DIGITAL NARRATIVES FOR BIOLOGY LEARNING

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ABSTRACT

Digital storytelling implies creating reflective or instructive stories, which engage the learner and may promote higher order thinking skills and deeper learning. Moreover, digital technology allows for creating meaningful and attractive stories at low cost and with little technical requirements, enhancing motivation and engagement with the task. However, successfully implementing DS requires, on the one hand, good Digital Competence and, on the other, a sound Content Knowledge. Here we present the results of a 5-session training program that sought to provide specific instruction and to accompany teachers in the implementation of Digital Storytelling. It comprised tools for structuring scientific knowledge, ideas about good questions, representations modes alternative to written language, the integration of art and edition tools. The teachers had major difficulties in organizing information in meaningful ways and working with crosscutting, structuring concepts. From the analysis, it became evident that the complexity of the digital artifact attracted most of the time and effort, detracting from treatment of the scientific concepts; although the attendants assimilated well the technical tips offered, there was a great resistance to changing the way of teaching, which may preclude the implementation of innovative methodologies of this kind.

Keywords: Digital artifacts, digital narratives, biology learning, teachers training, teaching innovation

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1. Introduction

Storytelling, or telling stories, is a didactical strategy inspired in the oral transmission of culture via songs and stories. This technique relies on the power of narratives - and the emotions they raise - to transmit their message more efficiently. Although narratives often refer to personal reflective writing - used to launch creative writing and education in values - they can also encompass instructive stories to explain concepts or processes. On the one hand, Storytelling can mean, for teachers, an opportunity to transmit knowledge more effectively (in a more interesting, more attractive or clearer) way. On the other, it can grant students a much more active role in the learning process: for students, it implies the opportunity of becoming creators of knowledge: to comprehend, analyze and synthesize, fostering creativity and other competences.

Storytelling is a simple but powerful method to help students to make sense of the very complex and unordered world of experience by crafting story lines (Sadik, 2008) that help students organize and express their ideas and knowledge in an individual and meaningful way (Robin, 2005). Reflection required to tell stories can be a powerful tool to engage in deep learning that is, in nature, reflexive, integrative and progressive (Barrett, 2006). This is especially true for biological concepts, very often complex, multifaceted and where causal links are not always easy to disentangle.

In *Digital Storytelling (DS)*, the inclusion of Information and Communications Technology (ICT) and authoring tools, such as video or interactive resources, means the opportunity to craft meaningful and attractive stories at low cost and in a relatively short time. And, given the recent proliferation of intuitive creation tools, it can be done with low and decreasing technical requirements (Robin, 2005). Moreover, ICT adds not only interactivity, but also multimodality, or exploring other modes of elaborating and communicating knowledge. In other words, it promotes students from consumers to collaborative producers.

In this sense DS is one example of meaningful introduction of ICT into instruction (Sadik, 2008), one ensuring transformation of teaching (levels Modification or Redefinition of the SAMR model; i.e., tasks that could not be achieved without ICT; (Puentedura, 2006)). But designing impactful situations with ICT requires Digital Competence on the side of both teachers and learners. Digital Competence includes, according to the DigComp framework (Ferrari, 2013) 5 areas: Informational literacy, Communication and Collaboration, Security, Content Creation and Problem Solving; those five areas are prerequisite but can also be enhanced by introducing technology-rich activities in the classroom.

However, there are many potential barriers to the implementation of the above suggested approaches. Indeed, they rely heavily on the interconnectedness of scientific concepts, the ability to propose scenarios of situated learning, and meaningful integration of ICT. Taking into account all the above, we launched a research and transference project that sought to provide specific instruction and to accompany teachers in the implementation of Digital Storytelling for the teaching of science.

2. Objectives

Our objective was to design, implement and test a training programme, specifically designed to provide teachers with the conceptual and technological knowledge required for developing Digital Narratives about biology in their classes. It was delivered purposefully built to serve as a scaffold for repeating the work with Secondary School students.

The addressed research questions were:

- Which of the concepts and tools were successfully integrated for the teachers and proved most useful for building stories about science?
- Which were the main difficulties experienced by teachers during the training?
- Was the level of Digital Competence of the teachers high enough to integrate ICT in their practice?

Our specific interest in these questions was derived from the understanding that they could be used as an indicator of the affordances and difficulties that students might also face, and thus should be specifically tackled during implementation in class.

3. Research design and method

3.1 Context

The described intervention belongs to the project "From research to development and innovation in Secondary Education: Digital Narratives in science using chromebooks" (Gobierno de Navarra, Dept. of Education, grant nº CENEDUCA 08/2019).

The project included 15 hours of face-to-face training (5 sessions of 3 hours), plus 10 hours of autonomous work. As a requisite for the completion of the training program, attendants were requested to submit a 3-5' minute-long history answering a driving question related with biology, incorporating Visual Arts and composed using Scratch or tools for video edition.

23 teachers of grades 6 to 12 attended the training. It was an open call, included in the catalogue of courses offered by the Department of Education to all teachers in Primary and Secondary levels. As such, it can be considered a convenience sample.

3.2. Description of the intervention

A. Model Digital Story

Firstly, the researchers designed a digital story that was used as a model during the training sessions. The process to build the digital story was similar to the cycle suggested by Morra (2013), with special focus on some specific aspects of science teaching (Table 1).

Table 1. Design of an example of digital science narrative.

STEP (Morra, 2013)	**Specific steps suggested in the training (*With examples from the model story*)**
1. The idea/topic	To define a driving-question: *Why do a frog, a mushroom, and a woodlouse need water to live?* (Cañal de León *et al.*, 2016)
	To identify Disciplinary Core Ideas (DCI) (NSTA, 2014b) - LS1.A: Structure and function: *How do the structures of organisms relate to life functions?* - LS1.B: Growth and development of organisms: *How do organisms grow and develop?* - LS1.C: Organization for matter and energy flow in organisms: *How do organisms obtain and use the matter*

	and energy they need to live and grow? - LS2.A: Independent relationships in ecosystems: *How do organisms interact with the living and nonliving environments to obtain matter and energy?*
	To consider Crosscutting concepts (NSTA, 2014a) - systems and system models - energy and matter - structure and function - diversity and unity*
2. Research	Use of Thinking routines for exploring ideas (Harvard Graduate School for Education, 2020): *Example of Know, Want to Know, Learnt routine:* *K :"I know frogs are amphibian thus they need water to reproduce, and to breath.* *W: "Why do mushrooms need water?", "What kind of animal is a woodlouse?"*
	Search for information in our PLE[#] in Science: For example: *PBSlearning*, *Khan Academy*, *Encyclopedia of Life*, *Exploratorium*, *Proyecto Biosfera.*
	Design a concept map.
3. The script: choose the characters,dialogues and scenarios.	- Tadpole*:"Mum, look what a pretty plant!"* - Mother frog*: "It's not a plant darling, it's a fungus. Fungi feed by decomposing dead organic matter".*
4. Storyboard	 Transform the language of the script into images and graphics.
5.Gather and create images, audio, video	 Carlos de Haes Nijmegen (Holland) Prado Museum  Designed by the authors
6. Put it all together	*Openshot* and *Scratch*, to produce a final mp4 video product.

7. Share	The Digital Story created by researchers was shown during teacher training.
8. Reflection and feedback	Researchers realized the most complex steps of the DS cycle where teachers and students will need support.

*crosscutting concept suggested by (Cañal de León, García Carmona, & Cruz-Guzmán Alcalá, 2016)
#PLE: Personal Learning Environment: diverse physical locations, contexts, and cultures in which students learn.

B. Training sessions

The 5 training sessions followed the process described above, interspersed with more detailed explanations on topics specific to science teaching, integration of the arts and the language, and technological tools. Transversely, it also included references to different aspects of Digital Competence (INTEF, 2017). Briefly, contents and activities developed in session were the following (Table 2):

Table 2. Content of the training sessions

Title of the session	Topics	Area of Teacher Digital Competence (INTEF, 2017)
S1. Digital Narratives.	Concept of DS.	Informational literacy.
S2. Elements for creating good histories in biology.	Big ideas and crosscutting concepts (CC) in science. Good questions. Heuristic tools	Informational literacy.
S3. Let's talk biology.	Language and scientific thinking. Tools for telling science stories.	Problem solving.
S4. Visual Arts (VA) as a tool for creating DS.	Consuming and creating VA.	Content creation. Informational literacy.
S5. Digital tools.	Scratch and other digital edition tools.	Content creation. Problem solving. Security.

Session 1: Digital narratives: The first session served to introduce the fundamentals of DS; examples from journalism, science communication and science education were shown. The examples were selected to highlight the relevance of designing DS to capturing the attention of the audience, and making it part of the story, rather than mere consumers.
During the session, teachers were requested to do a task where they analyzed the narrative strategies, technology and interactivity presented in the different examples.

Session 2: Elements for creating good histories in biology

During this session, the big ideas of science education (Harlen, 2010), scientific competence and crosscutting concepts (CC) (NSTA, 2014a) were introduced. Researchers also discussed the importance of starting from powerful questions, and distinguished among essential, driving and research questions (McTighe and Wiggins, 2013; Cañal de León *et al*., 2016). To highlight the importance of the interplay between activity and theory, the attendants were prompted to reflect on what they knew and they needed to know, before starting to write the story.

The session focused on the Informational literacy dimensions of Digital Competence: where and how to search for information for biology lessons, and also how to organize it.

Teachers attending the training performed different tasks during this session:

- To analyze the core and crosscutting concepts included in the DS used as a model (*Why do a frog, a mushroom, and a woodlouse need water to live?*)
- To transform this driving question into research and essential questions.
- To perform a thinking routine about the science topic.
- To organize newly gathered information using a concept map (optional).

Session 3: <u>Let’s talk biology</u>

In this third session, researchers discussed the central role of language in the building of scientific knowledge, and how the use of proper grammatical structures and lexicon is essential to science communication.

Attendants exercised interpreting, expressing ideas or shifting between different modes of representation (drawings, graphics, symbols including equations, etc.).

Session 4: <u>Visual Arts as a tool for creating DS</u>

The following step implies transforming the script into an audiovisual artefact. In this fourth session the importance of making a good selection of images, voices and audios was discussed. Selection criteria included not only technical features, but also transversal elements that contribute to the hidden curriculum in the school. Teachers were provided in this session with links to search images with licenses compatible with educational uses, and also software to edit them.

Together with these technical aspects, the trainer emphasized the need to go far in the use of visual arts, and consider their intrinsic value in STEAM, which goes beyond illustrating or serving to communicate scientific ideas.

The teachers’ task included a reflection about their artistic references, and the selection of a background and a character for their own DS, applying the acquired tools and strategies.

Session 5: <u>Digital tools</u>

During this session, the researchers showed different software for editing video and audio in different platforms. Since there is an ongoing plan in the region to provide all Secondary School students with Chromebooks and to implement Google Classroom, the training was focused on free apps available for the Google Education suite and evaluation of its features.

As an alternative to videos, *Scratch* authoring tool (https://scratch.mit.edu/) was also introduced to allow for more interactive narrative schemes, while developing other aspects of the Digital Competence.

3.3 Research Methodology: Evaluation of the intervention

The evaluation of the teachers’ outcomes was performed following an interpretative qualitative approach. All the pieces of work produced by the attendants were collected, including both the productions during the training sessions and the final story (3’ to 5’ minutes video or Scratch story). Individual productions were examined, and assessed to evaluate compliance with the quality criteria for each of the tasks (Table 3). All the evidence was evaluated jointly by the three researchers, until full agreement was reached. Summaries of the main findings are provided task by task. The inferences based on the analysis of the submissions were completed with non-formal interactions with the attendants.

Table 3. Analysis criteria for the assessments of the teachers' tasks.

Task	Analysis criteria
During training sessions	
● To analyze the crosscutting concepts (CC) included in the DS used as a model.	● CC identified, in comparison with the CC initially identified by researchers.
● To identify a driving question, and to transform it into research and essential questions.	● The transformed questions met the criteria of essential and driving questions.
● To gather information (Informational literacy)	● Types of sources (descriptive).
● To use a thinking routine to organize previous knowledge and the newly gathered information (concept map or other).	● Present/absent.
● To use different modes of representation (drawings, graphics, symbols including equations, etc.) to express science.	● The alternative modes of representation convey the same message.
Teachers' digital stories	● Presence of driving question.
● Scientific content	● DCI, CC, scientific practices or elements of Nature of Science identifiable in productions.
● Technical and artistic aspects	● Dynamism of characters expressions and dialogues, role of Visual art, Interactivity. ● Balance of content/ technical aspects.

4. Results

4.1. Analysis of the teachers' work during the training sessions

One of the most complex activities for the teachers was to analyze the core disciplinary ideas and crosscutting concepts (CC) included in the model story (*Why do a frog, a mushroom, and a woodlouse need water to live?*). Most of the attendants had never considered CC in their science classes, nor were acquainted with this concept. Indeed, pretty much all the 7 concepts defined by the NSTA (NSTA, 2014a) were identified in the model story, only part of them were adequately justified, and the proportions were comparable for CC present and absent (according to the judgement of the researchers) (Table 4).

Table 4. Cross-cutting concepts identified by the participants in the model story

Crosscutting concept	Researchers selection?[1] (YES/NO)	Identify	Justify
Cause and effect	N	17	8
Unity and diversity	Y	16	16
Energy and matter	Y	10	5
Patterns	N	9	2
Structure and function	Y	9	6
Stability and change	N	9	7
Systems and system models	Y	5	0

[1] Initially identified by the researchers in the model story

Most frequently identified concepts were "cause and effect", "unity and diversity", doubling the frequency of the rest. Except for "stability and change" and "unity and diversity", the attendants had difficulties to justify their choice with reasoning that was coherent with both the content of the story and the meaning of the concept. For example, 7 out of 9 alluded to taxonomy to justify the choice of "Patterns". One third of the teachers (6/17) that selected "cause and effect" provided justifications that linked with other concepts; namely, "patterns" and "stability and change".

As for the transformation of questions (driving to essential/ research), the 19 tasks that were submitted included 22 essential and 29 research questions. 10 of the 22 (45%) complied with the requisites for being considered essential, and resembled the model question. Likewise, 17 (59%) were considered acceptable research questions, all of them related to the lack of water in the scenario of the model story.

The teachers had no major difficulties in interpreting different graphical representations, shifting between modes of representation or expressing meanings using graphic organizers.

However, two activities are remarkable for their poor quality. First, only six teachers submitted a thinking routine reflecting about the scientific concepts that would be included in their own digital story, and only 3 of them were complete. No complete concept maps were submitted. This could be one of the reasons for the absence of sound science conceptualization in some of the artifacts. Second, the teachers stated limited knowledge about sources of information to prepare their science classes, as main sources of information were Google, Youtube and Wikipedia, with much lower frequency of specialized science or educational sites.

4.2. Analysis of the teachers' final productions

All the groups submitted a full story complying with the technical and formal requirements of the task (format, length, requisites of delivery).

All the stories had an implicit driving question, explicit science contents, and could potentially be linked with one or more crosscutting concepts (Table 5).

Table 5. Components of the digital stories submitted at the end of the training

Title	Driving question/ problematic scenario	Content	Crosscutting concepts
Noe’s Mission	The “Noe’s rocket”. Distribute species in the stars of the Milky Way Galaxy	Universe and biodiversity	Structure and function
Drop by drop, stop floodings.	Why do floods happen?	Ecosystems; interactions, energy and dynamics.	Cause/Effect
A drop of water	How is life in a drop of water?	Monera and proctista kingdom	Patterns Models and System models
“Hidratomik and the cells”	Are we the dust of the stars?	The origin of life [In]organic chemistry	Energy and Matter Stability/Change
A football match in Kepler 10-B	Would it be possible to score a goal from mid field in Kepler 10B?	Force and Movement	Cause/Effect
Model catwalk	The evolution of the atomic model	Atomic models	Models and System models
Everybody moving	Will Spiderman and Usain Bolt arrive in time to save the child?	Movement	Energy and matter

A closer analysis of the content of each of the stories revealed some aspects of interest:

Scientific content vs. digital artifacts

Based on the analysis of the final artifacts (videos or Scratch programs) submitted after the training, it became evident that much more time and effort had been devoted to the elaboration of the product than to the process of construction of knowledge, in most of the cases. The dialogues with teachers served to confirm this perception.

Nevertheless, the sample of tasks submitted included some interesting examples, where scientific concepts (science, how is science, how it is done) were at the center. For example, in the story titled “A drop of water” the dialogues guide observation of the anatomy of several microorganisms, emphasizing distinguishing features and introducing scientific vocabulary in a natural way. In this video, teachers also included procedimental aspects such as the use of a microscope.

The video “Everybody moving” succeeded to exploit multimodality, and to combine graphic representations with mathematical formula and text captions to enhance comprehension (Figure 1a).

Figure 1. Remarkable examples in teachers’ final productions- a) A graphic representation of the parameters needed to solve the question in *Everyone moving;* b) Slow speed motion in Scratch creates the realistic illusion of astronauts floating in *Noe’s mission*; c) final credits and user’s licenses.

The video “Model catwalk” is also an excellent example to teach the Nature of Science, showing that science knowledge is limited and subject to change in light of new evidence.

Technical and artistic aspects in the videos

The groups made a detailed selection and conscious inclusion of images, some of them famous artworks. As it was shown in the training, they even edited images and fragments of video that enhanced the quality and dynamism of the productions.
Although only used by two of the groups, Scratch proved especially useful for introducing movement and certain degree of interaction, making the scenes and the characters more realistic (especially if they are synchronized with the story) and also to add interactivity with the audience (asking questions, for example) (Figure 1b).

Digital competence

We have no evidence whether there was any improvement in the informational literacy (increasing the quality or the diversity of the information sources).
In spite of the training specifically addressing the need to consider licenses and author’s rights both when using others’ work and when distributing their own work, few groups included credits, specified the license type or referenced their sources (Figure 1c).
The interactions with the teachers made evident their self-consciousness about their technical command of tools, in spite of the training received (content creation), and that this might be limiting their ability to innovate with ICT.

5. Discussion

The training sessions, scheduled according to Morra’s 8 steps for DS (Morra, 2013), and with constant reference to the model story built by the researchers, were aimed to get the attendants familiar with this methodology and facilitate later use in their classrooms.
Moreover, the sessions sought to emphasize certain aspects that guarantee the quality of the process and the product, such as the necessity to structure teaching in reference to crosscutting concepts and big ideas, the power of questioning and the utility of considering

alternative representation modes (multiliteracy). Lastly, they facilitated teachers resources and tools with which they are usually not familiar, such as art facilities and coding tools.

The analysis of the productions of the attending teachers during or after the training shed light on some of the dynamics that emerged and the difficulties they encountered during the process. They are developed in the following paragraphs.

As it becomes evident in the final artifacts (videos or short Scratch codes), the technological challenge often attracts all the attention, deviating the focus from the contents. As it is also common in some instances in PBL, the context - the artifact or task - takes over the contents in the control of the real conflict of the project (Domènech Casal, 2019). To prevent this, it could be interesting to use a template to make explicit the objectives of the project (*i.e* to elaborate a video to tell a story) and the learning objectives (i.e. science concepts), and to review them at different moments during the project development, to analyse where are we inverting more time and effort (Domènech Casal, 2019).

Likewise, there was a rapid identification and good assimilation of the methodological and technical aspects, such as the incorporation of visual resources or the structure of the process. But, at the same time, we observed a great resistance to changing the way of delivering scientific contents. Indeed, most of the products served to convey a closed fragment of knowledge, far for representing the process of knowledge construction. This could be related to the fact that all but two groups created lineal, non- interactive videos, being the main reason they did not feel capable of using Scratch programming interface. The reason alluded was their perceived lack of confidence in using new digital tools. These results are in broad agreement with the data emanating from a previous survey about Teachers' Digital Competence on a wider sample in the same population. Respondents to the survey (n=229) scored highest on Informational literacy and Communication and Collaboration, and lowest on Content Creation (own unpublished data).

This is a clear example that Digital Competence of Teachers is not independent, but may refrain pedagogical integration. Indeed, only moderate to high levels of technical performance allow for appropriation of ICT, or technology- based innovation (Krumsvik, 2011), while teachers in the sample obtained low-medium levels compatible with adoption or implementation.

In the same vein, concepts tended to be treated - as it happens in most classrooms - as isolated concepts, with difficulties to identify and incorporate crosscutting concepts. It became clear that being able to tell stories allows for but does not guarantee knowledge is (re)built, and that it is technically feasible to construct narratives without developing deep understanding. This raises awareness about the importance of ensuring this entailment, if we want Digital Storytelling (DS) to have real impact on the significant acquisition of concepts.

The gap between the initial expectations and the final result could be attributed to several factors, including deeply held beliefs and powerful inertias, and also limitations of the training program. On the one hand, it was quite a specific program, that gave for granted several prerequisites pertaining, mainly, science teaching. This was, obviously, an overoptimistic assumption; the training should have been longer, and/ or start from more basic concepts to make it more meaningful and easier to grasp. Other possible limitations were related to the scheduling of the sessions, and of the delivery of the final product with respect to the end of the "lectures". The process of creation of the final artifact was a perfect black box for the researchers, which did not get any insight on the progress of the project until it was delivered. In cases requiring such a profound revision of their own schemes, it is essential that the learners are accompanied in the process.

To conclude, in the literature, Digital Storytelling ((Barrett, 2006; Robin, 2005; Robin & Pierson, 2005; Sadik, 2008) is presented as a methodology with positive impact on students' deeper learning of science content, and that can also be a very motivating activity for 21st century students, who are used to communicating in a digital environment. In our experience, DS may be also a transversal approach that allows integrating arts and digital competences, fostering multiliteracy. However this process of creation of knowledge, especially in terms of science learning, is a complex process that requires time and significant supervision during the construction process.

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