

# The Effect of the Difference in Presenting Digital Stories (three-dimensional – interactive) in the Flipped Classroom Environment on the Development of Arithmetic Skills Among Sixth Grade Students in Mathematics in Muscat Governorate Schools

Rahima ALrubkhy

Arab Open University

Sami ALMAZRUI

sami.m@aou.edu.om

Arab Open University

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## Research Article

**Keywords:** Three-dimensional digital storytelling, interactive digital storytelling, flipped classroom, arithmetic skills development.

**Posted Date:** August 25th, 2026

**DOI:** <https://doi.org/10.21203/rs.3.rs-10172411/v1>

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**Additional Declarations:** No competing interests reported.

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# Abstract

The study aimed to investigate the effect of differences in presenting digital stories in their two formats—three-dimensional (3D) and interactive—within a flipped classroom environment on the development of arithmetic among sixth-grade female students in Muscat Governorate. In order to achieve the objectives of the study, the researcher adopted an experimental approach using a quasi-experimental design. The sample of the study consisted of (94) sixth-grade female students from one school in Muscat Governorate, as they are classified in two groups ,(32) students in the first experimental group, the other (32) students in the second experimental group, and (31) students in the control group.

The study instruments were developed by the researcher and they are an achievement test and an observation checklist. The achievement test consisted of (22) items distributed as follows: (7) items measuring recall and thinking skills, (10) items measuring application skills, (5) items measuring analysis skills, and one item measuring the level of reasoning. The test was administered to the three groups— the two experimental groups and control—both before and after the intervention.

The observation checklist is consisted of four domains: addition and subtraction of numbers, multiplication and division of numbers, fractions and fractional/decimal numbers, and ratio, proportion, and percentage. Each domain included four indicators, except for the domain of fractions and fractional/decimal numbers, as it encompasses a wide range of counting, conversion, and calculation skills. The observation checklist was applied in two phases: pre-application and post-application.

The results of the study revealed statistically significant differences between the pre-test and post-test applications in favor of the post-test in the development of arithmetic skills. The findings as well indicated statistically significant differences among the results of the three groups—the two experimental groups and the control group—in the post-administration of the arithmetic skills test, in favor of the two experimental groups. This demonstrates the superiority of the experimental treatments over the traditional method in developing arithmetic skills.

In light of the aforementioned findings, the researcher proposed several recommendations, the most important of which include integrating the use of digital storytelling in its various forms into instructional practices; developing interactive digital environments that incorporate digital stories; and providing teachers with training on designing and generating digital stories that support educational content. The study also recommends updating curricula so that their content and embedded skills are addressed through purposeful digital stories. In addition, the researcher recommends conducting similar studies to examine the impact of digital storytelling on the development of skills related to different branches of mathematics (geometry, algebra, numbers, statistics, and probability) and to investigate its effectiveness in improving students' academic achievement.

# Introduction

Various sciences have existed since ancient times; however, they have developed rapidly and have now reached the era of the knowledge and technological explosion, which is characterized by rapid and remarkable changes across different sciences and various aspects of life. Among the fields that have witnessed the most significant developments are technological sciences, which can today be considered the main driving force behind change in various domains. Technology is no longer merely a tool employed to accomplish specific tasks; rather, it has become an integrated system of software, technical and technological tools. Moreover, it is scientific discoveries that assist humans in solving problems and enable them to interact and communicate with the surrounding world with ease and efficiency.

All the developments have brought about significant changes in the ways knowledge and sciences are acquired, which in turn have had a noticeable impact on the educational process across its various domains. In the educational field, for example, technological advancement has transformed education from traditional instruction—largely dependent on memorization and rote learning—into a form of learning that emphasizes the use of digital learning environments and electronic platforms. These platforms incorporate a wide range of educational technologies and software, such as educational games, virtual reality, augmented reality technologies, and various forms of digital storytelling, among many other digital tools. The integration of such technologies has led to a substantial qualitative shift in the educational field. Therefore, it has become imperative to keep pace with these developments by employing and implementing diverse software applications and technological tools in different areas of life in general, and particularly in education, due to their significant impact on enhancing educational outcomes across all educational levels and subject areas.

Digital storytelling is considered one of the most prominent modern programs and technologies that have been widely adopted in the educational process by teaching staff, due to its clear and tangible impact on simplifying and explaining instructional content in a smooth and flexible manner for learners. It transforms learning into an engaging and enjoyable experience, as it is not limited to presenting written facts, theories, and rules. However, it presents rich narratives that incorporate well-structured and carefully designed texts aligned with learners' developmental levels and the educational content being delivered. Digital stories seek to capture learners' attention and provide them with a novel way of understanding and acquiring knowledge and skills, particularly in abstract scientific topics and content.

Tosun and Engin (2023) defined digital storytelling as a process that integrates a variety of multimedia elements in a dynamic manner through several stages, including selecting a topic, conducting research, and developing an instructional scenario appropriate to the topic. This is followed by writing the story and producing images, audio, sound effects, videos, and animations to create a digital story with a duration ranging from two to five minutes.

Similarly, Chaabi and Younes (2025) defined digital storytelling as a modern instructional approach that relies on integrating multiple multimedia elements in order to present educational content in an engaging and effective way, with the aim of enhancing understanding and developing higher-order thinking and creativity skills.

Given the rich and fertile learning environment provided by digital storytelling—especially when it is produced in a well-organized and engaging manner—it offers a modern instructional approach that enables teachers to employ it effectively within the educational process and across various instructional situations. In addition, digital stories contribute to the development of numerous learner competencies, as students acquire these competencies through engaging with digital stories. The engagement of learners enables them to develop 21st-century skills, including the ability to interact with multimedia and diverse applications. Specifically, when learners are producing a digital story themselves or interacting with its content.

Moreover, digital storytelling is suitable for a wide range of academic subjects due to the diversity of its types. In terms of content, one of these types is the personal narrative, which presents events related to a specific individual.

Guided stories are the stories that are designed to teach learners specific concepts or behaviors. On the other hand, fictional stories include imaginary events that consist of educational situations and enable learners to achieve the intended learning aims. There are many other types of digital stories that existed.

From a technical design perspective, digital storytelling likewise includes various formats, such as interactive digital stories, two-dimensional (2D) digital stories, and three-dimensional (3D) digital stories. Digital storytelling is the one which has given a high potential especially in integrating technology into the educational process. It is very essential to give digital storytelling greater attention and to employ it consistently in different classroom settings by diverse instructional strategies, such as collaborative learning and flipped classroom strategies which were both adapted by the researcher in the present study.

Frequent studies have shown the effectiveness of the flipped classroom in the educational process. One of the studies is the study of Mengesha et al. (2024), which concluded that students who were engaged in the classes that apply the flipped classroom strategy proved a significant improvement in their academic achievement, advanced success rates, and increased classroom interaction. As a result, all the above led to higher levels of satisfaction with their academic performance and the instructional content.

Similarly, Murtiningsih et al. (2023) highlighted the importance of the flipped classroom in promoting learners' self-directed learning and enhancing their motivation toward learning. In addition, the study found that the flipped classroom contributes to increase the learners' self-confidence. There are numerous advantages of the flipped classroom, according to Colclasure (2022), the flipped classroom enhances learning by providing flexible access to instructional content, supporting personalized learning through self-paced review, and promoting active classroom engagement. It also enables teachers to implement learner-centered activities more effectively while fostering higher-order thinking and problem-solving skills, making it a pedagogically effective approach for digital-age education.

Therefore, the researcher chose to employ this strategy in conjunction with two types of digital storytelling—three-dimensional (3D) digital stories and interactive digital stories—in mathematics instruction. Interactive digital storytelling defined as a form of digital story that enables learners to take part and interact with the events of the story by allowing them to choose different pathways and engage in interactive activities, such as responding to questions by clicking specific buttons. It also enables learners to alter the course of the story, which is why many scholars considered it to be one of the most effective and impactful types of educational storytelling (Petousi et al., 2022).

Digital storytelling has shown clear effects on learners' academic achievement. In this regard, Bratitsis and Mantellou (2020) reported that interactive digital storytelling improved learners' understanding of the skill of subtracting natural numbers, reduced their errors, and increased their motivation and engagement while studying subtraction in classroom settings. Consequently, it is led to enhanced participation, interaction, and overall improvement in academic achievement. Many students face several challenges when they are studying mathematics, many educational studies have revealed low levels of academic achievement in mathematics and insufficient mastery of its basic skills among learners. These shortcomings affected the results of national and international assessments.

The results of the TIMSS study illustrated a decline in the performance of Omani students compared with the overall international and regional averages. These findings published in national reports, which confirmed—particularly in the reports issued in 2019 and 2023—weaknesses in the fundamental mathematics skills, most notably those related to arithmetic skills.

Algorithms and mathematical skills considered among the most essential components of mathematics, as they are indispensable for enabling individuals to solve problems and simplifying the learning of other areas of mathematics as well as other scientific disciplines. Among these skills is arithmetic which enables learners to master algorithms and various mathematical operations. Arithmetic skills defined as a set of mathematical abilities that require learners to understand and analyze numerical information and make the right decisions to solve a given problem by applying mathematical skills related to numbers and numerical operations involved in the problem (Al-Jarrah, 2021)

Traff et al. (2025) defined arithmetic skills as learners' ability to perform basic numerical operations—specifically addition and subtraction—using multiple strategies such as verbal counting, decomposition, finger counting, and retrieval. Arithmetic skills have immense importance, and their significance exceeding learning mathematics alone; rather, they extend to various scientific disciplines. Several researchers have addressed aspects of this importance, including LeFevre et al. (2021) and Al-Laithi (2019), have highlighted the importance of mathematics learning in enhancing learners' mathematical competence and academic achievement, strengthening self-confidence and learning motivation, fostering analytical and critical thinking as well as problem-solving skills, and improving memory, concentration, and information retention.

Despite the significant importance of arithmetic skills, the researcher noticed—through her experience as a teacher in several schools in the Sultanate of Oman and as a curriculum specialist at the General

Directorate of Curriculum Development at the Ministry's headquarters—that many students lack mastery of basic mathematical foundations. As a result, that problem has negatively affected their interest in learning mathematics and their willingness to choose it in post-basic education stages. The researcher believes that one of the main reasons for this issue lies in the challenges students face when performing arithmetic operations

Consequently, the researcher emphasizes the importance of developing students' various arithmetic skills and equipping them with mental arithmetic skills and strategies through modern digital technologies and programs. Based on the findings of the earlier studies and the challenges remarked by the researcher in students' understanding of mathematics and acquisition of its knowledge and skills, this study looks to employ digital storytelling specifically interactive digital stories and three-dimensional (3D) digital stories to develop different arithmetic skills among learners.

Gulengul and Ruhsen (2023) confirmed the positive impact of digital storytelling on academic achievement in mathematics and its role in reducing students' anxiety during learning. In addition, studies by Bratitsis and Mantellou (2020), Tosun and Engin (2023), and Taha et al. (2024) stated the effectiveness of digital storytelling in enhancing academic achievement and classroom participation. Furthermore, Nasir et al. (2024) emphasized that integrating digital storytelling into the educational process plays a significant role in improving students' understanding and retention of knowledge, due to the coherent and sequential events presented in digital stories, which enable learners to link scientific content with narrative sequences that remain in learners' memory for extended periods.

Digital storytelling represents an effective instructional approach for teaching mathematics by connecting mathematical concepts to authentic real-life contexts and learners' experiences, thereby increasing engagement and meaningful learning. Furthermore, its integration of visual, auditory, and interactive elements facilitates learners' understanding of mathematical concepts, accommodates diverse learning preferences, and promotes higher-order cognitive processes, including thinking, reflection, and imagination.

Despite the several number of studies that examined the impact of digital storytelling on improving achievement in mathematics, there is a lack of research of investigating the effect of differences between employing two distinct digital storytelling formats. As a result, this study aims to examine the effect of presenting digital stories—three-dimensional (3D) and interactive—on the development of arithmetic skills among sixth-grade students in mathematics in schools in Muscat Governorate.

The following are the research questions:

- What is the effectiveness of three-dimensional (3D) digital story content within a flipped classroom-based learning environment in developing arithmetic skills among sixth-grade female students in mathematics?
- What is the effectiveness of interactive digital story content within a flipped classroom-based learning environment in developing arithmetic skills among sixth-grade female students in

mathematics?

- What is the effect of the difference between the two digital storytelling formats (three-dimensional vs. interactive) within a flipped classroom environment on the development of arithmetic skills among sixth-grade female students in mathematics?

## Research Methodology

The study adopted an experimental approach using a quasi-experimental design to examine the effect of differences between two digital storytelling formats—three-dimensional (3D) and interactive—within a flipped classroom environment on the development of arithmetic skills and motivation among sixth-grade female students in mathematics in schools in Muscat Governorate. This approach considered as the most proper approach for deciding the extent of differences between the two types of digital stories employed in the study and their impact on developing learners' arithmetic skills. Therefore, a quasi-experimental design included 64 sixth-grade students. The students divided in two groups based on their existing classroom distribution, the first group received instruction through 3D digital storytelling **in the Flipped Classroom Environment**, while the second group was taught through Interactive Digital Stories in the same type of environment.

Both groups received self-directed learning through digital storytelling delivered via the Canvas virtual learning platform. The instructional content presented for learners in multiple formats, including digital stories, interactive games, and electronic activities, all of which provided immediate feedback and implemented within the flipped classroom strategy. In addition, a short achievement test applied before and after instruction to measure the extent to which students' arithmetic skills developed.

### Study Sample:

The study sample comprised 94 sixth-grade female students drawn from three intact classes at Fayd Al-Ma'rifah Basic Education School (Grades 5–9). The classes were randomly selected from all sixth-grade sections within the school. Two classes were assigned to the experimental groups and received instruction using two digital storytelling modes (three-dimensional and interactive) within a flipped classroom environment, whereas the third class served as the control group and was taught using the conventional instructional method.

### Study Instruments:

After reviewing previous studies related to the use of Blended learning, particularly in flipped classroom environments., as well as research examining the two modes of digital storytelling (3D and interactive) and their impact on Arithmetic Skills, the researcher designed and developed digital stories in both modes (2D and interactive), in addition to preparing a flipped classroom environment based on these stories. The researcher then developed an achievement test to assess the scientific knowledge related to the The Number Unit, Unit Three of the sixth-grade mathematics curriculum, The test consisted of 23 items and constructed based on a detailed table of specifications that relied on the relative weightings

of the unit aims. This ensured the alignment between the instructional content and cognitive levels according to Bloom's taxonomy, as well as appropriateness in terms of score distribution and the time given for responding. The test items distributed according to the learning aims, as illustrated in the following table:

**Table (1):** test items distributed according to the learning aims and Bloom's cognitive objectives:

| Skill / Objective Level                                | Recall & Understanding | Application  | Analysis     | Reasoning   | Total       | Relative Weight |
|--------------------------------------------------------|------------------------|--------------|--------------|-------------|-------------|-----------------|
| Addition and subtraction of whole numbers              | 3                      | 2            | –            | –           | 5           | 21.7%           |
| Multiplication and division of whole numbers           | 2                      | 1            | 2            | –           | 5           | 21.7%           |
| Order of operations with numbers                       | –                      | 1            | –            | –           | 1           | 4.4%            |
| Fractions, operations on fractions, and conversions    | –                      | 5            | 3            | –           | 8           | 34.8%           |
| Equivalence among fractions, decimals, and percentages | 2                      | 1            | –            | 1           | 4           | 17.4%           |
| <b>Total</b>                                           | <b>7</b>               | <b>10</b>    | <b>5</b>     | <b>1</b>    | <b>23</b>   | <b>100%</b>     |
| <b>Percentage (%)</b>                                  | <b>30.4%</b>           | <b>43.5%</b> | <b>21.7%</b> | <b>4.4%</b> | <b>100%</b> |                 |

## Results

The researcher presented the results of the statistical analysis of the data obtained from the instruments applied in the study, which aimed to examine the effect of differences between two digital storytelling formats—three-dimensional (3D) and interactive—within a flipped classroom environment on the development of arithmetic skills. In order to find out the effectiveness of 3D and interactive digital storytelling and their impact on developing arithmetic skills, the achievement test was given to the target sample. The resulting data enabled the researcher to conduct statistical analyses, draw conclusions, and interpret the findings to answer the research questions derived from the main research question. Through these analyses, the researcher was able to verify the study hypotheses in accordance with the related research questions, as follows:

### First: Verification of the first hypothesis

The first hypothesis states that there is a statistically significant difference at the level ( $\alpha = 0.05$ ) between the mean scores of the first experimental group, who were taught using three-dimensional (3D) digital story content within a flipped classroom–based learning environment, and the control group in the post-administration of the achievement test for the development of arithmetic skills in mathematics, in favor of the first experimental group.

**Table (2): Independent-samples t-test for identifying differences in mean scores between the first experimental group (three-dimensional digital stories) and the control group**

| Group                                                       | N  | Mean  | Standard Deviation | t value | Degrees of Freedom | p value | Effect Size (Cohen's d) |
|-------------------------------------------------------------|----|-------|--------------------|---------|--------------------|---------|-------------------------|
| Three-dimensional digital stories                           | 30 | 19.50 | 4.42               | 3.191   | 54.07              | *0.002  | 0.82                    |
| Control group                                               | 31 | 16.29 | 3.35               | —       | —                  | —       | —                       |
| * Significant at the significance level ( $\alpha = 0.05$ ) |    |       |                    |         |                    |         |                         |

Table (2) shows that the mean score of the first experimental group (students who were taught using three-dimensional digital stories) was 19.50 with a standard deviation of 4.41, whereas the mean score of the control group (students who were taught using the traditional method) was 16.29 with a standard deviation of 3.34. The results of the independent-samples *t*-test presented in Table (4) illustrated a statistically significant difference between the mean scores of the two groups ( $t = 3.191$ ,  $df = 54.07$ ,  $p = 0.002$ ). This suggests that the observed differences between the two groups are not due to chance but rather can be attributed to the effect of the instructional treatment.

Moreover, the difference between the mean scores was approximately 3.21 points in favor of the first experimental group (three-dimensional digital stories). The effect size was large (Cohen's  $d = 0.82$ ), shown that the use of three-dimensional digital storytelling within a flipped classroom–based learning environment was highly effective in developing arithmetic skills among sixth-grade female students compared to the traditional method.

## Second: Verification of the second hypothesis

The second hypothesis states that there is a statistically significant difference at the level ( $\alpha = 0.05$ ) between the mean scores of the second experimental group, who were taught using interactive digital story content within a flipped classroom–based learning environment, and the control group in the post-administration of the achievement test for the development of arithmetic skills in mathematics, in favor of the second experimental group.

**Table (3): Independent-samples t-test for identifying differences in mean scores between the second experimental group (interactive digital stories) and the control group**

| Group                             | N  | Mean  | Standard Deviation | <i>t</i> value | Degrees of Freedom | <i>p</i> value | Effect Size (Cohen's <i>d</i> ) |
|-----------------------------------|----|-------|--------------------|----------------|--------------------|----------------|---------------------------------|
| Interactive digital story content | 33 | 21.06 | 3.61               | 5.475          | 62                 | 0.000          | 1.369                           |
| Control group                     | 31 | 16.29 | 3.35               | —              | —                  | —              | —                               |

\* The correlation is statistically significant at the significance level ( $\alpha = 0.05$ ).

Table (3) shows that the mean score of the second experimental group (students who were taught using interactive digital stories within a flipped classroom environment) was 21.06 with a standard deviation of 3.61, whereas the mean score of the control group (traditional method) was 16.29 with a standard deviation of 3.35. The results of the independent-samples *t*-test presented in Table (5) reveal a statistically significant difference between the two groups ( $t = 5.475$ ,  $df = 62$ ,  $p = 0.000$ ), at a significance level of less than 0.01. Given that the difference between the mean scores was 4.77 points in favor of the second experimental group (interactive digital stories), this reflects a substantial improvement attributable to the instructional treatment.

It can be concluded that interactive digital storytelling within the framework of the flipped classroom strategy had a strong and effective impact on the development of arithmetic skills. The calculated effect size using Cohen's *d* reached 1.369, which is considered a very large effect size according to Cohen's classification. This high value reflects that the use of interactive digital storytelling contributed to a substantial improvement in the development of arithmetic skills among sixth-grade female students, indicating a high level of instructional effectiveness with clear educational significance.

## Third: Verification of the third hypothesis

The third hypothesis states that there is no statistically significant difference at the level ( $\alpha = 0.05$ ) between the mean scores of the two experimental groups (three-dimensional digital stories and interactive digital stories) within a flipped classroom-based learning environment in the post-administration of the achievement test for the development of arithmetic skills in mathematics

**Table (4): Independent-samples *t*-test for identifying differences in mean scores between the two digital storytelling formats (three-dimensional and interactive) within a flipped classroom-based learning environment in developing arithmetic skills among sixth-grade female students in mathematics**

| Group                             | N  | Mean  | Standard Deviation | <i>t</i> value | Degrees of Freedom | <i>p</i> value |
|-----------------------------------|----|-------|--------------------|----------------|--------------------|----------------|
| Three-dimensional digital stories | 30 | 19.50 | 4.42               | -1.527         | 56.118             | 0.132          |
| Interactive digital stories       | 33 | 21.06 | 3.61               | —              | —                  | —              |

Table (4) presents the results of the independent-samples *t*-test conducted to identify differences in mean scores between the group taught using three-dimensional (3D) digital stories and the group taught using interactive digital stories on the post-test of arithmetic skills among sixth-grade female students in mathematics. Descriptive results shown that the mean score of the interactive digital story group was 21.06 with a standard deviation of 3.61, whereas the mean score of the three-dimensional digital story group was 19.50 with a standard deviation of 4.42. These values suggest a descriptive advantage in favor of the interactive digital storytelling group. However, the results of the *t*-test revealed that this difference was not statistically significant, as the *t* value was  $-1.527$  with  $df = 56.118$  and a *p* value of  $0.132$ , which exceeds the adopted significance level ( $\alpha = 0.05$ ).

This pinpoint that the differences between the mean scores of the two groups cannot be considered statistically meaningful differences; rather, they may be attributed to random variation in the scores

## Discussion

The results of the study addressed the research questions after implementing the experimental treatment, following the required procedures, and testing the hypotheses to verify their validity. The present study aimed to examine the effect of differences in presenting digital stories—three-dimensional (3D) and interactive—within a flipped classroom environment on the development of arithmetic skills among sixth-grade female students in Muscat Governorate. Based on the methodological procedures and analyses conducted, the results of the study hypotheses can be interpreted as follows:

### First: Discussion of the results of the first hypothesis

The first hypothesis of the study was verified, which stated that:

There are statistically significant differences at the level ( $\alpha = 0.05$ ) between the mean scores of the first experimental group, who were taught using three-dimensional (3D) digital story content within a flipped classroom-based learning environment, and the control group in the post-administration of the achievement test measuring arithmetic skills, in favor of the first experimental group.

The results of the study revealed a statistically significant difference between the mean scores of the two groups ( $t = 3.191$ ,  $p = 0.002$ ). This indicates that the differences between the groups are not due to chance; rather, they can be attributed to the effect of the instructional treatment. Moreover, the difference between the mean scores was approximately 3.21 points in favor of the first experimental group (three-dimensional digital stories), which represents an educationally meaningful difference.

To achieve the objectives of the study and to examine the effect of applying three-dimensional (3D) digital storytelling compared with the traditional method within a flipped classroom environment for the purpose of developing learners' arithmetic skills toward learning mathematics, the researcher first verified the equivalence of the two groups by administering a pre-test to both groups.

The results marked slight differences between the two groups, as the mean scores ranged from 5.90 for the control group to 7.60 for the first experimental group (three-dimensional digital stories). The differences were very small which indicates that the groups were equivalent at the outset, which enhances the reliability of the results obtained and supports the validity of the subsequent analyses.

Likewise, the post-test was administered to both groups after the experimental treatment. The results showed that the use of three-dimensional (3D) digital storytelling was more effective in developing arithmetic skills among sixth-grade female students compared to the traditional method, as the mean score of the first experimental group reached 19.50, whereas the mean score of the control group was 16.26.

These results indicate a difference of approximately 3.21 points between the two groups, in addition to the presence of statistically significant differences. This reflects a noticeable improvement among the students who were taught using three-dimensional (3D) digital stories implemented within a flipped classroom strategy, compared to those in the control group.

These findings are consistent with several previous studies that emphasized the importance of integrating digital storytelling into the educational process and its role in enhancing the learning of academic skills. studies by Talakhan (2025) and Taha et al. (2024) indicated that three-dimensional digital stories contribute to the improving learners' understanding of various mathematical skills and enhancing their overall academic achievement in mathematics.

The findings of these studies are also consistent with the study conducted by Zanqour (2021), which point out that employing digital storytelling in teaching mathematics enables learners to develop scientific imagination, thereby enhancing their mathematical problem-solving skills. The use of digital stories, with their rich multimedia elements, contributes to a deeper understanding of abstract concepts—particularly those related to mathematics topics. Moreover, the study found that students who learned through digital storytelling achieved higher academic outcomes than those who were taught using traditional instructional methods.

## **Second: Discussion of the results of the second hypothesis**

The second hypothesis of the study was verified, which stated that there are statistically significant differences at the level ( $\alpha = 0.05$ ) between the mean scores of the second experimental group, who were taught using interactive digital story content within a flipped classroom–based learning environment, and the control group in the post-administration of the achievement test measuring arithmetic skills, in favor of the second experimental group.

The results of the statistical analysis revealed a statistically significant difference between the pre-test and post-test results of the arithmetic skills test in favor of the post-test, indicating the positive impact of employing interactive digital storytelling on developing and enhancing learners' abilities to perform arithmetic operations compared to their performance on the pre-test of the same skills. This

improvement can be attributed to the role played by the implementation of interactive digital stories within a flipped classroom environment in enabling learners to master arithmetic operations and acquire these skills. The mean score of the second experimental group in the post-test reached 21.06, compared with a mean score of 16.29 for their peers in the control group.

These results reveal a substantial difference of approximately 4.77 points, confirming the effect produced by the application of interactive digital storytelling in the instructional context. To verify the credibility and nature of these differences—whether they represent statistically significant differences or merely random variation—the researcher conducted an independent-samples *t*-test. The results indicated a statistically significant difference between the second experimental group and the control group, with a *t* value of 5.47 at a significance level of 0.005. Accordingly, it can be concluded that employing interactive digital storytelling had a clear and tangible impact on the development of arithmetic skills among the students.

Moreover, the implementation of interactive digital storytelling within a flipped classroom environment played a significant role in enabling learners to engage in coherent learning experiences and in reducing the forgetting of knowledge and information acquired during the learning stages. The flipped classroom strategy enhanced information retention, skill acquisition, and skill correction among learners. In addition, it enhanced the connection between latest information and learners' prior knowledge, which underscores the importance of applying constructivist theory in instructional contexts.

Furthermore, the availability of engaging educational multimedia within interactive digital stories—designed to suit different learning styles—enabled learners to enjoy the learning experience and meaningfully engage with the instructional content. This allowed them to connect the events of the story with its mathematical structure and to understand how to address and solve the embedded problems, which in turn simplified the skill acquisition. In addition, the inclusion of interactive activities within digital stories that provide immediate feedback helped learners to identify their errors as well as correcting them, encouraged repeated attempts at learning stage, and supported the integration of information presented through the story events in an interactive and well-organized manner.

These findings are consistent with the results of several previous studies that examined the impact of interactive digital storytelling on the educational process. For example, the study by Soboleva et al. (2021) highlighted the clear and positive effect of implementing interactive digital storytelling on learners' academic achievement.

The findings of the present study are also consistent with those of Geraets (2021) and Khalil et al. (2021), which indicated that employing the flipped classroom strategy in instructional contexts related to mathematics topics has a clear positive impact on learners' academic achievement, enhances their classroom interaction, and supports the acquisition of abstract mathematical skills. In addition, these studies reported improvements in learners' creative and critical thinking skills. Furthermore, Llamas-Nistal et al. (2025) emphasized that integrating multiple instructional strategies has a significant effect

on improving learners' academic achievement and enhancing their learning, as well as facilitating the acquisition of knowledge and diverse skills

Based on the foregoing, the results of this hypothesis demonstrate the effectiveness of employing interactive digital storytelling within a flipped classroom environment in developing learners' arithmetic skills. This confirms the importance of integrating diverse instructional strategies within active digital learning environments, particularly for abstract scientific subjects such as mathematics, as such integration contributes to reducing students' reluctance toward learning the subject.

## **Third: Discussion of the results of the third hypothesis**

The third hypothesis of the study was verified, which states that:

There are no statistically significant differences at the level ( $\alpha = 0.05$ ) between the mean scores of the two experimental groups (three-dimensional digital stories and interactive digital stories) within a flipped classroom-based learning environment in the post-administration of the achievement test measuring arithmetic skills in mathematics.

The results of the statistical analysis indicated that there were no statistically significant differences between the post-test results of the first and second experimental groups on the arithmetic skills test. This suggests that employing digital storytelling—whether three-dimensional or interactive—has a tangible role and a clear impact on developing learners' arithmetic skills when compared to the traditional method. Numerous previous studies have confirmed the positive role of digital storytelling in the educational process, such as the study by Talakhan (2025), which sought to examine the effect of employing digital storytelling on developing learners' skills in dealing with fractions and solving related problems.

The study concluded that digital storytelling is effective in developing learners' skills in dealing with fractions and performing related arithmetic operations, as well as in improving their academic achievement in mathematics. Similarly, the study by Bratitsis and Mantellou (2020) indicated the positive impact of employing interactive three-dimensional digital storytelling on developing problem-solving skills related to subtraction. Learners achieved tangible results and demonstrated substantial improvement in academic achievement, in addition to showing outstanding participation during the instructional process.

## **Recommendations:**

The researcher proposes a set of recommendations aimed at improving and enhancing instructional practices and raising learners' academic achievement levels, as follows:

- Integrating digital storytelling into various instructional contexts and across different subject areas.
- Implementing training programs for teaching staff on the design and production of digital stories using diverse formats.

- Developing educational curricula and incorporating various artificial intelligence technologies.
- Establishing virtual learning environments and enriching them with diverse digital content that supports the educational process.
- Conducting further future studies to examine the impact of differences among digital storytelling formats on the development of skills related to educational curricula.

## Declarations

### **Ethical Approval:**

Ethical approval for this study was obtained from the Research Ethics Committee of the Arab Open University Sultanate of Oman prior to data collection. All study procedures were conducted in accordance with the ethical standards of the committee.

### **Consent to Participate:**

Written informed consent was obtained from the parents or legal guardians of all participating students before their participation in the study.

**Consent to Publish:** Not Applicable.

### **Competing Interests:**

The authors declare that they have no competing interests.

**Clinical trial number:** not applicable

## Funding

The authors received no financial support for the research authorship or publication of this article.

## Author Contribution

R.A.R. (Rahima Al-Rabkhi) and S.A.M. (Sami Al-Mazruii) contributed to the conception and design of the study, as well as the development of the research methodology. R.A.R. was responsible for data collection, analysis, and drafting the main manuscript text. S.A.M. contributed to supervision, critical revision of the manuscript, and validation of the research findings. Both authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

## Acknowledgement

AcknowledgementI would like to express my profound gratitude to the Arab Open University (AOU), Oman, for its supervision and continuous support in conducting this study entitled: “The Effect of the Difference in Presenting Digital Stories (Three-Dimensional vs. Interactive) in a Flipped Classroom Environment on the Development of Arithmetic Skills Among Sixth-Grade Students in Mathematics in Muscat Governorate Schools.”

## Data Availability:

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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