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Digital Storytelling Learning Outcomes and Critical Factors: A Scoping Review

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Abstract. Students gain various learning outcomes through digital storytelling (DST). However, there is a lack of understanding about the facilitating factors and challenges of DST in achieving learning outcomes across all dimensions of learning. To bridge this research gap, the Arksey and O'Malley methodological framework was utilized to conduct a scoping review. The search process involved surveying the relevant literature using seven electronic databases: Web of Science, Scopus, ScienceDirect, EBSCOhost, ProQuest, Google Scholar, and Google. The content analysis of 43 reviewed studies indicated that in the cognitive dimension, the facilitating factors for significant learning outcomes achieved include the involvement of multisensory learning, adequate opportunities to practice, an evaluation of one's own ideas, and the DST iterative process. In the affective dimension, the facilitating factors involve reflected personal experiences, the use of interactive multimedia, and a sense of control while learning. In the social dimension, safe collaborative environments for students in which ideas are shared and feedback is received through digital media continually stimulate social communication and interaction during the DST-making process. However, DST is not a direct strategy; its implementation should be planned based on consideration of three challenges that affect learning outcomes: 1) suitability of approaches, 2) variability of duration, and 3) compatibility of technology. In conclusion, by recognizing and harnessing DST facilitating factors and challenges in relation to learning outcomes, educators, researchers, and policymakers could create more fulfilled learning goals. Future researchers should build on these critical factors in educational settings so that DST learning outcomes can be maximized.

Keywords: digital storytelling; challenges; facilitating factors; learning outcomes; scoping review

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1. Introduction

For thousands of years, educators have employed storytelling as a useful teaching method because it involves a straightforward communication approach in which written or spoken life stories are used to clarify teaching concepts (Ryan & Aasetre, 2020). The emergence of personal computers and user-friendly communication technologies has enabled storytellers to transition into the digital realm (Yamaç & Ulusoy, 2016). The fundamental differentiation between digital storytelling (DST) and conventional storytelling is the technological instruments employed when telling stories (Addone et al., 2021). DST activities include writing story plots using storyboards and creating three- to five-minute DST videos incorporating multimedia to support the story, alongside using editing software (Kazazoglu & Bilir, 2021).

The application of DST in education is not a recent development. The term 'digital storytelling' originated in 1980, derived from ‘short personal narrated films’ (Nunvarova et al., 2023). Educators’ widespread adoption of digital stories has been attributed to the versatility with which they can be shared across diverse digital platforms like websites, social media, and mobile applications (Musfira et al., 2022). Within educational practice, various components have been incorporated into DST, such as collaborative-based approaches, web-based tools, novel- or comic-based storytelling formats, and robotic-based storytelling activities (Addone et al., 2021; Cheng & Chuang, 2019; Kazazoglu & Bilir, 2021; Rutta et al., 2021; Tengler et al., 2021).

In addition to its versatile technological features, educators favor DST because the process of making it provides records of students’ thinking, which teachers can use to assess progress toward achieving learning outcomes (Ryan & Aasetre, 2020; Wu & Chen, 2020). Additionally, the study conducted by Niemi et al. (2018) demonstrated that multidimensional aspects of learning outcomes have been achieved by students. For instance, some applied the learned topic of geometry in mathematics by writing their comprehension into the story and producing DST videos in order to teach other students. Overall, Niemi et al. (2018) reported that students achieved better mathematic learning outcomes, improved twenty-first-century thinking skills for the cognitive dimension, and increased motivation for the affective dimension. In another study, the process of making DST based on game-design learning among high school students showed significant improvement in developing their communication skills in the social dimension (Chen 2020).

Although reviews of research on DST learning outcomes have been undertaken, most have focused on a single learning dimension, such as academic achievement (Tarik, 2021) or engagement (Greene et al., 2018). Therefore, there is a lack of understanding about which DST facilitating factors enable learning outcomes to be achieved across the cognitive, affective, and social dimensions more broadly because each dimension comprises various learning achievements. Furthermore, the existing reviews concerning learning outcomes focus on a single type of component integrated into DST, such as authoring tools (Quah & Ng, 2021). Thus, a limited overview is available of the DST facilitation with regard to learning

outcomes because, in practice, different types of components have been integrated into DST. Gaining such an overview is important as it would inform educators on how to focus on facilitating factors, thereby maximizing the educational benefits for students. Lastly, no educational reviews have identified the challenges in implementing DST to achieve learning outcomes, although identifying these factors is important when planning effective DST strategies. Based on this evidence, several pieces of information necessary for a better comprehension of the DST method are absent, indicating the significant need for the current research.

1.1 Research conceptual framework

To establish the theoretical basis of this study, the technology-based learning model developed by Yim and Su (2024) was adapted as the research conceptual framework. The framework consists of theoretical references and related domains; their interconnectedness was used to guide this study, as illustrated in Figure 1.

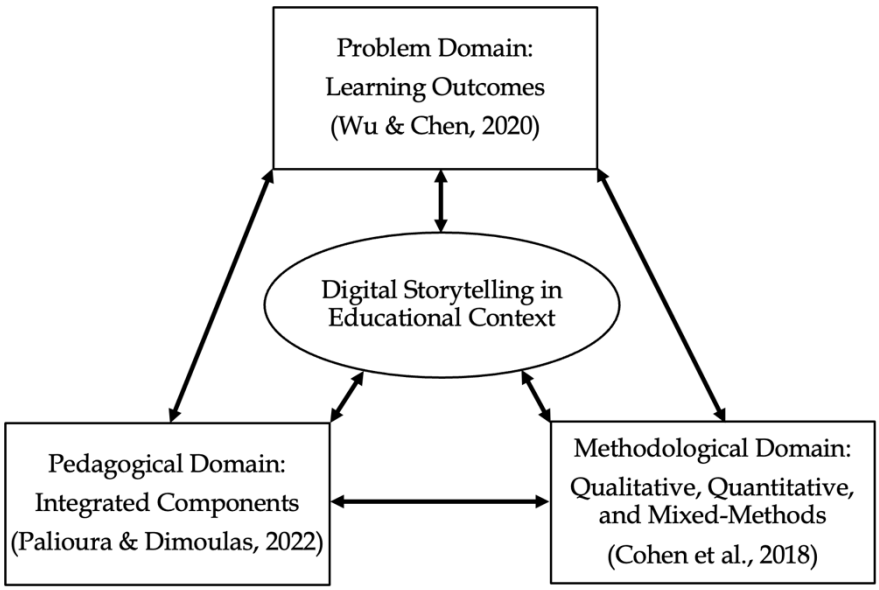

Figure 1: Research conceptual framework adapted from Yim and Su (2024)

Based on Figure 1, Yim and Su (2024) recommended creating a coding scheme that was relevant to the application of technology in an educational context. They suggested synthesizing various academic findings by referring to three important domains: problem, pedagogical, and methodological. Therefore, in the current study, the problem domains consist of DST learning outcomes classified into three main categories: cognitive, affective, and social, based on the work of Wu and Chen (2020). The pedagogical domain refers to the components integrated into DST, which can be described as the approach, technological platform, digital materials, and other technological tools, based on the study by Palioura and Dimoulas (2022). Finally, the methodological domain refers to the type of method used in the educational research context, which could be qualitative, quantitative,

or mixed-methods, according to Cohen et al. (2018). The conceptual framework helped in devising the research objectives of the current study.

1.2 Research objectives

To bridge the aforementioned knowledge gaps, this study was driven by the following research objectives: 1) to provide comprehensive insights into the digital storytelling (DST) facilitating factors needed to achieve learning outcomes across various learning dimensions within educational settings and 2) to identify and analyze challenges in the attainment of DST learning outcomes.

2. Methodology

To conduct an effective review involving obtaining from many databases various results related to digital storytelling (DST) interventions that aligned with the objectives and nature of this study, a scoping review was used as the search strategy to locate previous studies because this approach offers a breadth and flexibility of procedures (Yahaya et al., 2022). Therefore, the researcher referred to and was guided by the Arksey and O'Malley scoping review methodological framework (advanced version) developed by Levac et al. (2010). This consists of five steps: 1) identifying the research question, 2) identifying relevant studies, 3) selecting the studies, 4) charting the data, and 5) collating, summarizing, and reporting the results. The scoping review employed a mixed-methods research approach encompassing both quantitative and qualitative methods to comprehensively describe the learning outcomes achieved through DST. Quantitative analysis was employed to quantify the frequency and distribution of the learning outcomes reported in the literature, while qualitative analysis enabled a deeper explanation based on the constructed themes and sub-themes related to the factors facilitating and the challenges in the attainment of these outcomes. This scoping review synthesized findings from studies conducted at elementary, middle, and high school level to generate insights into the effectiveness of DST in K-12 educational contexts.

2.1 Identifying the research question

The primary objective of this scoping review was to undertake a critical examination of the learning outcomes resulting from digital storytelling (DST) and their various facilitating factors and challenges. According to Levac et al. (2010), while it is important to develop a wide range of research questions when using the original scoping review framework proposed by Arksey and O'Malley, it is also important to clearly identify the concept, targeted population, and outcomes to ensure the scoping study has a clear focus and to direct the search efficiently. In this review, these three elements were as follows: the concept was digital storytelling strategies; the targeted population was K-12 school students; and the outcomes were learning outcomes, their facilitating factors, and challenges. Based on these three identified elements, the following research questions (RQs) were proposed:

- RQ 1: Which digital storytelling (DST) facilitating factors enable learning outcomes to be achieved across cognitive, affective, and social dimensions?

- RQ 2: What are the challenges in achieving learning outcomes from DST interventions?

2.2 Identifying relevant studies

This scoping review aimed for breadth rather than depth, so the search string consisted of search terms broad enough to capture a wide range of relevant literature within the study scope. Therefore, to gather the relevant literature, a search string involving three key related terms was formulated by referring to the research questions and objective of the scoping review. The review involved searching for information about "digital storytelling intervention", "learning outcomes", and the "targeted population" of "elementary, middle, and high school students". The formulated search strings used for each database are listed in Table 1.

Table 1: Search strings for each database used in this study

Databases	Search strings
Web of Science	(AB=("Digital storytell*" OR "digital narrat*" OR "Multimedia storytell*" OR "interactive storytell*" OR "animation storytell*" OR "virtual storytell*") AND AB=("learning outcome*" OR "educational objective*" OR "Learning goal*" OR "academic" OR achievement* OR "performance" OR "result*" OR "learning impact") AND AB=("school" OR "middle school" OR "high school" OR "primary*" OR "secondary*"))
Scopus	TITLE-ABS-KEY (("Digital storytell*" OR "digital narrat*" OR "Multimedia storytell*" OR "interactive storytell*" OR "animation storytell*" OR "virtual storytell*") AND ("learning outcome*" OR "educational objective*" OR "Learning goal*" OR "academic" OR achievement* OR "performance" OR "result*") AND ("school" OR "middle school" OR "high school" OR "primary*" OR "secondary*"))
ScienceDirect	(("Digital storytelling" OR "digital narrative" OR "Multimedia storytelling") AND ("learning outcomes" OR "educational objectives" OR "Learning goals" OR "academic" OR achievement OR "performance") AND ("school" OR "middle school" OR "high school" OR "primary" OR "secondary"))
EBSCOhost	AB ("Digital storytell*" OR "digital narrat*" OR "Multimedia storytell*" OR "interactive storytell*" OR "animation storytell*" OR "virtual storytell*") AND AB ("learning outcome*" OR "educational objective*" OR "Learning goal*" OR "academic" OR achievement* OR "performance" OR "result*" AND AB ("school" OR "middle school" OR "high school" OR "primary*" OR "secondary*")
ProQuest	("Digital storytelling" OR "digital narrative" OR "Multimedia storytelling") NOT (at.exact("Evidence Based Healthcare" OR "Commentary" OR "Editorial" OR "General Information" OR "Front Matter" OR "Table Of Contents" OR "Audio/Video Clip" OR "Bibliography" OR "Correspondence" OR "Undefined")
Google Scholar	(("Digital storytell*" OR "digital narrat*" OR "Multimedia storytell*" OR "interactive storytell*" OR "animation storytell*" OR "virtual storytell*") AND ("learning outcome*" OR "educational objective*" OR "Learning goal*" OR "academic" OR achievement* OR "performance" OR "result*"))

Google	("Digital storytelling" OR "digital narrative" OR "Multimedia storytelling" OR "interactive storytelling" OR "animation storytelling" OR "virtual storytelling") AND (“learning outcomes” OR "educational objectives" OR "Learning goals" OR "academic" OR achievement OR "performance" OR "results")

2.3 Study selection

In the study selection stage and before the process of data charting, the inclusion and exclusion criteria were clearly predefined, as shown in Table 2.

Table 2: Inclusion and exclusion criteria

Document Criterion	Inclusion	Exclusion
Publication year	1993 until 2023	Less than 1993
Type	Journal articles, theses, dissertations, reports	Review articles, books, book chapters, book reviews, conference papers
Language	English or Malay	Non-English or non-Malay
Target Population	School students (elementary, middle, and high school)	Gifted or disabled students, undergraduate students, or non-students
Academic Subject	All formal school academic subjects	All advanced higher education subjects or non-academic or medical subjects

Based on Table 2, the timeframe included in the retrieval process was filtered to cover the period January 1993 to December 2023. The year 1993 was selected as the term ‘digital storytelling’ was first introduced then (Wu & Chen, 2020). The inclusion criteria involved selecting studies that mainly involved populations of elementary, middle, and high school students. This was because the current review aimed to focus primarily on K-12 education settings. Regarding the exclusion criteria, Cohen et al. (2018) stated that conference papers might not have undergone the same rigorous peer review as journal articles. Meanwhile, books or book chapters contain insufficient empirical data (Cohen et al., 2018). Thus, to ensure higher-quality and reliable review outcomes, conference papers, books, and book chapters were excluded as they would potentially lead to information of varied quality and reliability being presented to support the outcome of DST as an intervention.

After the authors had decided on the inclusion and exclusion criteria, the selection process was conducted by adhering to the preferred reporting items for meta-analyses extension for scoping reviews (PRISMA-ScR) reporting guideline, adapted from Page et al. (2021). This would ensure a transparent selection process and clarify the record screening steps. To avoid biases when selecting studies, the inclusion of articles was determined through an assessment process in which all the authors evaluated the methodological quality and relevancy of each article before including it in the review. To do this, the corresponding author created an assessment matrix using an Excel template. Then, in the columns of the Excel spreadsheet, all the authors were required to independently assess each screened article and assign a 'yes' or 'no' based on the title, abstract, and keywords. For each

article, a score of 1 was assigned if the article's relevance to the study was 'yes', and a score of 0 was given if the article's relevance was 'no'. If the total score for an evaluated article was greater than 50%, it was included for review in this study (Aromataris & Munn, 2020). Consequently, the scoping review includes 43 articles of moderate and high quality. The complete study selection procedure followed during this scoping review is illustrated in Figure 2.

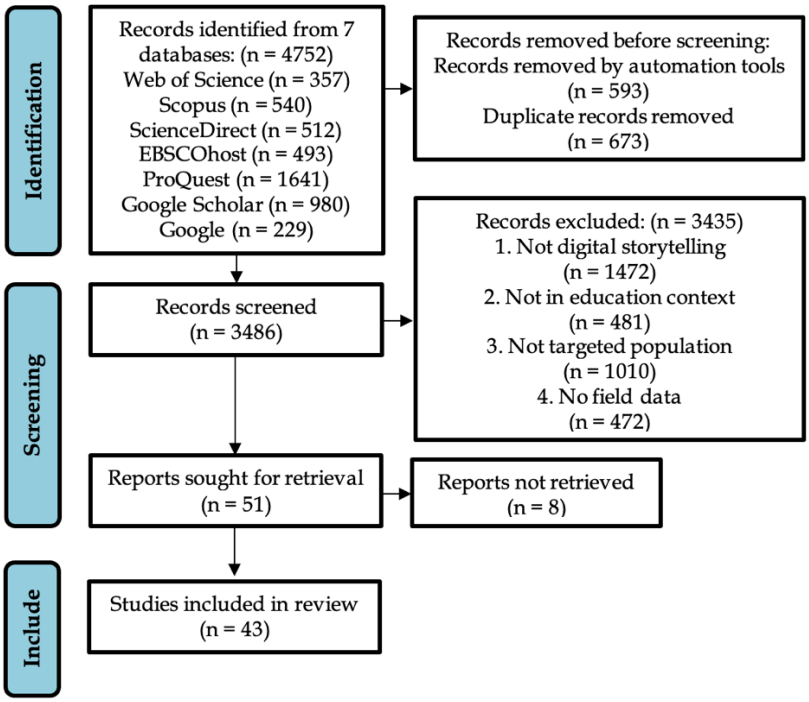

Figure 2: PRISMA-ScR flow diagram of the study selection procedure adapted from Page et al. (2021)

Figure 2 illustrates the search across all the databases. The first selection procedure was identification, whereby all the records were filtered using the automation tool in each database. The records were then saved and combined in a single Microsoft Excel spreadsheet to run the duplication-removal process. The second step was the screening process, in which all the records were evaluated based on the predefined inclusion and exclusion criteria (see Table 2). The screening process involved all the authors assessing the titles, abstracts, and keywords using the Excel customized assessment template, based on the work of Aromataris and Munn (2020). Consequently, (n = 51) records were selected for retrieval. Eight articles failed to be accessed despite various attempts to locate and contact the authors by email. This led to a final number of (n = 43) studies being reviewed in the final third phase, inclusion.

2.4 Charting the data

After the selection stage, the subsequent stage involved charting the data in the 43 included studies, whereby pertinent information was systematically organized, including visual representations. During the data charting process, all the authors collaboratively designed the data charting form and determined which variables to extract in order to effectively address the research objectives.

The researchers continually extracted data from the 43 studies and refined the data charting form.

2.5 Collating, summarizing, and reporting the results

After clearly elucidating each data extraction point, the data extracted from the articles were then compiled into a structured summary. Subsequently, the data underwent descriptive quantitative and qualitative analysis through thematic synthesis to identify key information related to the study demographic data: DST facilitating factors and challenges across the cognitive, affective, and social learning outcomes dimensions. Finally, the study's findings are discussed, guided by the research questions.

3. Results and discussion

The demographic data were obtained from 43 reviewed studies published from 2015 to 2023. These consisted of articles in journals (n = 41) and doctoral theses (n = 2), all of which were in English. Regarding the school level distribution, middle school students predominated (n = 26, 60%), followed by high school students (n = 15, 35%), with elementary school students comprising the smallest proportion (n = 2, 5%). The distribution of research methodologies shows that quantitative studies were slightly more prevalent (n = 18, 42%) than qualitative (n = 14, 32%) and mixed-methods (n = 11, 26%). This diverse methodological distribution provided a wide range of perspectives, offering comprehensive insights into DST interventions and their learning outcomes. Figure 3 illustrates the distribution of the studies, based on the countries where they were conducted.

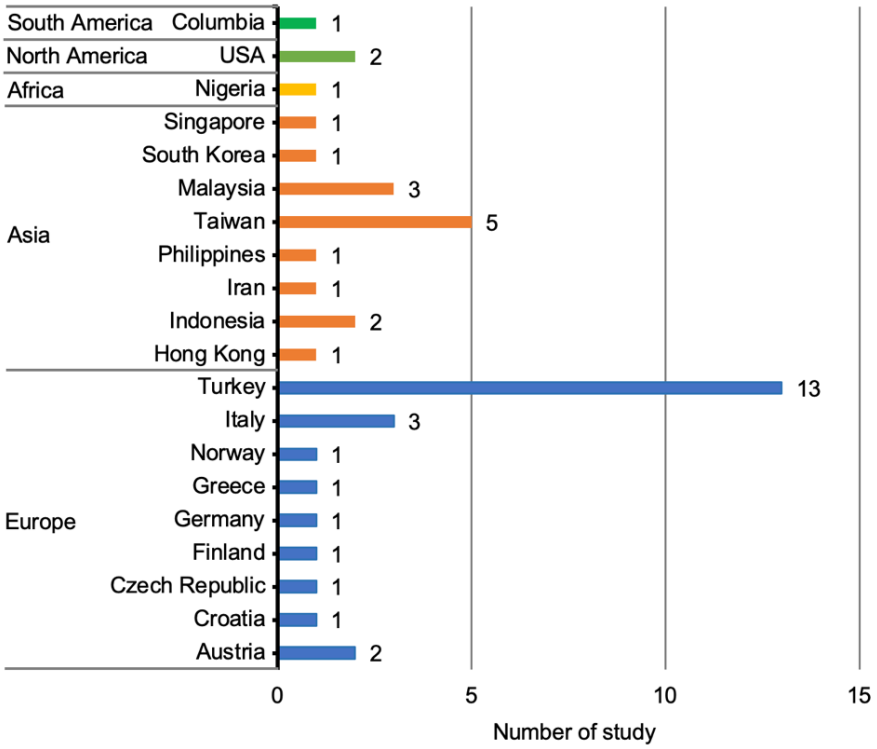

Figure 3: The distribution of studies based on country location

Figure 3 shows the distribution of studies in terms of location. A geographical overview indicates that Europe was the primary region in which DST studies were conducted (n = 24, 56%), while Asia followed closely (n = 15, 35%). However, Africa, North America, and South America were less well represented, amounting to (n = 4, 9%). From the 43 studies, the overall impacts of DST on learning outcomes are indicated in Figure 4.

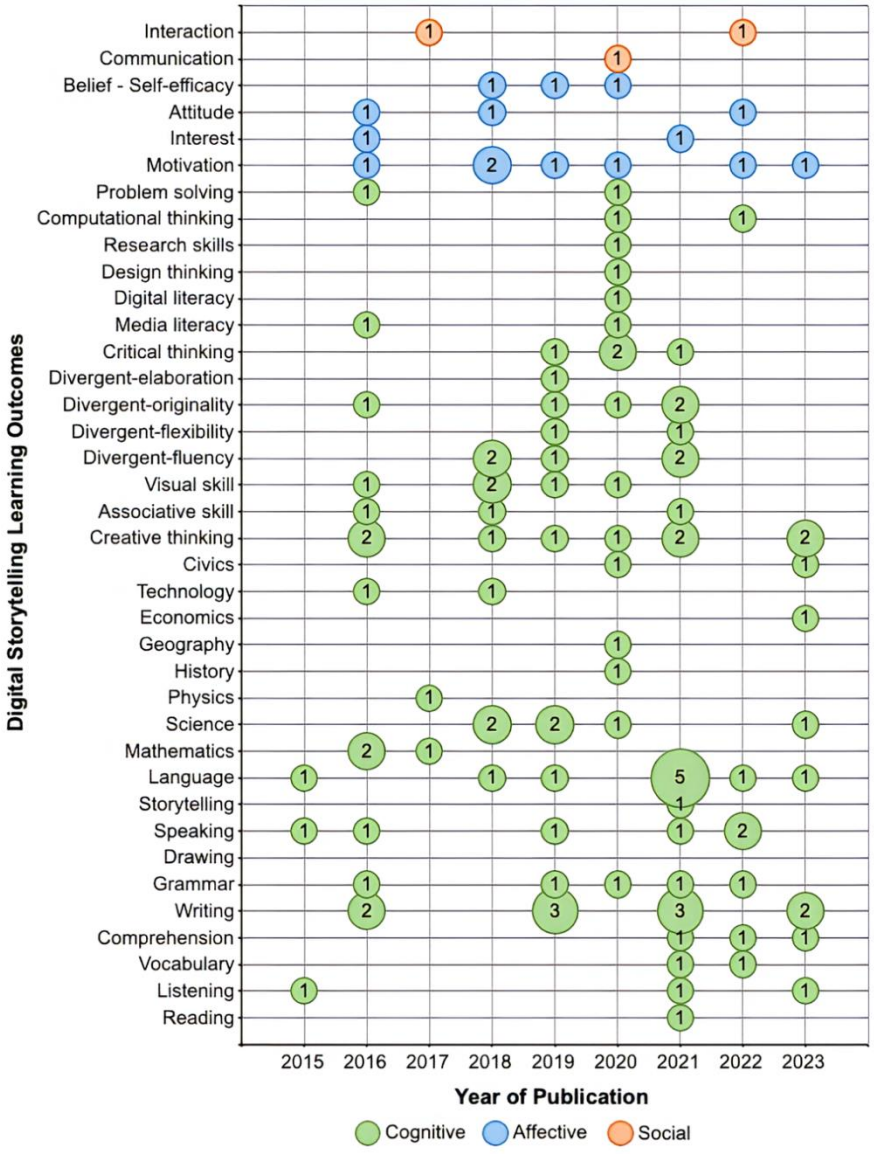

Figure 4: Bubble plot matrix of DST's learning outcomes over years with the frequency of significant results

Figure 4 shows the number of studies yielding significant results related to learning outcomes through DST across the three dimensions. The significant learning outcomes of DST over the period were predominantly in the cognitive dimension, accounting for (85%), followed by the affective (13%) and then the social (2%) dimensions. In the cognitive dimension, the highest frequencies of significant outcomes were obtained in writing skills (10%), language (10%), and

creative thinking (9%), with the remainder recording frequencies below 6%. For the affective dimension, the most frequent aspect of learning outcomes revealing a significant result was motivation (47%), with the remainder being below 20%. For the social dimension, the highest frequencies of significant outcomes were in interaction (67%) and communication skills (33%).

RQ 1: Which digital storytelling (DST) facilitating factors enable learning outcomes to be achieved across cognitive, affective, and social dimensions?
Based on the review of 43 DST studies in relation to learning outcomes, the DST facilitating factors that produced significant learning outcomes are discussed in detail, with supporting evidence provided according to the three dimensions.

DST facilitating factors in relation to cognitive learning outcomes
In the cognitive dimension, 85% of the DST studies produced significantly positive cognitive learning outcomes based on four facilitating factors: 1) the involvement of multisensory learning, 2) adequate opportunities to practice, 3) evaluation of one's own ideas, and 4) the DST iterative process. These factors enhanced language acquisition skills among students, supported the learning of complex concepts, promoted thinking skills, and led to greater academic subject-specific success. All the studies are summarized in Table 3.

Table 3: DST learning outcomes in the cognitive dimension

Study & Location	Method & Level	DST Cognitive Learning Outcomes	Approach, Duration, & Technology Platform
Towndrow (2015), Singapore	Qual, High	+Speaking, +Listening, +English Achievement	Collaborative Project-Based, 10 Weeks, Digital Material
Nam (2016), South Korea	Quan, Middle	-Chemistry Achievement	Collaborative, Online
Çiçek (2018), Turkey	Mix, Middle	+Science Achievement	Collaborative Contest-Based, 14 Weeks
Dewi et al. (2018), Indonesia	Quan, High	+Associative Thinking, +Divergent Thinking	Collaborative, Module-Based
Niemi et al. (2018), Finland	Mix, Middle	+Mathematics Achievement, +Creative Thinking	Collaborative, 4 Weeks, Tablet or Mobile Phone
González Mesa (2020), Colombia	Qual, High	+Writing, +Speaking	Collaborative, 3 Weeks
Dewi et al. (2019), Indonesia	Quan, High	+Critical Thinking	Collaborative, Contextual-Based
Ertan and Duran (2019), Turkey	Mix, Middle	+Language Achievement, +Divergent, +Visual, +Associative Thinking	Collaborative, 19 Weeks, Scratch Block Based Coding
Churchill (2020), Hong Kong	Qual, Middle	+Digital and Media Literacy, +Visual, +Design, +Research Skills	Collaborative RASE Model, 2 Weeks, Tablet or Mobile Phone
Chen (2020), Taiwan	Mix, High	+Civics Achievement, +Critical Thinking	Collaborative Gamification, 9 Weeks, Ren'Py Software

Smyrnaiou et al. (2020), Greece	Qual, Middle	+Science Achievement, +Creative Thinking, +Originality	Collaborative Two-Mixed Model, 26 Weeks
Addone et al. (2021), Italy	Qual, Middle	+Literacy Skills, +Divergent, +Visual Thinking	Collaborative Novel-Based, 8 Weeks, Novelette Editor
Kazazoglu and Bilir (2021), Turkey	Qual, Middle	+English Achievement, +Writing	Collaborative, 14 Weeks, Storybird Web 2.0
Rutta et al. (2021), Italy	Qual, Middle	+English Achievement, +Grammar +Reading	Collaborative, 5 Weeks, Desktop
Uslu and Uslu (2021), Turkey	Quan, Middle	+Writing, +Originality, +Fluency, +Flexibility	Collaborative, 11 Weeks
Nair and Md Yunus (2022), Malaysia	Quan, Middle	+Speaking, +Literacy Skills	Collaborative, 8 Weeks, Toontastic 3D Software
Chen et al. (2023), Taiwan	Mix, Middle	+Science Achievement, +Creative Thinking, +Writing	Collaborative Project-Based, 2 Days
Tengler et al. (2022), Austria	Quan, Middle	+Computational Thinking	Collaborative Robotics-Based, 3 Weeks
Abimbade et al. (2023), Nigeria	Quan, Middle	+Civics Achievement	Collaborative Think-Pair-Share, 6 Weeks
Kotluk and Kocakaya (2017), Turkey	Quan, High	+Physics Achievement	Cooperative, 6 Weeks
Bilen et al. (2019), Turkey	Mix, High	+Science Achievement	Cooperative, 4 Weeks
Ryan and Aasetre (2020), Norway	Qual, High	+Geography Achievement	Cooperative, 2 Weeks, Desktop
Sönmez and Dadandı (2023), Turkey	Quan, Middle	+English Achievement, +Writing	Cooperative, 4 Weeks
Demïrbaş and Şahïn (2023), Turkey	Quan, Middle	+Listening, +Comprehension	Cooperative, 8 Weeks, Adobe After Effects
Albano and Pierri (2016), Italy	Qual, High	+Mathematics Achievement, +Problem Solving Skills	Individual, Blended Mode, 3 Weeks
Sarica and Usluel (2016), Turkey	Quan, Middle	+Writing, +Visual Thinking	Individual, 13 Weeks, Microsoft Photostory
Schmoelz (2018), Austria	Qual, High	+Creative Thinking	Individual, Socratic Dialogues-Based, 1 Week, Desktop or Mobile Phone
Francis (2018), USA	Mix, High	+Science Achievement, +Visual Thinking	Individual, Topical-Based, 5 Weeks
Karaoglan and Durak (2018), Turkey	Mix, Elemen	+Technology Achievement	Individual, Programming, 10 Weeks, Scratch Block Coding

Rong and Noor (2019), Malaysia	Quan, Middle	+Grammar, +Writing	Individual, Elements of Robin, Storybird Software
Cheng and Chuang (2019), Taiwan	Qual, Middle	+Science Achievement, +Creative Thinking, +Visual Skill	Individual, Comic-Based, 9 Weeks, Movie Maker Software
Vu et al. (2019), USA	Mix, Middle	+English Achievement	Individual, Cinematic-Based, 3 Weeks
Barsch (2020), Germany	Mix, High	+History Achievement, +Critical Thinking	Individual, Topical-Based, 4 Weeks
Nunvarova et al. (2023), Czech Republic	Quan, High	+Economics Achievement	Individual, Evaluation-Based, 52 Weeks
Ramalingam et al. (2022), Malaysia	Qual, Middle	+Speaking	Individual, Online, 3 Weeks, Google Meet
Borong and Yamson (2023), Philippines	Quan, High	-Writing	Individual, Module-Based, 3 Weeks
Balaman (2016), Turkey	Mix, High	+Technology Achievement, +Creative Thinking	Flexible, Drawing-Based, 14 Weeks, Microsoft Photostory
Preradovic et al. (2016), Croatia	Quan, Elemen	+Mathematics Achievement, +Media Literacy	Flexible, Animation-Based, 2 Weeks, Prezi Canvas
Yamaç and Ulusoy (2016), Turkey	Qual, Middle	+Writing	Flexible, 8 Weeks, Microsoft Photostory
Liu et al. (2018), Taiwan	Quan, Middle	+English Achievement	Flexible, 2 Weeks
Girmen et al. (2019), Turkey	Qual, Middle	+Writing	Flexible, 10 Weeks
Parsazadeh et al. (2020), Taiwan	Quan, Middle	+English Achievement, +Computational Thinking	Flexible, 6 Weeks, Microsoft PowerPoint

Note on abbreviations: Quan = Quantitative, Qual = Qualitative, Mix = Mixed-Methods, Elemen = Elementary School, Middle = Middle School, High = High School, (+) = Significant outcome, (-) = Not significant outcome

Based on Table 3, the first facilitating factor of DST in relation to cognitive outcomes is multisensory learning, which significantly enhances students' language acquisition skills and supports their learning of complex concepts. For instance, DST can support listening skills by allowing students to watch interesting story videos containing content that is close to their experiences, which stimulates curiosity among them and encourages them to listen carefully to the digital stories (Towndrow, 2015; Demïrbaş & Şahïn, 2023). DST also enhances reading comprehension by incorporating multimedia elements that support visual and auditory learning, thereby improving understanding and memory retention (Rutta et al., 2021). In supporting learning about complex concepts, multisensory involvement through DST supports students' understanding of complex subjects such as physics by making abstract ideas more tangible and easier to grasp (Kotluk & Kocakaya, 2017).

Secondly, ensuring adequate opportunities to practice through DST intervention was found to be a facilitating factor in improving students' writing skills, resulting in better narrative structure, vocabulary usage, grammar, and overall writing quality. This was achieved by engaging them in story writing construction (Sarica & Usluel, 2016; Yamaç & Ulusoy, 2016; Girmen et al., 2019; Kazazoglu & Bilir, 2021; Uslu & Uslu, 2021). On the other hand, DST can enhance speaking skills by creating adequate opportunities to, first, practice language in oral storytelling and, second, evaluate one's own speech from recorded voiceovers. These opportunities encourage students to speak better English (González Mesa, 2020). Improvements in speaking skills have been demonstrated in terms of voice clarity, fluency, articulation, and pronunciation (Nair & Md Yunus, 2022; Ramalingam et al., 2022). Besides, adequate practice through DST helps develop students' technological literacy by improving their proficiency in the use of various digital tools. For instance, students creating DST projects using laptops and digital cameras enjoyed a hands-on experience with technology in the process of making digital storytelling (Towndrow, 2015). In addition, familiarity with digital tools and platforms increases students' comfort and willingness to engage deeply with learning tasks, as well as making them media literate (Preradovic et al., 2016).

The third DST facilitating factor in relation to cognitive achievement is students having opportunities to evaluate their ideas through thinking skills. For instance, Barsch (2020) found that DST develops students' critical thinking abilities when they can critically evaluate their own ideas after producing a DST video and during the display sessions. Additionally, Chen (2020) explained that critical thinking can be promoted through activities such as analyzing information and making decisions. Moreover, this facilitating factor promotes students' creative thinking skills through the assignment of story dialogue writing tasks that involve imaginative and generative skills rather than relying solely on logic (Balaman, 2016; Schmoelz, 2018; Cheng & Chuang, 2019). Creative thinking skills can be assessed through four indicators of creative ideas in students' story work: fluency, flexibility, originality, and elaboration (Smyrnaiou et al., 2020; Uslu & Uslu, 2021). Next, Tengler et al. (2021) demonstrated how integrating educational robotics into digital storytelling can effectively promote computational thinking in school students. By combining stories, texts, and literature with educational robotics, this approach has shown promise in equipping students with skills such as decomposition, pattern recognition, abstraction, and algorithms, which are essential sub-components of computational thinking (Parsazadeh et al., 2020). Furthermore, DST developed students' problem-solving skills by using research activities to address real-life issues through DST projects, which involved creating and refining digital stories to solve complex problems (Churchill, 2020).

The fourth and last facilitating factor of DST in relation to cognitive outcomes is the DST iterative process, which positively increases academic subject-specific success in courses such as English, history, geography, civics, economics, mathematics, and science (Niemi et al., 2018; Bilen et al., 2019; Vu et al., 2019; Barsch, 2020; Ryan & Aasetre, 2020; Abimbade et al., 2023; Sönmez & Urfalı Dadandı, 2023; Nunvarova et al., 2023). In addition, Çiçek (2018) explained that students who used DST in their science course showed improved comprehension

and retention of scientific concepts. This was due to the DST iterative process of creating, revising, and presenting stories, which reinforces learning and enables students to continuously explore the learning content further (Çiçek, 2018).

DST facilitating factors in relation to affective learning outcomes

In the affective dimension, 13% of the DST studies produced significantly positive affective learning outcomes based on three facilitating factors: 1) reflections of personal experiences, 2) the use of interactive multimedia, and 3) a sense of control in learning. These factors increased students' motivation, fostered positive attitudes to learning, increased interest, and enhanced students' self-efficacy. All the studies are summarized in Table 4.

Table 4: DST learning outcomes in the affective dimension

Study & Location	Method & Level	DST affective learning outcomes	Approach, Duration, & Technology Platform
Nam (2016), South Korea	Quan, Middle	-Attitude	Collaborative, Online
Niemi et al. (2018), Finland	Mix, Middle	+Motivation	Collaborative, 4 Weeks, Tablet or Mobile Phone
Kotluk and Kocakaya (2017), Turkey	Quan, High	+Self-Efficacy, -Attitude	Cooperative, 6 Weeks
Bilen et al. (2019), Turkey	Mix, High	-Attitude	Cooperative, 4 Weeks
Zarifsanaiey et al. (2022), Iran	Quan, Middle	+Motivation	Cooperative, 4 Weeks
Sönmez and Dadandı (2023), Turkey	Quan, Middle	-Self-Efficacy	Cooperative, 4 Weeks, WeVideo Online
Schmoelz (2018), Austria	Qual, High	+Motivation	Individual, Socratic Dialogues-Based, 1 Week, Desktop or Mobile Phone
Karaoglan and Durak (2018), Turkey	Mix, Elemen	+Self-Efficacy	Individual, Programming, 10 Weeks, Scratch Block Coding
Vu et al. (2019), USA	Mix, Middle	+Self-Efficacy	Individual, Cinematic-Based, 3 Weeks
Balaman (2016), Turkey	Mix, High	+Interest, +Attitude	Flexible, Drawing-Based, 14 Weeks, Microsoft Photostory
Parsazadeh et al. (2020), Taiwan	Quan, Middle	+Motivation	Flexible, 6 Weeks, Microsoft PowerPoint

Based on Table 4, the first DST facilitating factor in relation to the affective learning dimension is reflected personal experience, which can significantly increase students' motivation (Schmoelz, 2018; Niemi et al., 2018; Parsazadeh et al., 2020; Zarifsanaiey et al., 2022). Students were reported to display higher motivation levels when they created digital stories that reflected their personal experiences and backgrounds, and they felt deeper connections to the learning material (Niemi et al., 2018). In addition, DST projects often have lasting motivational effects, as demonstrated during group discussions integrated with

DST. These significantly boosted motivation among elementary school students, which persisted even after the project had ended (Zarifsanaiey et al., 2022).

The second DST facilitating factor is the use of interactive multimedia, which positively affects students' attitudes to learning and their interest. For instance, positive changes in students' attitudes were noted when multimedia was used in preparing the story content for their learning (Balaman, 2016). Balaman explained that this positivity derived from students believing that the use of multimedia-based instruction would assist their learning. Meanwhile, students were also reported to exhibit greater interest through their enjoyment of learning via DST because the interactive multimedia approach made lessons more dynamic and captivating (Balaman, 2016).

The third and last facilitating factor is that DST intervention gives students a sense of control during learning, which enhances their self-efficacy and belief in their ability to succeed in specific tasks (Vu et al., 2019). According to Karaoglan and Durak (2018), by allowing students control over the learning content they need in order to create and share stories, DST helps students build confidence in their abilities and skills. Additionally, Towndrow (2015) found that students engaging in DST projects felt more confident and a greater sense of control during their learning, which translated into higher self-efficacy in solving problems and tasks related to their learning.

DST facilitating factors in the social learning outcomes

In the social dimension, 2% of the DST studies produced significantly positive learning outcomes based on one facilitating factor: a safe collaborative environment for students to share and receive feedback through a digital medium. This can improve their communication skills and foster social interaction. The studies are summarized in Table 5.

Table 5: DST learning outcomes in the social dimension

Study & Location	Method & Level	DST Social Learning Outcomes	Approach, Duration, & Technology Platform
Niemi et al. (2018), Finland	Mix, Middle	+Interaction	Collaborative, 4 Weeks, Tablet or Mobile Phone
Chen (2020), Taiwan	Mix, High	+Communication	Collaborative, Gamification, 9 Weeks, Ren'Py Software
Zarifsanaiey et al. (2022), Iran	Quan, Middle	+Interaction	Cooperative, 4 Weeks

Table 5 shows that a safe collaborative environment in which students can share and receive feedback through a digital medium in DST is a factor that has facilitated improvements in students' communication skills. For instance, Chen (2020) found that high school students participating in DST collaborative gamification projects displayed improved communication skills. This was facilitated by the process of sharing digital stories requiring students to articulate their ideas clearly and listen to other perspectives (Chen, 2020). Additionally, using a digital medium allowed students to feel safe to communicate their stories

via forms of creative expression and reduced anxiety levels compared to traditional forms of communication. As a result, students were better able to express their thoughts and ideas (Chen, 2020).

On the other hand, DST has been effective in fostering students' social interaction. The collaborative nature of DST encourages students to interact with their peers and participate actively in group activities. For instance, Niemi et al. (2018) highlighted that students participating in DST projects using mobile devices socially interacted with their peers more frequently compared to when traditional teaching methods were used. Zarifsanaiey et al. (2022) observed that the teamwork storytelling process encouraged students to share their ideas and actively receive feedback from each other when creating their digital stories, leading to better social interaction.

RQ 2: What are the challenges in achieving learning outcomes from DST interventions?

The thorough analysis of DST learning outcomes based on 43 studies revealed three challenges in the attainment of learning outcomes: 1) suitability of approaches, 2) variability of duration, and 3) compatibility of technology. Referring to the conceptual framework, "approaches" in this study refers to specific practices employed in DST. These can be categorized into collaborative, cooperative, individual, and flexible, based on how learners engage with the task (Wu & Chen, 2020). Meanwhile, "duration" refers to the length of time required to implement digital storytelling interventions (Palioura & Dimoulas, 2022); in this study, this varied from short-term (two days) to extended periods (weeks, months, and up to one year). Lastly, "technology platforms" refers to the various digital tools used to create, edit, and share digital stories (Palioura & Dimoulas, 2022).

Suitability of approaches

First, in the cognitive dimension, the two approaches of individual or teamwork settings - such as collaborative and cooperative - both had significant impacts on students' learning outcomes (Chen, 2020; Sönmez & Dadandı, 2023). However, Nam (2016) found that when implemented online, the collaborative learning approach demonstrated negative impacts on students' achievements in chemistry. In contrast, when using offline modes of collaboration, most studies consistently demonstrated positive outcomes (Çiçek, 2018; Dewi et al., 2018; Niemi et al., 2018; González Mesa, 2020). On the other hand, a project-based approach consistently ensured significant learning outcomes from DST implementation (Towndrow, 2015; Chen et al., 2023). Second, in the affective dimension, individual, cooperative, collaborative, and even flexible approaches to DST implementation demonstrated the development of emotional competencies (Kotluk & Kocakaya, 2017; Niemi et al., 2018; Bilen et al., 2019; Vu et al., 2019; Parsazadeh et al., 2020). DST consistently emerged as a tool that could cultivate positive attitudes (Nam, 2016; Kotluk & Kocakaya, 2017). However, Nam (2016) showed that collaborative approaches delivered online had negative effects on attitudes. This was because students faced frequent technical problems during online instruction, such as software glitches, connectivity issues, or hardware

malfunctions, which tended to frustrate students and negatively impact their attitudes to learning (Nam, 2016). Third, in the social dimension, the collaborative approach can improve students' communication skills and interaction. For instance, a game-based collaborative approach through digital storytelling demonstrated positive outcomes (Chen, 2020).

Variability of duration

In the cognitive dimension, longer programs like the year-long evaluation showed positive effects on subject achievement, with DST making concepts more understandable and easier to recall in the memory (Nunvarova et al., 2023). In the affective dimension, the methods ranged from brief one-week or intensive four-week interventions to prolonged 14-week immersive experiences (Balaman, 2016; Schmoelz, 2018; Niemi et al., 2018). A longer duration appeared to be linked to fostering depth and sustained emotional impact (Zarifsanaiey et al., 2022), whereas shorter DST interventions focused on immediate responses (Schmoelz, 2018). In the social dimension, the DST intervention time periods ranged widely, from a four-week program to extended interventions spanning several months (Niemi et al., 2018; Chen, 2020; Zarifsanaiey et al., 2022). Longer interventions tended to focus on higher competencies in social intelligence (Zarifsanaiey et al., 2022).

Compatibility of technology

In the cognitive dimension, different technology platforms were employed, and each demonstrated positive outcomes. For instance, Towndrow (2015) utilized print-based and digital materials, leading to language improvements. Similarly, Ertan and Duran (2019) employed a visual programming language known as Scratch Block Coding, which also improved language and creative thinking skills. In the affective dimension, the chosen platform often aligned with the subject and the desired emotional outcomes, emphasizing the adaptability of DST. For instance, the integration of programming technology platforms such as Scratch Block Coding enhanced students' self-efficacy in technology-related subjects (Karaoglan & Durak, 2018). However, due to the technical problems mentioned previously, the use of online platforms such as WeVideo editing software did not bring about significant improvements in affective learning outcomes or in students' self-efficacy and attitude (Nam, 2016; Sönmez & Dadandı, 2023). In the social dimension, the choice of platforms - from commonly used tools such as the ready-made video editing software built into mobile devices to the sophisticated simulation platforms like Ren'Py Software - influenced both dimensions of social learning outcomes: interaction and communication (Niemi et al., 2018; Karaoglan Yilmaz & Durak, 2018).

4. Conclusions

In addressing the first research objective about the facilitating factors of DST in relation to cognitive, affective, and social learning outcomes, this review identified significant facilitating factors. In the cognitive dimension, the essential facilitators are multisensory learning, adequate practice opportunities, self-evaluation, and the iterative process, which collectively can enhance language acquisition, twenty-first-century thinking skills, technological literacy, and subject-specific achievement. In the affective dimension, facilitating factors

involve reflected personal experiences, interactive multimedia, and a sense of control during learning, which can boost motivation, positive attitudes, interest, and self-efficacy. In the social dimension, a safe collaborative environment can foster communication skills and social interaction through continuous digital feedback.

For the second research objective regarding the challenges in achieving learning outcomes from DST interventions, three major challenges emerged: suitability of approaches, variability of duration, and compatibility of technology. The suitability of approaches such as collaborative and cooperative settings generally enhance cognitive and affective outcomes, although online collaboration can encounter technical challenges. The variability of duration impacts the outcomes, with longer interventions providing deeper cognitive and emotional benefits. The compatibility of technology platforms support various learning dimensions, although online tools might induce technical frustrations, presenting challenges that influence affective outcomes.

Implications

The findings suggest that DST is an effective strategy for cognitive, affective, and social development in education. By recognizing and harnessing DST facilitating factors and challenges in relation to three-dimensional learning, educators can create more holistic and fulfilling learning objectives that not only enhance academic achievement but also support the emotional and social growth of students. Policymakers and researchers benefit when designing and implementing educational interventions because DST has the potential to transform traditional learning environments into more comprehensive developments. Lastly, these factors are essential aspects to consider when educators, policymakers, and researchers plan to deploy DST to optimize learning outcomes.

Recommendations

Future researchers are recommended to undertake studies in higher educational or other educational settings that were not incorporated into this review. Exploring DST facilitating factors and challenges in greater depth is also suggested. Gaining insights into the effects of DST on various age groups, learning environments, and implementation issues might enhance the overall comprehension of DST outcomes and maximize their impact.

Limitations

This scoping review is constrained by several factors. Firstly, focusing solely on English and Malay publications might mean relevant research in other languages and from other regions was overlooked. Secondly, excluding conference papers could have led to the omission of important recent findings. Lastly, the exclusive focus on school settings meant neglecting insights from other educational contexts, thus reducing the applicability of the findings. Addressing these limitations in future research might enhance the understanding of DST learning outcomes and critical factors.

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