Digital storytelling in teacher education: Developing pre-service teachers' critical thinking

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Digital storytelling is a pedagogical strategy that relies on constructing digital artefacts, such as videos, to develop skills like critical thinking. However, clear actions that students need to engage in to develop these skills are often lacking. Therefore, in this qualitative study, we aimed to explore pre-service teachers' perceptions of the relationship between creating a digital story and developing critical thinking. More specifically, we examined pre-service teachers' reported actions and experiences used to build their digital stories, analysing how critical thinking skills were brought into play during this process. The analysis of the interviews showed the actions pre-service teachers take when creating a digital story and how these actions, in turn, promote the development of critical thinking. The results suggest that (a) a wide range of critical thinking skills are at play when constructing a digital story and (b) the most reported skills are those related to planning and design, solving emerging challenges to pursue a critical argument and representing ideas with the use of rhetorical elements. Furthermore, we discuss the implications for pre-service teachers' training. Finally, we address the limitations of this study and provide suggestions for future research.

Implications for practice or policy:

- Student teachers and teacher trainers can count on a set of actions that will allow them to visualize the development of critical thinking when their students create digital stories.
- Teacher trainers can benefit from a pedagogical strategy that can facilitate the development of critical thinking in pre-service teachers.

Keywords: digital storytelling, critical thinking, teacher education, skills development, teaching strategies

Introduction

Digital storytelling (DST) is a pedagogical strategy that promotes students' engagement in learning processes by integrating personal stories with curricular content (Wu & Chen, 2020). DST refers to a short form of video creation where students create a story relating to their field of study. It is based on "combining the art of telling stories with a variety of multimedia, such as images, audio, and video" (Robin, 2016, p.18). Studies led by Hull et al. (2009), Niemi and Multisilta (2016) and Kumpulainen et al. (2020) have shown that the use of DST can empower students, increase motivation, and engage them in the learning process. Moreover, the wide range of actions in which creators are involved when designing these artefacts can promote the development of several so-called 21st-century skills, particularly critical thinking (CT) skills (Robin, 2008).

Developing thinking skills has become an essential element for multiple educational stakeholders. Institutions and organisations such as the European Commission and the Organisation for Economic Co-operation and Development have put forward CT as a required competency to contribute to 21st-century

society and, therefore, consider it crucial to be addressed in educational curricula (European Commission, 2019; Organisation for Economic Co-operation and Development, 2018; Voogt et al., 2019). However, authors such as Abrami et al. (2015) have suggested that research has been inconclusive regarding which teaching strategies increase CT skills. In teacher training education, there is no clear consensus on the best way to train CT (Voogt et al., 2019). Nevertheless, Lorencová et al. (2019), in their review of CT practices in teacher education, suggested that there is an agreement in the teacher training community that it is a core skill for professional performance and is often under-trained in pre-service teacher programmes. Therefore, although CT is considered an essential 21st-century skill in their future classrooms, teachers still find it challenging to teach (Thijs et al., 2014). Considering the above, there is a clear need to support educators in developing CT in their students. This article explores pre-service teachers' perceptions of DST creation as a digital strategy to promote the development of CT skills. We delve into the actions that the pre-service teachers reported while creating a digital story, identifying those conducive to the fostering of CT.

Background

DST

DST presents itself as a promising tool for the 21st-century classroom at various levels of education (Al-Amri, 2020; Kumpulainen et al., 2020; Niemi & Multisilta, 2016; Røkenes, 2016; Schmoelz, 2018). It allows digital media users to become critical creators and creative storytellers by selecting a topic, researching, writing scripts, and developing an exciting and personal story for an audience (Robin & McNeil, 2012). These creative outcomes are combined with multimedia, graphics, audio, text, video and music, resulting in a digital artefact that can be shared with others (Robin, 2008).

Digital stories are, typically, videos that can be classified into three categories: (a) personal narratives – stories containing accounts of significant incidents in a person's life (b) historical events recounting – stories examining dramatic events of the past and (c) stories informing the viewer on a particular concept (Lambert & Hessler, 2018; Meadows, 2003; Robin, 2008). Regardless of which category teachers decide to introduce in their practice, the dynamic process of creating digital stories intends to develop a deeper connection with the subject matter, allowing students to reflect on different viewpoints and personal experiences, giving them a sense of ownership and empowerment regarding their learning (Lambert & Hessler, 2018; Ng & Nicholas, 2015; Park, 2019; Yang et al., 2020; Yang & Wu, 2012). Each story requires students to carefully select and edit artefacts, with other multimedia resources, to complement the narrative and learning objectives meaningfully. This process also helps students to improve their media and technical abilities (Lombardi & Oblinger, 2007) (e.g., managing high-quality images or considering copyright regulations).

CT acquisition

CT is a so-called higher-order thinking skill many experts have attempted to define (Ennis, 1962, 1987, 2015; Facione, 1990; Lipman, 2003; Paul & Binker, 1990; Scriven & Paul, 1987). One of the more extended definitions derives from the philosophical perspective and was proposed by Ennis (2015, p. 32), who described it as "reasonable and reflective thinking focused on deciding what to believe or do". In deciding what to believe or do, a person is helped by using a set of critical abilities and dispositions. Ennis (2015) proposed a framework of 18 skills divided into five groups (Table 1): basic clarification, basis for inference, inference, advanced clarification and suppositions and integration.

Table 1
Group of skills – adapted from Ennis (2015)

Name of the group	Description
Basic clarification	Related to the analysis of arguments and clarifying concepts
Basis for inference	Related to judging the credibility of sources and corroboration of arguments
Inference	Deductions and the creation of explanatory hypotheses
Advanced clarification	Connected with defining terms and results of the analysis, reporting and expression positions
Suppositions and integration	Related to the consideration of the reasons for the thinking process

Becoming a critical thinker is a process that occurs over time (Paul, 2005). Within this process, university teachers must be aware of the need for a transformation to adjust their teaching methodologies to their student's learning, as educators' ways of thinking may generate fixed routines in their teaching practices (Ossa-Cornejo et al., 2018). Dewey, in 1933, had already noticed the need to overcome these processes by arguing that these thinking skills must be taught. Therefore, these practices should be embedded within pre-service teachers' educational trajectories using different strategies that will allow them to use their judgement and thinking in a different context.

Furthermore, a report by Ananiadou and Claro (2009) for the Organisation for Economic Co-operation and Development shows that 17 of 37 countries emphasise 21st-century skills, including CT, in most educational policies. Unfortunately, they fail to clearly define these skills' assessments or teaching guidelines. A potential explanation for the oversight of CT education is posited by L. W. Anderson and Krathwohl (2001), who suggested that so-called lower-order teaching activities that do not involve CT (e.g., remembering, understanding) are more accessible for teachers to design, implement and assess. These lower-order activities are mainly related to memorisation, repetition and reproduction of information. They do not encourage students to engage in higher-order thinking, like CT (Tienken et al., 2009). However, these so-called lower-thinking activities are (often) an essential component in carrying out higher-order thinking activities (Krathwohl, 2002).

DST and CT development

According to authors such as Robin (2016), Wu and Chen (2020) and Yang et al. (2020), DST in teaching and learning could foster the development of subject skills, reflection skills, language skills, social skills, research skills and artistic skills of both educators and students. Additionally, students could be encouraged to enhance their communication skills as they learn to conduct research on a topic, ask questions, organise their ideas, express opinions, construct meaningful narratives, assess their work and give feedback to their peers (Niemi et al., 2019; Robin, 2008; Robin & McNeil, 2012; Sadik, 2008).

Teachers can encourage students to develop CT skills in an activity that asks them to create content-based artefacts as digital stories. As building a well-structured DST project demands that the problems presented are linked to the course content, students are encouraged to think critically about effective combinations of content and multimedia elements while considering the audience's perspective (Yang et al., 2020). Even though DST can empower students, increase motivation and engage them in their learning process, CT requires more than simple engagement. It involves students' personal information discovery, and DST can provide opportunities for that personal discovery (Park, 2019; Snyder & Snyder, 2008).

Goals and context of the study

DST as an inquiry approach to teaching and learning, this strategy is no doubt challenging for teachers and students (Flores et al., 2012). Today, improving pupils' CT abilities is recognised as a highly relevant educational goal. Hence, there is a need to provide tools for future teachers to handle the challenges and confront the demands of 21st-century society. For authors such as Fry et al. (2008), this learning must involve CT actions such as mastering abstract principles; understanding proofs; remembering factual

information; acquiring methods, techniques and approaches; recognising; reasoning; debating ideas or developing behaviour appropriate to specific situations (p. 8). Hence, it is pertinent to investigate how educators can utilise innovative instructional approaches, such as DST, to foster CT skills in students (Naidoo, 2021).

Our research focused on pre-service teachers' actions carried out to create digital stories and how these actions connect to the development of their CT. Therefore, this study aimed to explore the perception of the relationship between creating a digital story and developing CT. More specifically, we examined pre-service teachers' reported actions and experiences to build their digital stories, analysing how CT skills are brought into play during this process. Pre-service teachers are often expected to obtain a high level of critical reflection, affecting their performance. However, a Belgian study amongst Flemish pre-service teachers showed that these students are not necessarily achieving a deep level of CT in their reflections (Callens & Elen, 2011). Moreover, the challenges are not limited to a student's abilities. Beneitone et al. (2007) researched the curricula of 189 universities from 19 Latin American countries in nine specific areas of knowledge. They found that university curricula are inadequately prepared to address this area. This forms a deficit, as educational professionals should be effectively trained to master these skills for their future classrooms. Besides, although there have been several attempts to generate research in the area (Chisholm & Trent, 2013; Kumpulainen et al., 2020; Pieterse & Quilling, 2018), there is limited research on the teacher training context and its relationship with CT development.

Methodology

To target our research goal, we implemented a DST activity for a 1-year master's degree in a teacher education programme at a Flemish university in Belgium. A DST strategy was used in five didactics courses in the cultural, social and behavioural science domains. Two of us were the lecturers of those courses. The total number of students involved in the courses was 60. Students participating in the class had completed one of their semester-long internships or were in the middle of it during the course.

Procedure

The inquiry-based activity we designed encouraged the students to reflect on their practical experiences concerning the content of the didactic frameworks. To carry out this reflection activity, the students had to create a 7-minute digital story to relate their internship experience connected to their selected course content. Courses had similar instructions for achieving the task, and there were only some variations in integrating specific didactic concepts into the DST. The DST project was designed in three phases (see Table 2).

Table 2
Phases of the DST project

Phase	Topic of the session	Academic year 2019-2020 – 2nd semester				
		Feb.	Mar.	Apr.	May	Jun.
Phase 1	Framing the topic: selecting the topic and conducting research					
Phase 2	Structuring the story: elaborating and analysing their story					
Phase 3	Creating the story: building and editing the video					

Phase 1 focused on framing the ideas. This phase focused on presenting the project, describing its elements, what would be required and the learning objectives. Students were presented with the factors to consider when creating their digital stories and they brainstormed preliminary ideas for their stories. It is important to stress that the sessions were redesigned for an online setting due to the COVID-19 health crisis. Further activities were conducted online.

Phase 2 involved structuring the story. The students worked in an online session, having the opportunity to discuss in small groups, where they shared their analysis process and the initial drafts. They followed an instrument that encouraged them to analyse their topic critically, leading them into a more in-depth analysis of their story, checking their biases, prejudices and previous knowledge. This phase also included a session about assembling the story's elements, where they received guidelines to write a script and use a storyboard to organise the narrative. Additionally, they could give and receive feedback throughout the learning platform.

Phase 3 focused on making and editing the video. The students were offered a voluntary session to learn basic editing skills. Question-and-answer sessions and materials on the learning platform were provided for support. By the end of the semester, the students delivered a DST video as a product to be assessed.

Participants

After this process, 60 students involved in the five courses received an invitation to participate in an interview. A total of 11 students joined the interviews (Table 3), conducted online once the semester ended. The study asked for ethical permission from the participants, who signed an informed consent form and gave permission to video- and audio-record the interview for transcripts. Pseudonyms have been used to preserve the anonymity of the participants.

Table 3
Participants' background characteristics

Participants	Didactics course	Gender	Age
P1. Rose	Social Sciences, History, Behavioural Sciences	F	50+
P2. Armand	Social Sciences	M	30+
P3. Bern	History	M	40+
P4. Angèle	Social Sciences and Behavioural Sciences	F	20+
P5. Eliseo	Social Sciences and Behavioural Sciences	M	20+
P6. Cora	History	F	20+
P7. Kevin	Behavioural Sciences	M	20+
P8. Ana	Behavioural Sciences	F	40+
P9. Helga	Social Sciences	F	30+
P10. Laurent	Behavioural Sciences	F	20+
P11. George	Art History	M	30+

Data collection instruments

The data of this study were collected individually via online semi-structured interviews in English. This collection method focused on the conversation structure during the interviews, and the goal was to better understand the research topic by gathering similar data types from each participant (Holloway & Galvin, 2016). The topic list consisted of 18 guiding questions divided into four subjects: general experience with the project (e.g., "How did you select the subject?"), DST perception (e.g., "Do you consider that the process helps you to reflect on your teaching practice experiences?"), CT understanding (e.g., "How was CT involved in your process of reflecting?") and future teaching practice (e.g., "How could strategies such as DST be used in your teaching practice?").

Data extraction and analysis

The main objective of the analysis was to interpret the data to arrive at themes and categories that shed light on the pre-service teachers' perceptions of DST as a supporting strategy for developing CT skills. The transcriptions of the interviews were analysed on two levels: (a) self-report actions taken that could lead to developing CT skills and (b) perceptions of DST as a strategy for developing CT. Data from the interview transcripts were transferred into NVivo for analysis.

A deductive and inductive approach was used to analyse the interview, starting with a set of deductive codes and then inductively developing new ones to build a theoretical understanding of the experiences studied (Ligurgo et al., 2017). Our study followed the definition proposed by Ennis (2015) for the deductive approach since it provides a detailed overview of the listed skills. This level of detail and thoroughness of the definition facilitated the description and categorisation when designing this study and analysing the data.

The findings are defined by quotes from the participants during the interviews. To identify these findings, we implemented a top-down coding process under the 18 abilities described by Ennis (2015) in his CT framework. This process delivered 149 findings, and for each of these findings, there is a citation that demonstrates its origin. This step allowed us to delimit and specify theoretically the elements we encountered during coding and thus compare this analysis to the current conceptual framework. Once the findings were identified, we went through them with an inductive analysis. The result was an aggregation of new sub-categories based on similarities that enabled us to observe how CT is reported as actions by the pre-service teachers participating in this study. One of us carried out the extraction procedure, which was subsequently reviewed and validated by the remaining two of us.

The categories emerging from this study have been gathered based on the categories of CT skills described by Ennis (2015). In our results, four of the five Ennis clusters emerged in terms of the actions reported by the students. Following the inductive analysis, a list of nine sub-categories emerged. These describe the actions reported by the pre-service teachers who serve as drivers for CT development while creating a digital story. The following section analyses these actions.

Results

The Results section provides an overview of the actions that the students described performing to create a digital story. These are organised into the sub-categories that emerged from our analysis and their consequent aggregation into the categories of CT skills (Ennis, 2015) (see Figure 1). The four groups that emerged from the data are basic clarification, basis for inference, inference, and supposition and integration skills (Table 4).

Table 4
Presence of categories and sub-categories

Categories and sub-categories	No. of quotes	No. of interviews
1. Basic clarification	36	11
1.1. Defining and framing the topic to achieve a coherent and accurate narrative	15	11
1.2. Selecting and organising the component of the argument	21	9
2. Basis for inference	25	10
2.1. Supporting ideas with input from external sources such as peers, literature, or experts	18	9
2.2. Using previous experiences and background knowledge	7	5
3. Inference	18	7
3.1. Evaluating the arguments to be used in the story	11	6
3.2. Evaluating the inclusion of different elements to create a coherent digital story	7	4
4. Suppositions and integration	50	10
4.1. Solving challenges and conflicts that arise during the development of a digital story	19	8
4.2. Using purposely rhetorical elements to support the argument	22	10
4.3. Being aware of own thinking process while creating their digital story	9	6

Category 1 – Basic clarification

In this category, DST encouraged pre-service teachers to identify story topics and components to create their story's purpose and design how it would be told. They considered topics, components, and visuals that would enliven the story they wanted to tell. Two sub-categories were distinguished (Figure 1).

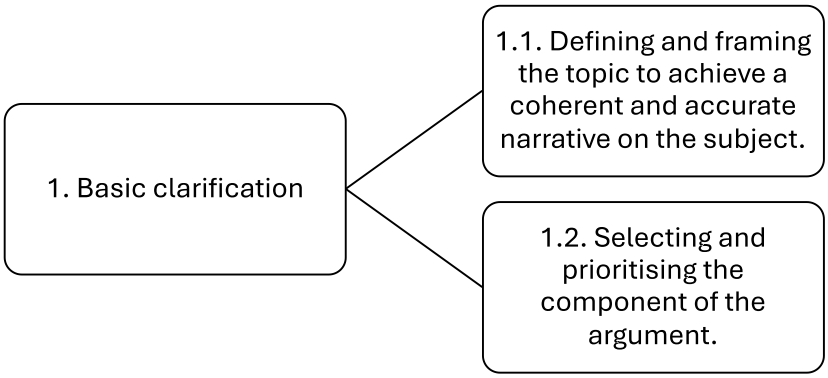

Figure 1. Actions promoting basic clarification

Sub-category 1.1 – Defining and framing the topic to achieve a coherent and accurate narrative. In this sub-category, present in 11 interviews, it was observed that pre-service teachers' focus and framing could arise in two ways. The first way was building from their internship experiences, literature review and course content. For example, P1-Rose shared:

> I first outline the big lines, so the theme and then what I saw in the classroom, how do teachers react. Based on that, I was looking for literature and studies on how to accompany this and based on that I built the story. (P1-Rose)

The second way was looking for inspiration solely from their internship experiences. For example, a student teacher wanted to frame his story around the first days of teaching during the pandemic, stating, "I wanted to promote an idea in the text because the inspiration came from a negative experience, and I wanted to turn around the negative aspect and the more sinister environment from those days to a solution towards this problem" (P3-Bern).

Sub-category 1.2 – Selecting and prioritising the component of the argument. In this sub-category, present in nine interviews, the students decided on the relevant elements and the contributions of these elements to construct a meaningful statement in their digital story: firstly, by looking for coherence within the aspects of the written text; secondly, by placing the elements that would enhance the argument and writing around them first; thirdly, by using structuring strategies like a storyboard and scripts. An example is how P7-Kevin conceived the process as a coordinated adjustment between the different elements. He said, “I do think in images (...) In my mind, I had the pictures, and then I wrote it, and I added some other pictures. I use the images to think about my text. Then, write the text and add more images”; fourthly, by prioritising the relevant elements with the time available and the amount of content used to construct the argument.

Category 2 – Bases for inference

This category describes how DST allowed the pre-service teachers to seek various sources of external support, either through expert or peer sources. They also had the opportunity to look for previously acquired knowledge and internship experiences to contribute to and support the elaboration of their argumentation. Two sub-categories emerged from the data (Figure 2).

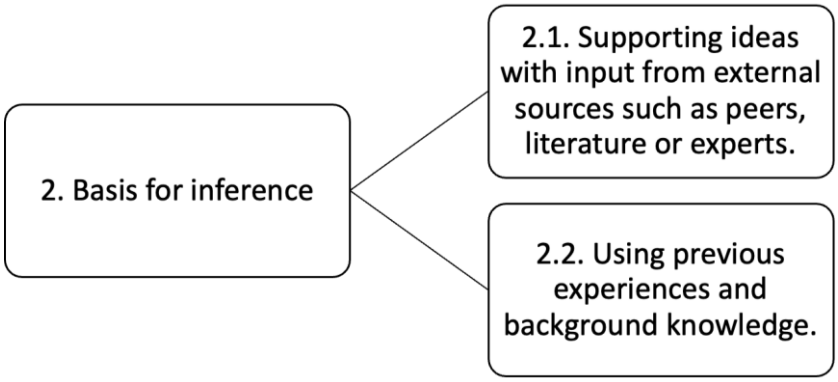

Figure 2. Actions promoting basis for inference

Sub-category 2.1 – Supporting ideas with input from external sources such as peers, literature, or experts. In this sub-category, present in nine interviews, the students sought support and guidance for their ideas from different sources of information and collaborators. Three different types of external sources have been identified. One is specialised literature. The students looked for specialised literature to support their arguments. Another source was seeking help from experts, such as teacher educators or mentors at the school where they were interns, who could guide them in their arguments. P8-Ana asked for support when she "talked about it with the teacher in [the] feedback session." The last type of source utilised by the pre-service teachers was to reach out to obtain feedback from their peers to improve their digital stories. Regarding this, P4-Angèle added, "When I got the peer review back, it really helped to see 'Oh, that's something I didn't think about yet'. So, yes, it gave me a second look at it".

Sub-category 2.2 – Using previous experiences and background knowledge. In this sub-category, present in five interviews, the students analysed their internship experiences and prior knowledge about the topic to develop the argument for their story. P11-George explained how the DST was an opportunity to share what his internship process meant to him. Basing his digital story on his internship experience, he said, "My teacher taught me how to be, so I try to show them what I learned and where I came from and the process that's actually what I wanted to do. That I learnt something".

Category 3 – Inference

In this category, we observed that DST allowed the students to create and judge their arguments, assessing the elements of their story to make it more transparent and engaging. They were open to accepting or rejecting their decisions and balancing whether these were appropriate for their story. Two sub-categories are identified below.

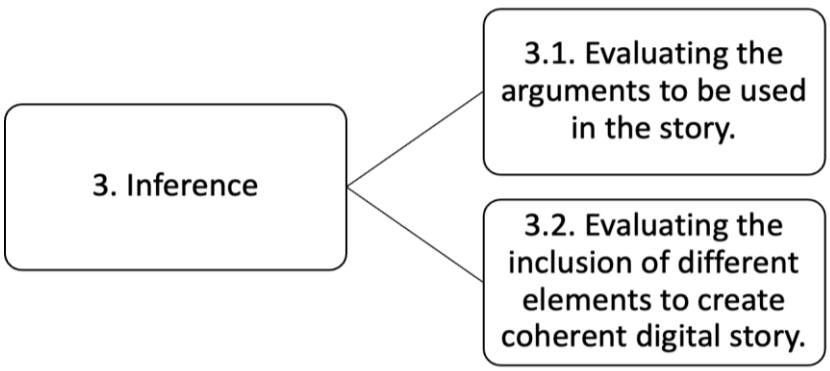

Figure 3. Actions promoting inference

Sub-category 3.1 – Evaluating the arguments to be used in the story. In this sub-category, present in six interviews, the pre-service teachers judged the arguments, conclusions and decisions made to create a

digital story. The analysis showed that the participants pointed out two types of activities: firstly, when the students assessed whether the non-verbal and para-verbal elements they had integrated into their story were appropriate for a good argument. P4-Angèle stated, “I just put the images that I wanted. I checked if it wasn’t too much, and then together with images, I spoke in the text that I already had”; secondly, actions where the students assessed whether their ideas and theoretical foundations were suitable for the digital storyline. P7-Kevin pointed out this idea, saying:

> I would have acted to my ideals, but I didn't do it that way. By making this story, I went deeper. I thought more concretely about what my ideals are. What are my ways? What is my vision, and what was the exact mismatch or the exact clash that I felt back then?

Sub-category 3.2 – Evaluating the inclusion of different elements to create a coherent digital story. This sub-category was present in four interviews. The students weighed and decided on the appropriateness of the parts they presented in their story and the product quality they were creating. For example, P6-Cora, described her process for achieving a coherent product that met her communicative and creative needs, "I wrote it out completely at first, then I proceeded to think about what pictures would best fit into [it]. I first made the text and worked on it a couple of times. I wrote a piece that had to be rewritten because it didn't fit perfectly. In the end, it was a combination of rising creatively".

Category 4 – Suppositions and integration

This category shows that the students combined CT skills with other skills such as communication, problem-solving and metacognition to get the most out of the creative process of building a digital story. The analysis revealed three sub-categories.

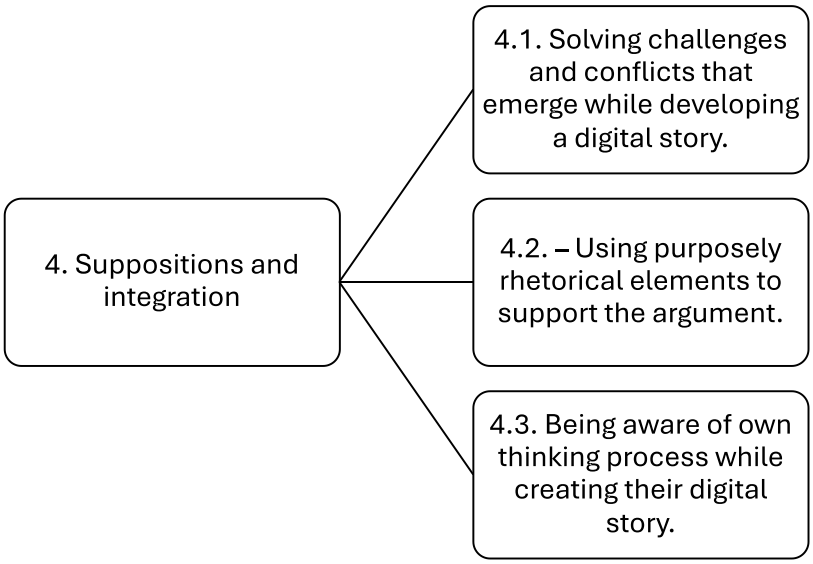

Figure 4. Actions promoting suppositions and integration

Sub-category 4.1 – Solving challenges and conflicts that emerge while developing a digital story. In this sub-category, present in eight interviews, the students devised a strategy to address the task in a way that gave coherence and clarity to their digital story. The students' first reported action was actively looking for ad-hoc solutions to their challenges while creating a digital story. For example, P6-Cora described how she handled the technical problems she encountered when editing her digital story, noting:

> The audio sort of got split into many different parts. I had to find another solution, which finally was a screen-capture. Then, I had to figure out how to put [in] the audio. I sort of had to figure out how that works. Once I figured out how to make it work, it was seven minutes, and it was done.

The second type of action the students reported is that they went through several iterations of their digital story, making improvements to achieve their argumentative goals. P1 -Rose described her process of coming back and forth many times to get the elements suitable for her digital story:

> When you're doing DST, you're doing research, writing your script, looking for pictures, you put everything together. So, it's not working on the subject once, but it's working on the subject twice, three, four times to make a nice storytelling. You're working more on the subject and manipulating it more than just a written report.

Finally, the students described solving challenges by changing or improving specific elements of their digital story.

Sub-category 4.2 – Using purposely rhetorical elements to support the argument. In this sub-category, present in 10 interviews, the students comprehended the value of visuals and other rhetorical strategies and resources to represent and enhance the understanding of their argument. The first reported action described the students' understanding of the potential of photos and videos and using them to express ideas and arguments in their digital stories, as P2-Armand shared:

> I just wanted something that was clear and reflected what I was saying, simple and good. Because when I'm looking for content, or videos about a project, or images, you have a lot of images that don't really work, don't really say what you want to say.

The second action was related to the students being aware of the expressive power that rhetorical elements can bring to emphasise their argument. The third action the students reported was to search and use the rhetorical elements in their digital stories to represent abstract elements such as emotions and atmosphere. P3-Bern described his intention to communicate something touching and expressive and resorted to rhetoric to portray these emotions. He said:

> I had images about emotions, I had diagrams, pictures just to develop an atmosphere. When I was talking about the lockdown, the images were all a bit dark, gloomy or sinister. In the end, there were blue skies and green grass fields. So that was deliberate. I thought there was an evolution in it, both in general feelings but also automatically.

Sub-category 4.3 – Awareness of their thinking process while creating their digital story. In this sub-category, present in seven interviews, the students were aware of their thinking processes and assumptions. They were watchful when arguing or making decisions while creating a DST. It is interesting to observe in the data that the students sought to avoid the possibility of bias in their argument as much as possible. P6-Cora described how acknowledging her bias was essential to her creative process, saying: "It really helped think about the aspects to own. Whether or not I had a bias. I had to pay attention to whether my bias influenced the topic. I really wanted to do it and to discuss it". However, the students also acknowledged that there were ideas and intentions that they wished to communicate through their digital stories. P7-Kevin shared, "I was just feeling vulnerable as an intern and 'being served on the race'. So, I started reflecting on that".

Discussion

In this study, we examined the perception of the relationship between creating a digital story and the development of CT. More specifically, we examined pre-service teachers' reported actions and experiences whilst building their digital stories, analysing how CT skills are brought into play during this process. In this section, we first discuss the skills that are put into play when students create a digital story. Then, we focus on some of the most reported actions that students took to make their DST and their relation to fostering the development of CT. Third, we examine some perspectives and guidance on how DST should be implemented in future teacher training programmes. Finally, we present the limitations of this study and recommendations for future research.

DST and a wide range of CT skills

This study has allowed us to observe diverse CT skills that can be actively employed while creating a digital story. Specific stages of creating a digital story revealed different CT skills depending on the challenges these stages had for the pre-service teachers. The DST design process allowed students to implement framing, planning and collaborative actions. On the other hand, the process of DST production allowed them to engage in activities of evaluation, representation and self-awareness. In designing a digital story, the students were challenged to focus on their issues, planning the elements that would be part of their arguments. During this stage, they were encouraged to analyse their ideas and knowledge, querying third parties such as peers, experts or literature. Likewise, for the digital story production, the students had to re-evaluate the decisions already made during the design process, looking for the internal coherence of the story to be aligned with their intentions and purposes. Thus, the students reported carefully selecting the elements representing these ideas and arguments, conjecturing how their audience would understand and interpret the story.

These findings show that a large part of the actions in which students engage while creating a digital story are similar to the CT skills described by Ennis (2015). It is even possible to group the emerging categories in this study into four of the five major groups of skills proposed by Ennis (notably basic clarification, basis for inference, inference, and suppositions and integration). Therefore, using a strategy such as DST would promote CT skills in the context of teacher education. However, it is essential to be clear that the categories of CT that emerged in this study are framed exclusively in the context of creating digital stories. Therefore, one of the explanations that can be proposed to understand the relationship between the creation of digital stories and the development of CT is that students are challenged to use their prior knowledge and personal experiences in the stories. This conclusion aligns with previous studies such as Wu and Chen (2020), who pointed out that creating a DST requires students to develop critical views by carefully analysing the issue and drawing on their personal experiences. As we observed in the interviews, the students focused on the topics by making sense of what they were learning during their training and enriching it with their experiences from the internship. They connected these elements with various rhetorical features, allowing them to improve their arguments and giving them more space for expressing ideas and creativity.

Aligned with the idea that DST can foster CT skills, Griffin et al. (2012) suggested that students must engage in high levels of thinking and reasoning to become critical thinkers. Moreover, creating a digital story pushes students to be aware of their thinking and their peers' thinking when they give feedback on each other's ideas, providing scaffolding to confront their biases and refine and deepen their understanding of the subject (Binkley et al., 2012). From a constructionist point of view, Papert's (1993) theory argues that people construct knowledge when they are the ones who design and build meaningful artefacts. DST aligns with Papert's constructionist principles by providing a platform for learners to actively create digital stories, promoting learner initiative and creativity, and facilitating the expression of their ideas and communication (Arlegui et al., 2008; Papert, 1993).

How does DST develop CT?

Our study sheds some light on the specific actions that pre-service teachers reported during their digital story creation that can be related to the development of CT. The actions reported by the students who were present in all of the interviews are those associated with Sub-category 1.1. – defining and framing the topic to achieve a coherent and accurate narrative, where actions such as planning, solving challenges, developing synergistic work and framing the topic are present (Table 3). These actions are essential as they can help to identify potential challenges and develop strategies for addressing them and minimising difficulties (Quah & Ng, 2022; Zellner, 2018). The results show that selecting and organising the components of the argument and framing the subject makes DST a demanding process in which several elements must be considered simultaneously to accomplish the final product. The creator of the DST must organise ideas, clarify objectives and determine the resources required to complete the project, meeting the demands of the course.

Also, the actions are related to Sub-category 4.2. – using purposely rhetorical elements to support the argument – had a high presence in our study in 10 interviews (Participants 1, 2, 3, 4, 5, 6, 7, 8, 9, 10). While creating a digital story, the students became aware of the potential of the rhetorical resources and looked forward to using them to represent their ideas and captivate their audience with the expressive power of the elements included in the story. As Lombardi and Oblinger (2007) proposed, this demands that the students research to carefully pick and edit the selected elements to complete their narrative. Therefore, DST enables students to broaden the formats and genres they can choose to make sense of and share their experiences, dreams, and social demands (Chisholm & Trent, 2013; Honeyford, 2013; Kim & Li, 2021).

Furthermore, other actions frequently reported by the students throughout nine interviews (Participants 1, 2, 3, 4, 6, 7, 8, 9) were those connected with Sub-category 1.2. – selecting and organising the component of the argument. This involved actions such as solving challenges and conflicts while developing a digital story, dealing with technical elements of editing (e.g., audio that does not work, a computer that freezes, locating the multimedia elements) or the time management of the story (e.g., complying with the requirement of not exceeding 7 minutes). With the technical challenges, the students' apprehensions and the difficulties they had to overcome to create their digital stories are framed in the literature as technical problems of incorporating DST in the classroom (Kesler et al., 2016; Liang et al., 2017; Quah & Ng, 2022). They had to reach for different sources of information or support, such as help from peers, teachers or family; in other cases, they looked for video tutorials with a description of the procedures or, in other cases, used trial and error until they completed the editing. The other interesting challenge was efficient time management in DST creation. This challenge involved making a strong and coherent argument while simultaneously encompassing all the elements necessary to generate knowledge within a limited time frame (Karakoyun & Lindberg, 2020). The students reported having to do multiple iterations to manage a coherent and attractive digital story.

Finally, the last group of actions reported by the students in nine interviews (Participants 1, 3 ,4 ,6, 7, 8, 9, 10, 11) are related to Sub-category 2.1. – supporting ideas with input from external sources such as peers, literature, or experts. In this sub-category, the students engaged in actions where they looked for synergistic work, where, in addition to specialised literature, the opinions and knowledge of others are welcome to support their ideas. The students pointed out several instances where it was necessary to ask someone's advice (e.g., peers, other teachers, experts) to achieve a solid and critical argument portraying their experiences and knowledge of the subject. These interactions promoted the iterative process of shaping and reshaping their understanding based on the input they received from others (J. Anderson & Macleroy, 2017; Kesler et al., 2016; Schmoelz, 2018). The above aligns with the literature about DST as a catalyst for collaborative actions (Girmen & Kaya, 2019; Oakley et al., 2018; Penttila et al., 2016). However, these findings also demonstrate the different moments where students collaborated and the different actors involved in the process.

These findings are of significant value as they allow us to closely look at and dissect the actions reported by the students during the digital story creation process that could contribute to improving CT. They enable the discernment of precise actions that could contribute to advancing CT skills during implementing a strategy like DST. Armed with these insights, teacher trainers can deliberate upon appropriate pedagogical strategies, considering how to effectively integrate the delineated actions into the training of pre-service teachers for the purposeful advancement of their CT skills.

Implications for teacher education

The findings emerging from this research have shown that DST is a pedagogical strategy that can be used to engage pre-service teachers to learn through design and as a catalyst for the development of CT skills. They also contribute to framing, analysing and assessing information, evaluating evidence, and building arguments using digital tools and platforms to plan, create, share, and interact with stories and others. Hence, educators should successfully teach how to think and not what to think and effectively teach how to create and not just what to create (Fasko & Fair, 2020). Generating unique, personal, and meaningful artefacts such as digital stories has the potential to empower students. They decide what to express based

on their accumulated knowledge, experiences and the theoretical content available to them (Niemi & Multisilta, 2016).

These results provide teacher trainers with resources to develop pedagogical skills associated with teaching CT and other so-called 21st-century skills, such as collaboration, creativity and problem-solving (Isaacs et al., 2024). This study offers specific actions that can be targeted to pre-service teachers. When pre-service teachers learn first-hand and in a contextualised manner what the virtues of such a strategy are, they could be enabled to train their future students in CT, among other skills that DST has been shown to favour. Using DST can potentially support pre-service teachers as a strategy that can promote unique, personally meaningful projects and artefacts using digital technologies in their future students.

Another implication for teacher education is that using DST in education can support the development of CT skills and enhance teacher education by providing learners and educators with a rich and engaging medium for exploring complex ideas and issues. However, a study made by Kimmons et al. (2015) has shown that integration of active learning activities, like DST, has an impact on pre-service teachers' application of technology in their educational contexts only if the goal is for them to reflect and think out of the box about their practice. If the goal is simply to have pre-service teachers apply technology, or in this case, just to create a digital story as if it is a narrated slides show or utilise the competencies to replace or amplify existing practice, the type of performance task used does not seem to matter. To empower pre-service teachers to use technology in transformative or disruptive ways, it is crucial to consider the types of technologies, the variety of experiences and the opportunities to engage in the teacher training programme (Karantalis & Koukopoulos, 2022; Tondeur et al., 2017).

Finally, in the case of higher education, the “cultivation of the intellectual character”, as recommended by Facione (1990, p. 13), is an ulterior goal of the curriculum, among other attributes. There is, therefore, a specific expectation about higher education, specifically in teacher education programmes, for a curriculum that advocates the value of CT and provides guidelines on how CT can be attained. In the case of the Dutch-speaking part of Belgium, the learning outcomes of teacher training programmes stipulate that their graduates must reflect permanently on their teaching practice (Flemish Government, 2023). Therefore, they are expected to achieve a certain level of CT in their reflections (Callens & Elen, 2011). In preparing future teachers to be effective skills promoters, it is crucial to develop their own skills and raise their awareness of the process behind learning. According to AlMarwani (2020), research with 56 students in a teacher training programme showed that pre-service teachers can effectively teach CT abilities to their pupils by increasing their own CT skills. However, pre-service teachers' programmes differ in their practices and approaches, resulting in differences in their students' learning outcomes and their capacity to effectively teach CT skills (Brookfield, 2017).

Limitations of the study and suggestions for future research

The COVID-19 pandemic's context challenged this research's initial implementation, forcing the course to move to an online setting, and it was necessary to seek a way to balance our research objectives with new pedagogical needs and student demands.

One of the first limitations we can acknowledge from this study is the modest participation of students, with 11 participants out of 60 students. Also, the absence of randomisation in our sample selection (due to volunteer participants) makes us aware of potential selection bias, as participants may be motivated by factors such as a personal interest in the topic or good or bad experiences during the process. However, it is essential to note that the views shared by these participants offered valuable guidance that aligns well with the existing body of research regarding the potential of DST as a tool to enhance CT, highlighting the importance of their contributions to this study.

Although extensive research describes the relationship between creativity and critical thinking skills, this study focused primarily on the role of CT. Further research should be conducted to investigate the role of creativity and its interaction with CT in creating DST. Contributing to making the relationship transparent

will significantly benefit teachers and stakeholders interested in using DST for students' skill development. For example, researchers could analyse the specific actions in which CT skills and creativity skills interact.

We understand that our study is only the beginning of a deeper understanding of the educational possibilities of DST in teacher education. Hence, more studies are needed in the area. For example, although the students reflected individually in this study, it was possible to observe that they highly valued feedback and collaboration between peers, especially during the first phase. It would be interesting to consider implementing a strategy where the construction of the artefact is group-based in future research. Furthermore, an interesting assessment would be to evaluate the concrete actions and specific processes students undertake to complete their digital stories and not only what they report as having done. In that sense, our study is limited to the students' perceptions and what they remember doing during the session. Additionally, it would be interesting to look at the artefacts the students created, evaluate the work's quality and analyse and assess the CT in the process. Finally, it would add tremendous value to implement these strategies with pre-service teachers in their professional practices at school, where they can assess the importance of this strategy for their students and their teaching goals.

Conclusion

This study set out to explore the perceptions of pre-service teachers on the influence of DST in the development of CT. The findings have shown that, according to our interviewees, DST is a fruitful pedagogical strategy for developing CT skills in the context of teacher education. The students have pointed out that due to the variety of actions that a strategy using technology such as DST has, it is possible to develop and become involved in diverse actions and activities that foster a range of skills. This research underscores the potential of DST as a flexible pedagogical strategy that can address the increasing demand for enhancing CT skills in teacher education.

The study contributes to our understanding of the key actions that are performed by students when creating a digital story and how these promote the development of CT skills in the process. By this, we mean actions such as defining, selecting and organising ideas; using rhetorical elements to represent ideas and searching for relevant information that can support arguments and conclusions. The study also reaffirms that a wide range of skills are brought into play during the creation of a digital story to produce a compelling product. Completing a solid DST artefact pushes the students to explore a wide range of skills to achieve harmony in the narrative, representation of thought and depth of content.

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