digital content for the experiment on the study sample to ensure the integrity and clarity of the instructional content.
- The advantage of feedback taken from the pilot application was used to make the final modification.

4.2.6. The Evaluation Stage

Evaluation is an ongoing process carried out at different stages during the formation of the clips and through the experimental operation in addition to discussions with some specialists and teachers of computer and information technology whereby information was collected and the proposed modifications were introduced.

4.3. Preparation of Measurement Tools

4.3.1. The Performance Observation Card for Programming Skills

The observation card has been designed through the following steps:

1. Determining the objective of the observation card: The observation card aims to identify the effect of video-based microlearning on intermediate school students' programming skills in the computer and information technology course.
2. The observation card building sources: The researcher relied on a list of programming skills specified in the computer and information technology course which included 14 skills.
3. The initial formulation of the observation card phrases: The construction of the phrases on the observation card required identifying the behavioral aspects to be observed and ensuring that the phrases concisely, specifically, clearly and accurately describe the performance they were designed to measure.
4. Determination of the skill assessment method of the observation card: A quantitative assessment method was used for the observation card based on four options scale (high, medium, low and poor level of a skill

performance) with an explanation of each performance and an illustration of the performance assessment method after consulting a number of specialists in measurement and evaluation as shown in Table 2.

Table 2. The assessment method of the observation card.

Level	Explanation of skill performance level	Score
High	The student performs the skill perfectly the first time without teacher direction.	4
Medium	The student performs the skill perfectly after several attempts and with only one direction from the teacher.	3
Low	The student does not perform the skill perfectly.	2
Poor	The student does not perform the skill.	1

5. Verification of the observation card validity: After the initial form of the observation card was prepared and instructions were written, it was presented to eight arbitrators specializing in curricula and teaching methods, education technology, computers and psychology to benefit from their opinions, notes and experience.
6. The pilot application of the observation card to an exploratory sample: The observation card for programming skills was applied to a random sample from the study population and outside the study groups which included 25 students so it is similar to the study sample.
7. Verification of the consistency of the performance observation card: The researcher used the Cooper equation to calculate the percentage of agreement between the observers by calculating the items of agreement and disagreement in the two observation cards of both the researcher and the teacher. The agreement percentage was 91.428% which is a high percentage given the nature of personal observation and it indicates that the performance observation card tool has a suitable degree of consistency and is suitable for measuring what it is designed for.
8. Adoption of the final form of the performance observation card: After completing the previous steps, the final form of the performance observation card was adopted.

4.3.2. The Technology Acceptance Scale

The technology acceptance scale was designed based on the following steps:

1. Determining the objective of the scale: The aim of the technology acceptance scale is to measure the level of acceptance of learning technology through video-based microlearning technology to develop programming skills among intermediate school students.
2. The technology acceptance scale building sources were as follows:

- Benefiting from previous studies that dealt with technology acceptance models and measures, the most important of which are Al-Rahmi et al., 2021; Al-Shahrani, 2022; Fauzi et al., 2021; Mazrur et al.' 2023 studies.
- Technology Acceptance Model (TAM).
- Interviewing a group of experts and specialists in the fields of curricula, teaching methods, education technology and psychometrics as well as educational supervisors and teachers who have prior technological experience.

3. The formulation of the statements on the technology acceptance scale. The scale consisted of 15 statements. The scale building sources showed that several factors were considered in the formulation of the scale statements.
4. Correction method for the technology acceptance scale. The scale correction was made using the 5-point Likert estimation method because it is suitable for students.
5. Verification of the validity of the technology acceptance scale. After the scale was prepared in its initial form, it was presented to a group of experts and specialists for their opinion.
6. Technology acceptance scale exploratory experiment: The scale was applied to a random sample from the study population and outside the study groups which was 25 students to ensure it was similar to the study sample.
7. Technology acceptance scale consistency: The Cronbach alpha equation was used to ensure the consistency of the scale after applying it to the exploratory sample. The general consistency of the scale was 0.881 which is an acceptable degree of consistency.
8. The final form of the scale: After confirming the above-mentioned procedures, testing the scale and verifying its validity and consistency, the final form of the scale was adopted which consisted of 15 statements.

4.4. Experimental Treatment Procedures

Control over variables: A number of procedures have been taken to verify the control over external variables to isolate them, prevent their impact on the research results or exclude them if they are confirmed to be available in the experiment groups.

Pre-application procedures: The performance observation card and the technology acceptance scale were applied at the beginning to the study groups. Levene's statistic test was used to understand the homogeneity of the groups. Table 3 shows the following results:

Table 3. The pre-application of the study tools to verify the equivalence of the study groups.

Study tool	Group	Mean	Standard deviation	Levene value	Statistical significance
The observation card	Control group	15.709	3.699	0.297	0.744
	Experimental group	16.322	3.411		
The technology acceptance scale	Control group	26.290	8.618	0.157	0.855
	Experimental group	24.967	8.540		

It is clear from Table 3 that there are no statistically significant differences at the level of significance (0.05) between the members of the experimental and control groups in the pre-application of the performance observation card and the technology acceptance scale which indicates the equivalence of the members of the study groups.

5. Findings

Results related to the question: What effect does video-based microlearning have on the following?

- Practical programming skills in the computer and information technology course.
- Technology acceptance among students of computer and information technology course.

The following two hypotheses were formulated to find the answers to this question:

The first hypothesis (H01): There were no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the study groups' students in post-application of the performance observation card for programming skills.

The significance of the differences between the mean scores of the study groups was calculated using the *t*-test for independent samples and Eta-square test $\eta 2$ to calculate the size of the effect between the independent samples in the post-application to verify the validity of this hypothesis. Table 4 shows the following results:

Table 4. T-test results for independent samples in the post-application of the performance observation card for study groups

Study tool	Group	Mean	Standard deviation	t-value	Significance	Eta-square η2
The observation card	Control group	31.749	6.831	2.131	0.744	0.220
	Experimental group	36.280	4.270			

Table 4 shows a *t* value (2.131) with statistical significance (0.744) which means that there are statistically significant differences at the $\alpha \leq 0.05$ level between the mean scores of the study groups in the post-application of the performance observation card for programming skills in favor of the experimental group. Figure 3 shows the mean scores of the study groups in the post-application of this card.

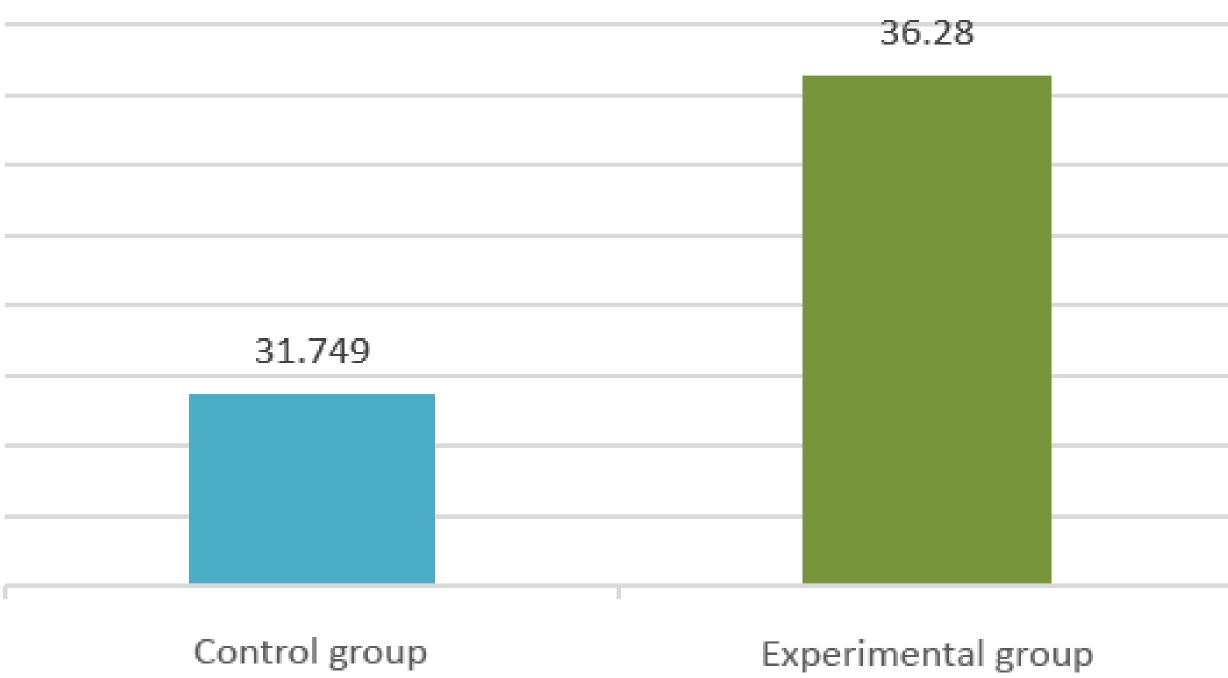

Figure 3. The mean scores of the study groups in the post-application of the performance observation card for programming skills.

The null hypothesis is rejected whereas the alternative hypothesis states that "there are statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the students of the study groups in the post-application of the performance observation card for programming skills in favor of the experimental group" is accepted. Using the Eta-square test $\eta 2$ to calculate the size of the effect between the independent samples, this study found the effect size was 0.220 which indicates a medium effect size.

The second hypothesis (H02): There are no statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the students in the experimental group in pre- and the post-application of the technology acceptance scale.

The significance of the differences between the mean scores in the experimental group in the pre- and post-application was calculated using the *t*-test for dependent samples and the Cohen equation (d) was used to calculate the size of the effect for dependent samples to verify the validity of this hypothesis. Table 5 shows the following results:

Table 5. T-test for dependent samples in the pre-and post-application of the technology acceptance scale for the experimental group.

Study tool	Group	Mean	Standard deviation	t-value	Significance	Cohen's (d)
The technology acceptance scale	Pre -application	24.967	8.540	16.178	0.031	0.674
	Post -application	52.090	13.212			

Table 5 shows a t value of 16.178 with statistical significance (0.031) which means there are statistically significant differences at the $\alpha \leq 0.05$ level between the mean scores of the experimental group in the pre -and post- application of the technology acceptance scale in favor of the post-application. Figure 4 shows the mean scores of the experimental group in the pre- and post-applications of this scale.

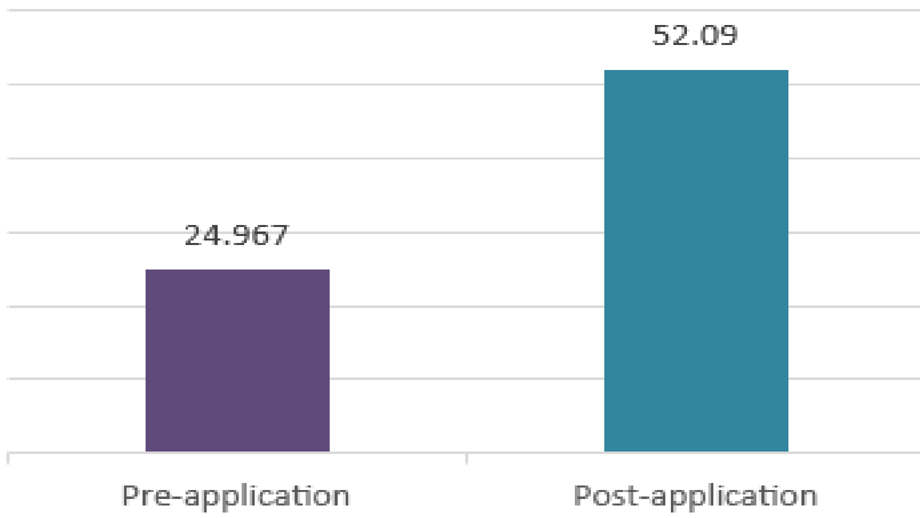

Figure 4. The mean scores of the experimental group in the pre-and post-applications of the technology acceptance scale.

Therefore, the null hypothesis is rejected whereas the alternative hypothesis states that "there are statistically significant differences at the significance level ($\alpha \leq 0.05$) between the mean scores of the students of the experimental group in the pre- and post-application of the technology acceptance scale in favor of the post-application" is accepted. By using Cohen's d to calculate the size of the effect between dependent samples, I found the effect size to be 0.674 which indicates a medium effect size.

6. Discussion

6.1. Research Question 1

The finding of this study is that video-based microlearning can serve as an effective tool for imparting programming skills for three main reasons.

First, given the characteristics of video-based microlearning and its various stimuli, the approach contributed positively to educational content because the use of video-based microlearning resulted in an engaging and visually appealing presentation of the content, thus facilitating student engagement, promoting skill development and minimizing distractions. The average human brain retains more information when content is organized into small chunks (Allela, 2021; Khong & Kabilan, 2022).

The instruction strategically deployed mini-learning units to optimize learning outcomes and alleviate cognitive overload. This approach aligns with the tenets of cognitive load theory (Sweller, Ayres, & Kalyuga, 2011) which emphasizes the limited capacity of short-term memory and the potentially detrimental impact of exceeding its resources. When cognitive demands surpass memory capacity, excessive cognitive load arises, hindering learning (Cheon, Crooks, & Chung, 2014; Lusk et al., 2009). Mini-learning units effectively mitigate this risk by segmenting knowledge into manageable portions, promoting efficient processing and enhancing knowledge retention.

Finally, the findings corroborate Mayer's (2005) cognitive theory of multimedia learning. This principle asserts that learning is optimized when content is presented in segmented units enabling learners to regulate their engagement with the material at their own pace rather than being overwhelmed by a continuous and uninterrupted flow of information.

The new study's findings were consistent with previous research (Alshehri, 2021; Kossen & Ooi, 2021; Sahin & Kırmızıgül, 2023). These authors suggested that microlearning can be an effective way to improve student achievement in a variety of courses. However, it is important to note that the effectiveness of microlearning may vary depending on the type of microlearning, the students' learning style and the way that microlearning is integrated into the curriculum.

6.2. Research Question 2

The results showed that students accepted the video-based microlearning technology for developing programming skills in the computer and information technology course. The researcher attributes this to three reasons: First, the brevity and focus of video-based microlearning modules enhanced their digestibility and overall appeal among students. That fostered interactions with the learning environment and promoted technology acceptance within the video-based microlearning context. Second, video-based microlearning was relevant to the students' needs covering the topics they were learning in class. Finally, video-based microlearning can be accessed on a variety of devices including computers, tablets and smartphones. This makes them accessible to students from many backgrounds. Additionally, microlearning videos can be accessed at any time.

The new study's findings were consistent with previous research (e.g., (Al-Shahrani, 2022; Javorcik, Kostolanyova, & Havlaskova, 2023; Nagy, 2018). A consensus emerged among these studies that video-based microlearning is well-received by students owing to its inherent benefits especially when it meets their needs and is designed in a way that is engaging and appealing to them.

6.3. Study Recommendations and Suggestions

This study offers support for several recommendations. It is advised that school computer labs teach instructors how to create and use video-based microlearning in their classes. This can be a useful tool for teaching a range of skills in various courses. Students' acceptance of video-based microlearning suggests this approach to learning can be effective for a variety of skills and courses. There are a number of ways to encourage students to use video-based microlearning such as making it easy to access and use, ensuring videos are available online or on school devices and making them easy to find and navigate. Videos should include activities and exercises that help students learn and retain information.

Future studies might look at using appropriate educational content as a variable in video-based microlearning according to student age as well as a study on the length of video clips through video-based microlearning. A comparison of the effects of different types of microlearning on the development of student achievement in courses might lead to a better understanding of the topic.

7. Conclusion and Limitations

Microlearning involves a targeted approach to learning design in which unjustifiably redundant information is filtered out. The results of this study suggest that video-based microlearning can be an effective tool for teaching programming skills to intermediate school students. Students also accepted learning through video-based microlearning. Teachers who use video-based microlearning can expect to see their students develop better programming skills and have a more positive attitude towards learning. It is important to note that the effectiveness of microlearning may vary depending on the type of microlearning used, the students' learning style and the way that microlearning is integrated into the curriculum.

Microlearning videos can be a valuable tool for teaching programming skills to intermediate school students. They are short, engaging, self-paced, accessible and relevant. These features make them well-suited for the needs of intermediate school students. Educational administrators can use these findings to make decisions about how to integrate video-based microlearning into the curriculum. However, this is not enough on its own.

It is important to consider the design of video clips in microlearning in light of specific standards and to train teachers on how to use them to ensure that educational objectives are met. The spread of technology is not a reason for its use or acceptance in education. Its existence within the educational system is not entertainment or an end in itself but rather a means of success in achieving the objectives of the educational institution.

Finally, several important limitations of the present study must be considered. The study was limited to public intermediate schools affiliated with the Department of Education in Saudi Arabia; the research period coincided with the first semester of the academic year 2023 and the experiment lasted 5 weeks. Further, the study only targeted developing HTML programming skills in 8th-grade male students.

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