



The Procedural Nature of Interactive Digital Narratives and Early Literacy

Cristina Sylla^(✉)  and Maitê Gil 

Universidade do Minho, 4710-057 Braga, Portugal
cristina.sylla@ie.uminho.pt

Abstract. Interactive digital narrative (IDN) has characteristics that challenge the traditional assumptions about narratives, in this sense IDN is defined as composed of system, process, and product, in a model which highlights the procedural nature of IDN as a reactive and generative system [14]. In this paper, we argue that educational applications of IDN can be enhanced by placing the emphasis on the procedural nature of IDN given by the specific framework. We present an authoring tool for IDN to support early literacy practices in pre- and primary school children and discuss how the preliminary findings benefit from an analysis oriented by the Specific Theory for IDN. We propose that the inclusion of system, process, and product in the analysis and the pedagogical use of IDN bring up two crucial aspects of young children's language development: embodied cognition (specially supported by the *system*) and interaction (specially benefited by the *process*). Finally, we argue that the procedural nature of IDN can provide a learning opportunity in educational applications of IDN, whereby we highlight the prominent role of the *user* within the proposed IDN framework.

Keywords: Interactive digital narrative · Authoring tools · Early literacy · Children · Storytelling

1 Introduction

Interactive digital narrative (IDN) has characteristics that challenge the traditional assumptions about narratives, for instance, the role of the author, the active role of the audience, and the malleability of the narrative itself. Based on these aspects, some authors have argued that analysing IDN with theoretical frameworks created to describe narrative in traditional media does not properly explore the nature of IDN [15]. Different answers to this demand were developed, one of them through a Specific Theory of Interactive Digital Narrative, which aims to overcome the output-centred view of legacy theoretical frameworks, recognising the importance of all elements of IDN, such as the computer system and the participatory process involved [14].

In this paper we argue that educational applications of IDN can be enhanced by placing the emphasis on the procedural nature of IDN [14, 16], and present results from Mobeybou, a research initiative to develop an authoring tool for IDN to support early literacy practices in pre- and primary school children.

We begin by presenting the key concepts proposed by [14] and providing a summarized review of relevant aspects of the role of narratives in language development. We then establish a dialogue between the specific theory of IDN and early literacy, exploring the procedural nature of IDN as an element which enhances young students' linguistic competences. Finally, we describe Mobeybou, a digital manipulative authoring tool for IDN designed to pre- and primary school children.

2 Interactive Digital Narratives: System, Process, and Product

An important contribution to the theoretical model of IDN is the distinction between the material artefact and its output proposed by Nick Montfort in his investigation of Interactive Fiction (IF) works. The assertion that “an IF work is an interactive computer program, but not directly a narrative” [19] is productive because it leads to the understanding of an IF or IDN artefact/system as something bigger and more complex than the narrative itself, as it contains the system, the process and the outcome. Another important characteristic of IDN is that it requires an interactive process to produce the output. Considering these premises, while classical narratology methods focus only on the output (the narrative), an adequate framework to IDN must also account for the combination of the software/hardware and the user's interaction process with it, which together result in a narrative output [14].

Based on these assumptions, IDN is understood as “comprised of system, process, and product” in a model which “takes into account the procedural nature of IDN as a reactive and generative system” [14:97].

In this definition, system refers to the digital artefact, including the executable programming code and virtual assets, as well as the connected hardware. In other words, the IDN system contains potential narratives, which are structured through protostory, narrative design and narrative vectors. The author uses the term protostory to denote a prototype that defines the space of potential narrative experiences; the term narrative design is used to refer to the structure within a protostory that enables a flexible presentation of a narrative; and the term narrative vectors is related to the substructures that provide a specific direction to the story. The second element, the process, is intrinsically interactive and can engage one or several participants. The process is defined by the opportunities the system provides and shaped by the user's actions. The interactions performed during this phase are fundamental to the output and represent a key distinction between IDN and narrative in traditional media. The third element, the product, is classified as an instantiated product, because the participatory process and the procedural nature of IDN make different narrative outputs possible.

Considering these definitions, IDN can be defined as “an expressive narrative form in digital media implemented as a computational system containing potential narratives and experienced through a participatory process that results in products representing instantiated narratives” [14:98]. Outgoing from Koenitz's model, we propose to give to the user a more evident role in the interactive process that takes place between user, system, process, and product. In this sense, a full analysis of IDN needs to include the three elements discussed by the author: system, process and product, as well as the user, who is a cross-cutting element in IDN.

The main difference between a specific theory of IDN and the applications of narrative theories to IDN [17, 1, among others] is the shift from an output-centred view to a procedural account. This shift is fundamental to this paper, once we argue that educational applications of IDN can benefit from it.

3 Narratives and Language Development

Children assimilate and produce narratives in connection with their own embodied experiences in real life and in other narratives, in other words, narratives are a form of human thinking that is fundamental in making sense out of one's social experiences, as well as in the development of one's emotions and cognition [5, 7, 9]. Regarding the development of language abilities, the propriety of creating new experiences and knowledge through temporal and causal organization enhances narrative to a privileged place in literacy development.

Storytelling is acknowledged as an effective instrument to boost early literacy, increasing children's active participation in the language learning process [18]. Studies have revealed that children's early exposure to narratives has a major influence on the development of early literacy skills, being a creative and playful way of linguistic exploration [6, 23]. The frequency and the variety of narratives to which a child is exposed also impact the complexity of the vocabulary as well as the syntactic complexity in oral language [23]. Besides, retelling or creating stories implies a mental reconstruction of the story events, which fosters the development of metanarrative consciousness, and the emergence of more advanced language skills, enhancing grammar, vocabulary, and sentence formation [6].

However, narratives are more demanding for children than the discourse they use in daily life, presupposing, for instance, the use of different verb tenses and a more elaborated and structured language, implying decontextualized use of the language, as the narrator always places himself at a distance from the related events [8].

Concerning the scope of this paper, it is relevant to mention that although there are well established evidences of the role played by narratives in language development, most of them focus on the product, namely, on the narrative itself and its structure, not on the system and the process that result in a narrative output. This does not diminish the value of these contributions, as they are aligned with the classical narratology theory and therefore mainly related to narrative in traditional media. However, it shows that investigations about the specific characteristics of IDN and its relation to educational settings are a fruitful area for new contributions.

4 The Procedural Nature of IDN and Early Literacy

Interactive process-based narrative has been pointed out as a powerful tool in a variety of situations, such as: technology-enhanced learning for children with autism [20] or cardiac illness [4], health promotion research and practice [11], vocabulary development practices [27] and 21st century literacy skills development [22]. Barendregt et al. define 'collective storytelling' as "the combination of cooperative technologies with storytelling in order to coordinate different authoring efforts" [3]. The authors present

digital storytelling and interactive storytelling as related concepts, arguing that collective storytelling differs from them because it puts a focus on the enriched collective authoring experience. Despite the specific particularities of each of these concepts and contributions, our core argument here is that, just as the IDN analysis benefits from the proposition of a specific theory, educational applications for fostering early literacy can also benefit from being designed taking into account the aspects in which IDN differs from other narrative forms. In this sense, the shift from an output-centred view to a procedural account moves the core contribution of IDN to language development from the narrative itself to the interactive process through which it is built.

While in more traditional narrative forms only the output (in the form of a text) is available for analysis - and it is merely possible to speculate about the author's thoughts and her writing process - with IDN, it is possible to record and analyse the output, as well as two additional elements: the system and the interaction process. So, instead of the established theoretical narrative framework used in traditional media, which is composed by an author-writing-output (fixed), a specific IDN framework should be composed by a system-interaction-output (which can be fixed) [14]. This means that an IDN analysis would allow to look at the system's configurations and observe the participant's exploratory process of creating a narrative. In this scenario, the analysis of the instantiated narrative can reveal not only aspects of its structure but also how particular interactions shape the outcome.

Within this framework, the procedural nature of IDN as a reactive and generative system becomes prominent. This is an important contribution to educational applications, because while traditional narrative approaches merely focus on the product, the obligatory interactive process when producing the output of a specific IDN makes the activity of planning and creating stories more concrete and transparent, as well as the activity of teaching how to plan and how to create stories.

Regarding early literacy practices, while the process of creating a narrative can be a challenging and abstract task for young children, the procedural nature of IDN enables a participatory process which is concretely guided by the system's configurations. The inclusion of these elements in the analysis and the pedagogical use of IDN brings up two crucial aspects of young children's language development: embodied cognition (supported by the system) and interaction (promoted by the process).

Children, both in their understanding and production of narratives, refer back to their own experience of reality. When a child narrates a story, she places herself at a distance from the momentary situation, imagines something, remembers, and participates in the portrayed reality. This is not an easy process, and research has called attention to children's need of structures that scaffold them in these tasks, which are intrinsically related to the embodied cognition thesis [2]. Knowing that children assimilate and produce narratives in connection with their own embodied experience in real life and in other narratives, it is possible to argue that the system's configurations aligned with the user's bodily and social interactions are a way to foster the development of storytelling competences. In this context, an IDN system can provide scaffolding structures to young children by: (i) structuring the space of potential narratives through the proto-story; (ii) guiding flexible presentations of a narrative through the narrative design; and (iii) determining possible directions to the story through the narrative vectors.

Considering the participatory nature of the IDN process, the obligatory interaction (whether with the system or with the system and other individuals at the same time) to produce the output is aligned with the sociocultural theory. Vygotsky (1979) accentuated the mediative nature of learning, either by means of signs or by means of human mediation. According to this author, the development of thought is determined by language, that is, by the linguistic instruments of thought and by the socio-cultural experience of the child. In consonance with this approach, it is possible to argue that the IDN interactive process accentuates the role of mediation as an important semiotic mechanism of learning. Here, it is particularly relevant to consider the role of the user not just in the creation process, but also in his interaction with the system. The user is, therefore, the central element that articulates the IDN as a meaningful whole and potentiates IDN as a learning tool. This is a relevant aspect to be considered in IDN educational applications, supported by recent research that has identified the need of fostering interaction with and through the artefact as a more knowledgeable other [10].

Bears et al. first introduced interactive storytelling at the CHI conference in 1998, since then IDN has been widely applied in the educational domain and many fruitful investigations have been done in this area, however not all of them highlight the aspects in which IDN differs from other forms of narrative. In this sense, in this section, we established an initial dialogue between a specific framework of IDN [14] and language development. In the following section, we introduce Mobeybou, an authoring tool for fostering early literacy and outline some aspects of its application to education aligned with the theoretical model for IDN.

5 Mobeybou: A Storytelling Authoring Tool for Pre- and Primary School Children

Here we present Mobeybou [26], a digital manipulative aimed at scaffolding the creation of multicultural stories among young children, enhancing the development of narrative competences. The reason for presenting Mobeybou is two-fold. On the one hand, we aim at illustrating how the IDN theoretical approach has an impact on the study, design and development of analytic methods regarding educational settings. On the other hand, we aim at analyzing the potential of this specific digital manipulative as an authoring tool for IDN.

Digital manipulatives are physical representations, materials or objects with embedded computational properties that allow interacting with and manipulating digital content [21]; they are often also named Tangible User Interfaces [12]. These tools are especially adequate for young children because they provide opportunities for exploratory physical embodiment, collaboration, verbalization, exchange of ideas and negotiation [24].

The development of Mobeybou followed an iterative and participatory design methodology, involving children and teachers along its development, thus undergoing several iterations.

5.1 The System

The digital manipulative is composed of a series of physical blocks that act as an interface for manipulating the digital content. A previous hardware version of the system is

composed of an electronic board that connects to a computer or tablet via USB. The board has six slots for placing blocks, which adhere to it through magnets located on the board and on the bottom of each block (see Fig. 1, left). A more recent hardware version of the system uses blocks that communicate with a computer or tablet via Bluetooth, and with each other through magnets embedded on the sides (see Fig. 1, right).



Fig. 1. The System: previous version (left), recent hardware version (right).

The software is the same on both systems. Each physical block embodies a story element having the respective visual representation on the upper face. Placing a block on the board or connecting the blocks to each other triggers its digital representation on a device's screen. Children can create their narratives by connecting the various blocks to each other, or by placing the blocks on the board (depending on the system's version they are using). Removing a block from the board or from the block chain makes its virtual representation disappear from the screen.

Presently, the blocks represent eight cultural sets, namely, India, Brazil, China, Portugal, Germany, Angola, Turkey and Cape Verde. Each set represents the respective culture and is composed of a landscape, two protagonists, an animal, an antagonist, a musical instrument and a magical object. There are also five atmospheric conditions blocks (rain, snow, wind, thunder, night), as well as ambient and background sounds.

Each block element has specific animations that display different actions. The visual narratives unfold according to the combination of blocks that the users place on the board, or connect to each other, while they verbalize their stories. A recording button allows recording/playing children's narratives.

Protostory. Considering that the protostory can be understood as a pre-story containing the necessary ingredients for any given walkthrough, the protostory in *Mobeybou* contains the space of possible stories embedded in the contents of the narrative elements, the narrative preconditions and definitions, as well as the possibility to let the users actively

interact with, explore and mix elements from different cultures. These are provided by the programming code and the interactive interface.

Narrative Design. The narrative was designed through behaviour trees (BTs), a concept well known in the field of computer games to model character behaviour, reactive decision-making and control of virtual characters [13]. The BTs describe general actions of entities; thus, each entity interacts with the environment according to a set of predefined rules that define its behaviour. The narrative design comprises following entities: environment (scenarios, weather conditions); Items (objects; instruments) and Characters (protagonists, antagonists, animals). The entities behave according the following rules: The antagonists attack the protagonists; The animals defend the latter; The protagonists and the animals can join forces to defend themselves from the antagonists; The antagonists can also join forces to attack the former; The musical instruments and the magical objects have magical properties and can be used by the protagonists to help the protagonists and the animals. When an element is defeated (depending on the system's version being used), the physical block needs to be disconnected from the others and reconnected or removed and replaced on the board, in order to bring it to life again.

Since the behaviour triggered for each entity depends on the other entities that are also present in the scene (on the board or connected), and the properties of those entities, there is a certain degree of unpredictability in the outcome of a given situation. When the users connect the blocks to each other or place the blocks on the platform, the BT of each element gets the inputs of the entities that are present in the scene. Regularly at a predefined time stamp, the BTs perform updates to check the scene and the defined priorities before triggering any actions. As a result, there are no predefined stories, nor a linear narrative. The users create their own narratives according to the sequence of blocks and the order in which they connect them/place them on the electronic platform. This way the narrative design opens up a space for experimentation and agency. So, in their story creation with the digital manipulative, the children are incentivized to find creative solutions for the situations that unfold by attending to the constraints given by the rules, which they therefore must infer and understand.

Narrative Vectors. Narrative vectors in the digital manipulative are combinations of elements and the constraints given by the underlying behaviour rules that are designed to create specific experiences, for example the usage of a particular instrument to protect a protagonist after the child has gathered additional knowledge about its properties.

Understanding the digital manipulative in this way facilitates the examination of aspects which are beyond the focus of traditional narrative studies. The participatory possibilities provided by the authoring system and its cultural sets can, for instance, be analysed as part of the protostory in terms of environment definitions and settings.

5.2 The Process

Similar to other IDN systems, the storytelling process with the digital manipulative is intrinsically interactive and it can engage one or several participants. The digital manipulative offers a space for exploring storytelling within a multimodal (verbal,

visual and auditory) embodied (through manipulation) collaborative process, moving beyond creativity processes based on individual mental imagery. In other words, it challenges individual-mind-and-mouth narrative construction transforming it into a process in which mind-hands-eyes-and-ears attune in shared embodied, multimodal and collaborative processes of narrative creation [25].

5.3 The Output

The digital manipulative offers the possibility to record the resulting product of the interactive digital narrative walkthrough, that is, the instantiated narrative. In this sense, another relevant contribution of this model is that the instantiated narrative can be analysed considering the specificity of the digital manipulative's narrative design, which is defined by certain narrative vectors, instead of applying "the output-centred view of legacy theoretical frameworks" [14:97]. This means that the analysis is no longer constrained by the need to adapt legacy theoretical positions and can instead fully focus on describing the particular narrative strategies of each IDN [14].

6 A Pilot User Study: Preliminary Notes on the Educational Application of the Theoretical Model for IDN

In this section, we briefly present a pilot user study carried out with Mobeybou, aimed at receiving feedback from the children about the IDN system in order to validate and inform future developments, as well as at understanding if the manipulation of the system and the interaction rules between the story elements were well thought and easy to understand by the target users. This study was carried out with the system's version that uses the electronic platform connected to the computer via USB.

The study was carried out at a local public school, with twelve, eight-years-old children from a class of 3rd graders. The children were grouped in pairs by the teacher. A researcher started by giving a brief explanation of the functioning of the IDN system. After that, each pair interacted and explored the tool for around 20 min. Following the exploratory phase, the researcher invited each pair to tell a story using the digital manipulative. The data was collected by two researchers (that stood in the background) through observation and written notes. A third researcher accompanied the children in their storytelling. All the interactions were audio-video recorded using a video camera on a tripod with a fixed focus and zoom. The video camera was placed behind the children focusing on the manipulation of the blocks. At the end of the intervention, the researcher carried out a semi-structured interview with the teacher. Considering the scope of this paper, we focus our discussion on the interaction of just one pair, in order to argue that the preliminary findings benefit from an analysis oriented by a specific theory for IDN.

6.1 Analysing the Interaction with Mobeybou Through the Lens of a Specific Theory of IDN

Here, we illustrate representative interaction behaviour of a pair of girls with the tool through two vignettes and one research note, selected for their relevance as representative

of children' interaction with the digital manipulative. The vignettes and the research note focus on three major contributions from the theoretical model for IDN to early literacy practices that came up in the analysis, namely: (i) the contributions of the interactive process to the instantiated narrative; (ii) the system's contributions to the instantiated narrative; and (iii) the procedural nature of IDN as a learning opportunity. As we have previously argued, both the vignettes and the note show the user as the central element that articulates the IDN (and IDN experience) as a meaningful whole.

The first vignette illustrates what we have identified (i) as the contributions of the interactive process to the instantiated narrative. It is relevant to say that this relation between the interactive process and the output (the narrative itself) cannot be considered or discussed by applying a traditional narrative theory when analysing the children's IDN production.

Vignette 1. A girl starts telling a story: "On a full moon night, it was snowing a lot in India, a little girl was playing ...", she places the pipa-block (Chinese instrument) on the board and looks at the researcher asking for the name of the instrument; the researcher answers: "this is a pipa"; so, the girl continues: "she was playing pipa. And the girl had an elephant and there was a boy. It stopped snowing (she removed the snow-block) [...], the girl stopped playing the pipa and started playing the flute. All of a sudden, a very strong wind started blowing" (she removes the snow-block from the board and places the wind-block and removes the pipa-block and places the pung-block (Indian instrument). The researcher asks her: "do you know the name of that flute? It's pung". The girl continues her story: "The boy went home [...] the girl played the pipa again, the wind stopped and it started raining. To stop the rain the girl started playing the ... ping" (she tries to remember the word and says ping, instead of pung).

Relevance. V1 exemplifies how the interactive process promoted by the IDN creates a mediative learning environment, accentuating the role of mediation as an important semiotic mechanism of learning. The interaction with the story elements triggered the child's curiosity providing an opportunity to learn new vocabulary. This curiosity was intrinsic and not imposed from the outside and the child immediately put the acquired knowledge into practice using it in her storytelling. Also, it provided an opportunity for a more knowledgeable person (here the researcher) to naturally introduce new vocabulary (the word pung). The interaction during the story creation opened up a space for learning new vocabulary, which the child immediately and spontaneously used in her narrative (her effort to learn new words was visible when she tried to remember and use the name of the Indian instrument). The possibility to look at this kind of process represents a relevant aspect to be considered in IDN educational applications, since it helps teachers to understand and to access the students' learning process.

The second vignette illustrates (ii) a behaviour that we have identified as the system's contribution to the instantiated narrative. Again, this dimension can only be considered or discussed using the specific theory of IDN when analysing the child's production.

Vignette 2. A girl places the panda-block (the Chinese animal) and the snake-block (the Indian antagonist) on the board and observes the screen. According to the rules of the system, the panda and the snake started to fight. As she visualizes the fight between

the two animals, the girl gets very stressed, saying: “Oh my God, poor panda!”. Some moments later, the girl places the panda-block and the lion-block (the Chinese antagonist) on the board and observes the screen. As they started to fight, the girl places the pipa (Chinese instrument) on the board, saying “the girl wanted to play the pipa so that they did not fight” (when a musical instrument is on the board the animals and the antagonists stop fighting and begin to dance).

Relevance. V2 exemplifies how the child defined the introduction of new elements after understanding the relations between certain story elements, that is, scaffold by the possible directions of the story determined by the narrative vectors within the protostory. The decision of introducing a musical instrument was consciously made by the student in order to stop the animals fight (this choice was provided by the protostory, which contains potential narratives, and by the flexible narrative design). Besides, this is an example of a particular interaction that shapes the outcome, and paying attention to it can help the teacher to analyse the instantiated narrative.

Finally, the research note is a starting point to the characterization of the procedural nature of IDN as a learning opportunity, and consequently as a major aspect to be explored in IDN educational applications.

Research Note. At the end of the interaction the researchers carried out a semi-structured interview with the teacher, who told that one of the girls of the group above described had major difficulty in reading and was one of the less accomplished students in her class. However, during the interaction with the digital manipulative, she stood out, taking a leading role and narrating most of the story. She used connection expressions in her storytelling (for instance: “On a full moon night, it was snowing a lot [...]”; “All of a sudden, a very strong wind started blowing”), asked questions about vocabulary and quickly applied what she had learned. She also quickly understood the rules behind the system, applying the offered strategies in her storytelling, e.g.: “the snake ate the elephant” while removing the elephant-block from the electronic board, because she knew it would disappear.

Relevance. This research note shows how IDN considered as a whole, that is, the triad of system, process, and product, triggers fundamental dimensions that foster language development, such as embodied cognition and interaction, and doing so, it creates an environment that encourages learning. Again, by giving attention to the participatory process, it was possible to perceive some narrative competences that the child was not able to demonstrate in a fixed narrative or through a traditional output-centred approach.

The vignettes and the research note illustrate some contributions from the theoretical model for IDN to early literacy practices. The extension from an output-centred analysis to a comprehensive analysis of the system, the process and the output represents an opportunity to inform the design of pedagogical applications of IDN. Moreover, the evident role of the user in the interactive process that takes place between user, system, process, and product opens up a window into the student’s learning process, enabling researchers and educators to guide and to better understand the development of the students’ language and narrative skills.

7 Conclusion

By synthesizing the key concepts of a specific theory of IDN [14] and reviewing the role of narratives in language development, we aimed at establishing a dialogue between the framework of IDN and early literacy. We argued that educational applications of IDN can be enhanced by placing the emphasis on the procedural nature of IDN.

The description of Mobeybou and the preliminary findings of a pilot user study, brought some evidence to the potential of the dialogue between the IDN theoretical framework and the educational context proposed in this paper. It also provided valuable insights for future developments of IDN's authoring tools for young children and, specially, for new educational applications relating IDN to early literacy and digital manipulatives devices.

In short, we proposed that the inclusion of system, process, and product (and the user) in the development of educational applications of IDN, especially the ones designed to early literacy practices, reinforce embodied cognition and interaction as relevant acting factors during young children's language development. We argued that the procedural nature of IDN offers different learning opportunities from the ones offered by narratives in traditional media and this aspect must be thoroughly explored in IDN's pedagogical uses. Finally, rather than a specific theoretical innovation, we aimed to illustrate how two bodies of literature can inform one another, producing novel insights.

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