Fables for Teachers and Pupils

Incrementally Defined Scenario-Based, Interactive and Spatial Stories

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Abstract. The Fables project is grounded on an ecological approach to e-learning, where we analyze the practice of e-learning as an information ecology, centered on the interaction among teachers, pupils and their tools, placed within the classroom. A simple Fable represents one of Schön's exemplars; a Fable can be interacted with digitally, as a simulation, to help understand and predict the behavior of a real-world system or scenario. In schools Fables can be used to represent the knowledge that pupils have, to be shared/showed interactively to others, and they are experienced as a more dynamic version of presentation slides. In this paper we strengthen the formal definition of Fables, and we investigate Fables' expressive power. A new version of the online Fables tool F4BL3s has been implemented and used in the evaluation. The main new features of this version are: better visualization of Fables in playback, possibility for the authors to associate custom images to the characters in their Fables, and new export functions to convert a Fable into Twine stories and Microsoft PowerPoint compatible slides. According to our knowledge of the needs of teachers and pupils, the last feature is needed to improve interoperability of F4BL3s with other standard tools, which is in turn a key factor for the acceptance of the tool. Future work includes an improved visual editor as suggested by the data from our evaluation, and continue in-classroom tests.

Keywords: Scenario-based learning · Education · Knowledge management · Simulation · Visualization

1 Introduction

In our previous work [11] we started an exploration of more natural ways of expressing behavior to create digital simulations, usable by primary school teachers and pupils. Instead of focusing on programming concepts, we looked at soft methods like *rich pictures* [5], and formalisms like *concept maps* and *mobile ambients* [4]. In [11] we define the concept of **Fables** and present an alternative and novel way to simplify digital game design and programming, aimed at a central problem in this area: how to

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express knowledge about interactive digital systems in a simple yet powerful enough way, so that new digital games or interactive simulations can be generated automatically by teachers (especially with non-technical background) and pupils descriptions.

E-learning classically relates to *"learning delivered fully online where technology mediates the learning process, teaching is delivered entirely via Internet, and students and instructors are not required to be available at the same time and place"* [26], however here we are interested in any blending of technologies for learning, classroom and home activities. In this paper we discuss how the fables project is grounded on an ecological approach [12] to e-learning; we analyze e-learning practice as an information ecology, centered on e-learning practice, defined by the relationships and interactions emerging between teachers, pupils and their tools. Tools are analyzed in this perspective as active participants in the ecology, acting as mediators, contributing to learning [15].

This e-learning ecology, present in Danish schools, involves the use of digital and analog media as well as other strategies in active learning practices. Fables are envisioned to support teachers in authoring digital branching scenarios for and with their pupils, and also for pupils to create contents for other pupils and teachers. A simple fable represents one of Schön's *exemplars* [3], and multiple fables can be composed together to create what Schön calls *repertoire of exemplars*. A fable can be interacted with digitally, as a simulation, to help *"achieving understanding and predicting the behavior of systems"* [2]. In schools Fables can be used to represent the knowledge that pupils have, to be shared/showed interactively to others, and they are experienced as a more dynamic, scenario-oriented version of presentation slides.

Fables are implemented as a web-based tool called F4BL3s, conceived to accommodate the different roles of teachers and pupils. This means that differently from current studies like [16], the roles of users are recognized and translated into distinct, interconnected working environments, hence partially reproducing the interactional ecology involving the participants and their different roles. In this respect, F4BL3s is designed to fit within e-learning practice seen as a social, transformative practice that teachers and pupils co-design through forms of distant and in person interactions, where the targeted result is mainly a learning experience for the pupils.

In the following sections we discuss related work and theoretical background for this study (Sect. 2), then we provide a formal syntax and semantics for Fables (Sect. 3); our latest prototype is presented in Sect. 4, and the evaluation is discussed in Sect. 5. Section 6 presents conclusions and future work.

2 Related Work and Theoretical Background

In our previous studies (see [1]) we found that the digitization of learning practice in Denmark has led towards the exploration of available digital media to enrich pupils' learning experience. As a consequence, the teachers have creatively explored how to engage in digitally mediated forms of learning and communication with their pupils, such as individual or shared assignments in which the pupils have to edit stories and slide-based presentations through free systems like Google Docs. A common aspect to these assignments is storytelling, that enables the pupils to creatively synthetize and

communicate in the classroom their understanding of the learned topics. Starting from these storytelling-oriented practices, we have analyzed e-learning practice in Danish schools as an information ecology [12], consisting an organized set of digital and analogue artefacts and individuals (teachers and pupils) engaging in shared learning related practices. We created F4BL3s as mediating tool, encouraging teachers' and pupils' self-expression through the simple creation of interactive forms of storytelling; the tool also aims at reflecting the roles played by teachers and pupils in their e-learning ecology, to better fit their mutual interaction. In the following subsections we present our theoretical framework (2.1) and related work from the field of interactive storytelling and scenario-based learning (2.2).

2.1 E-Learning as Information Ecology

The concept of information ecology was proposed by Nardi and O'Day [12] in a book published in 1999, in which the authors analyzed the roles of librarians in using the available digital artefacts to provide a service to the citizens coming to the local library. The concept of information ecology was defined as a biological metaphor to analyze the relationships among people, tools, and their practices. The notion of ecology was chosen to evoke an image of complex relations, interdependences and dynamics involving different species within a given environment. An ecology is defined as a complex system [12], characterized by diversity, coevolution and locality, as the ecology is formed by the co-presence of different species or actors, playing different roles, within a specific environment. These actors are in a dynamic balance of coevolution, as whatever major change might affect one of the species will affect the whole ecology, while minor changes might simply go unnoticed [15]. Analyzing e-learning as an information ecology, we find teachers and pupils sharing a flow of information through different tools. Interestingly the e-learning ecology is localized within two main environments: the classroom, where the pupils and their teachers interact directly with each other, and the home, where their interaction is indirect. In the latter case, the role of digital tools is more crucial, for instance when the pupils have to edit a story online through Google Docs, the pupils interact with each other through the document that they are editing together. At the same time, the teachers can access the same document and check the progress, discussing in class how are the pupils doing with the assignment and provide help. We see this ecology as experiencing an on-going co-evolution, as new tools and practices are being experimented by teachers and pupils, affecting their mutual interactions and the practices they participate in.

Tools and human actors within an ecology are seen as active and capable of producing changes within the different practices in which they participate. Latour [15] insists on the notion that tools can act as mediators, mediating and altering meaning among the human actors, facilitating or inhibiting specific exchanges and communications. In this sense tools act as means of translation, which can suggest different meaning to the different individuals. In our view, e-learning digital tools, like games or simulations, act as means of translation for complex meaning, which can be experienced by the learners, eliciting reflections and individual understanding. F4BL3s is in this sense supposed to act as a mean of translation between pupils and teachers,

enabling them to communicate their understandings of the topic in individualized and creative ways, creating simple stories, or Fables, on the learning content.

According to Schön's notion of *exemplars* [3], learners acquire new knowledge by participating in active learning activities, which reproduce real world situations, such as in his example of the architecture student dealing with the planning of a school building. In this way learners engage in a *reflection in action*, in which they reflect concretely on the situation at hand and practice forms of problem-solving. Each of these situations act as an exemplar, which the learners collect through their studies, becoming prepared to face new similar challenges in the future. In our view, each Fable should play the role of an objectified exemplar, interactive stories embodying the pupils' reflections and problem-solving strategies on complex topics.

In conclusion, we see e-learning as a complex information ecology, centered on an information exchange between teachers and their pupils as they engage in a variety of practices, such as: lecturing, hands-on and playful activities, and assignments. In the terms of Schön, all these practices are contributing to eliciting forms of reflective in action, hence providing exemplars for the application of knowledge. Teachers have recently engaged in exploring the affordances offered by a variety of digital platforms like Youtube, Kahoot and Google, and media like images, videos, and presentations, with the goal of enriching their pupils experience while dealing with children challenged by autism or dyslexia (as in [25]). We see F4BL3s entering this ecology, offering the possibility to pupils and teachers to create interactive exemplars of knowledge, to be shared and played with; hence contributing to the ongoing exploration of digital platforms conducted by teachers.

2.2 Storytelling and Scenario-Based Learning

Since our preliminary data suggests that storytelling is an emergent component of digitally-mediated learning practices in Danish schools, our design process aims at exploring how we can support digital storytelling, from the perspective of both teachers and students. As discussed in [4] our F4BL3s tool supports the creation of non-linear stories and branching scenarios, for scenario-based learning. Our goal is to support teachers and pupils to generate creative representations of knowledge, and taking full advantage of digital media without being limited by lack of coding skills. These representations are envisioned as resources for the teachers to show and explain abstract concepts in a more effective way than with textbooks only, also meeting the need for authorship expressed by the teachers we communicated with in our previous studies (see the attitudes of teachers towards technologies we found in [1]). The creation of these representations can also be an assignment given to the pupils, enabling them to express their knowledge in more creative and interactive ways, bridging school with young people's daily media engagement.

The use of storytelling and scenarios has been investigated in primary and secondary education, through the creation of simulations which might recreate scenarios taken from actual practice. For example a rich use of simulation has emerged in the field of medicine and other healthcare related educations. According to Bennet et al. [22] the use of scenarios and simulations has become widespread in the education of occupational therapy, including: simulated patients, through virtual simulations or

physical mannequin, video or written case-based scenarios, and role-play. The use of simulation has been defined as a particular learning technique, in which selected aspects of a phenomenon are reproduced (see Bennet [22] and Simon [2]), and in some cases that involves the creation of interactive scenarios taken from real life practice. This form of learning is aimed at fostering critical thinking and forms of hands-on-interaction with the learning material. An interesting example is [21] where Hook et al. discussing how occupational therapy students experienced a virtual environment in Second Life. The students had to navigate with an avatar through a house and had to reflect on the house physical barriers, which hindered occupational performance for a patient moving on a wheelchair. Interesting applications come also from a case-study in genetic analysis [23], in which a "laboratory scenario" is given to students, consisting of a series of locations, each containing actions, items or quizzes.

According to Broadbent et al. in [24] the use of digital simulations or scenarios within blended learning, has lead students in healthcare education to become more engaged with their study material, becoming self-regulated learners. By self-regulated learning it is meant an independent attitude towards learning, in which students engage in learning through a cyclical process applying cognitive, metacognitive and resource management strategies. The authors of [24] argue that through blended learning supported by simulations and scenarios, students become active agents in their learning, planning and setting goals for themselves, therefore, becoming self-reflective on their learning path. Hence, scenario-based learning has been acknowledged as a valuable form of learning, enabling students to become more independent and self-reflective. However, we find that there is a need to also investigate how teachers can be empowered in the creation of relevant scenarios for their own subject and their personal way of teaching.

Finally, we find scenario-based learning also outside the school context, and in particular in the domains of e-learning and digital games. Examples of scenario-based e-learning games are *Connect With Haji Kamal*, discussed by the author Moore in her book [7] and blog[1], and *LIFESAVER* an interactive film by Martin Percy freely available online[2]. *Connect With Haji Kamal* is a non-linear visual novel with the look of a comic book and the goal of is to support US Army soldiers to prepare for their missions in Afghanistan, and in particular to become aware and sensitive to the inter-cultural problems they will be facing once abroad. The game was developed using Twine, and the pace of the story is controlled by the player, as it would be in a turn-based game. By contrast LIFESAVER is an interactive move, where choices need to be made in real-time to help people suffering from heart attacks. We consider fables related to games like *Connect With Haji Kamal*, since manipulation of video footage seems too complex for primary school pupils, even if it is being currently considered in a related project discussed in [13]. Furthermore, a discussion of some of the most widely used authoring tools related to our F4BL3s is presented in Sect. 4.4.

[1] http://blog.cathy-moore.com/2010/05/elearning-example-branching-scenario/.

[2] https://life-saver.org.uk/.

3 What Are Fables: A Formal Definition

In this paper we strengthen the definition of Fables by better formalizing their syntax, what are their operations and semantics. We also investigate Fables' expressive power: from a formal stand-point Fables can only express a specific kind of non-linear story where in a world with fixed, eventually nested, rooms, a set of people move around picking up and dropping objects. In spite of this apparent limitation, we have a working hypothesis that states that many kinds of stories can in fact be expressed in the form of a Fable.

From a formal point of view, Fables are related to mobile ambients [4] without processes. A Fable can be thought of as semi-structured data, therefore it can be expressed as a tree of nodes (like an XML document). More precisely we define a Fable as a collection of slides forming a graph, and a palette composed of 3 lists: persons, things and rooms.

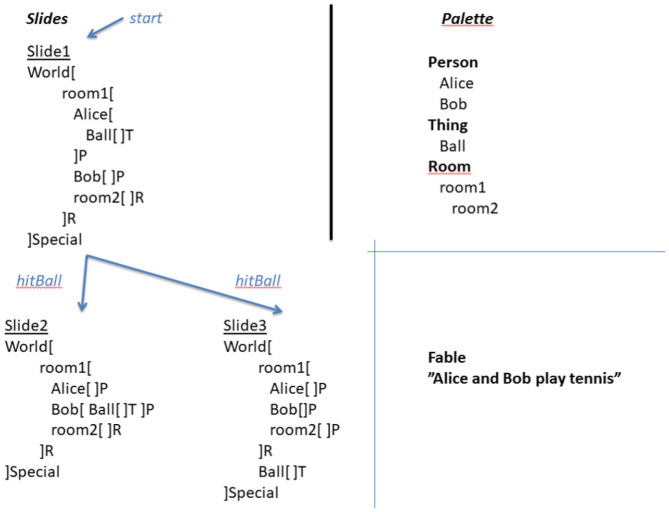

Fig. 1. Example of Fable "Alice and Bob play tennis". The Fable starts at Slide1 then the user will have to choose to go to Slide2 or Slide3. (Color figure online)

Figure 1 shows a Fable about Alice and Bob playing tennis. Inside each slide of the Fable, there is a single ambient-like container called World and inside it a list of rooms. Each room in turn can contain other rooms, persons or things. In the example in Fig. 1 Alice has a ball, and that is represented as follows: **Alice[Ball[]T]P**. The superscripts that follow the closing square brackets are indication of the type of the item: R stands for room-type, P for person-type and T for thing-type. The World has a special type, since it is similar but not the same as a room. The syntax for Fables is defined as in Table 1.

Table 1. Formal syntax for Fables. The syntax is inspired by Typed Ambients.

Fable := title slide* palette
slide := slideId description World[element*]^{Special} action$_1$ action$_2$ action$_3$
action$_i$:= *no-action* | label slideId
element := name[element*]^{type}
type := R | P | T
palette := personName* thingName* roomsTree
roomsTree := *empty* | roomName → (roomsTree) roomsTree

According to Table 1 a Fable has a title, a list of slides, and a palette; each slide has a unique identifier, a description, a world that contains a list of elements (possibly empty), and up to 3 actions. An action is just a label and a slide id, to which the Fable will jump if the action is activated during playback. The two blue arrows labeled "hitBall" in Fig. 1 are actions of slide1, and represent jumps to slide2 and slide3.

A Fable element has a name, a type and can contain other element, with some semantic restrictions. Room-type elements can contain any types of elements, while People- elements Thing-types cannot contain rooms. Moreover, we decided that a person should not directly contain another person. We differentiate the behavior of Person- and Thing-type elements mainly because we found that it better supports the intuition of our authors/users. The complex relationship among elements of the 3 types is explained in Fig. 2.

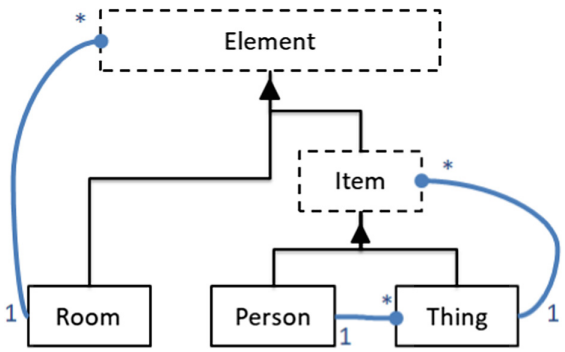

Fig. 2. The relationship among the 3 types of elements of a Fable: room, person and thing.

A palette has 3 elements: a list of person names, a list of thing names and list of rooms. The list of rooms can be empty or it can have a multiple rooms; each room can in turn have nested rooms (i.e. children rooms). Consider for example a house with a living room and a kitchen, and a broom closet in the kitchen; the representation as a *roomsTree* would be: **house→(living_room kitchen→(broom_closet))**, which corresponds to the following indented, nested list:

House
living_room
kitchen
broom_closet

Finally, all slides must have the same tree of rooms as the *roomsTree* in the palette, eventually populated with different people and things (see slide1 and slide2 in Fig. 1 as an example). Hence, the rooms are immovable elements in a Fable.

3.1 Operations and Semantics

We want Fable authors to be able to create interactive scenario-based stories in an incremental way, therefore we provide operations to create/clone, rename, move and delete any element of a Fable, at any moment during editing.

Table 2. Semantics of Palette-related operations.

Operation	*Palette*
Create	(room) Add room in same relative position in all slides (person/thing) Just add to the palette, no changes in any slide
Rename	Rename element in all slides (substitution)
Move	(room) Same move of the room in all slides, nested rooms follow (person/thing) NOT POSSIBLE or MEANINGLESS
Delete	(room) Remove the room in all slides, nested elements also deleted (person/thing) Remove in all slides

Table 3. Semantics of operations on a single slide.

Operation	*Slide*
Create/clone	(slide) local effect (room) global effect, same as create at Palette level (person/thing) to room of current slide: add to Palette, add to room
Add from Palette	(person/thing) local effect, check not present in slide, then add to room
Rename	global effect, same as rename element at Palette level
Move	(room) global effect, same as move room at Palette level (person/thing) local: from source element to destination element
Delete	(room) global effect, same as delete room at Palette level (person/thing) local: delete element and nested elements
Pickup	A pickup B: select any item B in same room as A, move B inside A
Drop	A drop B: select an item B nested inside A, move B outside A

Moreover, we distinguish between global and local operations, because palette operations have global effects across slides, while manipulation of individual slides only has localized effects (see Tables 2 and 3). In our definition of the semantics we assume that in each Fable all names are unique, i.e. rooms, people and things all have distinct, unique names across all slides.

The last operations in Table 3 are special, specific to a person picking up a thing or a thing being inserted inside another. They are inspired by the classic mobile ambients operations of *in* and *out*.

3.2 Expressive Power

Fables are incrementally defined scenario-based, interactive and spatial stories. By this we mean that the authors (a primary school teacher, a pupil or group of pupils) are able to create a story step-by-step, eventually defining and re-defining rooms, people and things as they like, while the Fable's palette keeps a consistent overview of all the elements and their relationships. For instance how the rooms are nested is kept coherent globally by the operations of a Fable, which accounts for these stories to be considered spatialized. Since each slide can be connected to a maximum of three slides via labeled actions (including looping back to the same slide if needed), Fables are clearly non-linear stories with a branching factor of 0 to 3. Therefore, Fables can be used to define interactive scenarios, where the actions chosen by the user of the Fable during playback lead to potentially different storylines and possibly alternative endings.

An important question in this project is: what can you express with a Fable? At first glance every Fable just is a non-linear story where, in a world with fixed nested rooms, a set of people move around picking up and dropping objects. Persons and things that are in the Fable's palette can appear or disappear from rooms, from one slide to the next.

It is our working hypothesis that many kinds of scenarios and stories can be assimilated to a Fable. Our first argument in favor of the hypothesis is that narration in different media is described in terms of locations, actors and objects, and their interplay. For example, a theatrical play is described by locations where the action takes place, characters and props (or theatrical property). In [18] the Drammar ontology is defined with the goal of annotating and formally reasoning about drama; the ontology is defined as follows: *"Drammar consists of two components, encoding respectively the conceptual model and the SWRL rules. The conceptual model, mainly grounding in AI theories, represents the major concepts of drama, such as agents, actions, plans, units, emotions and values."* As for drama itself, [18] explains it as this: *"[…] it is well known that in dramatic media (drama) the audience engages the story via the character's behavior […] rather than via the literary values; indeed the cause–effect chain results from a complex interplay of agents, objects and events, well known in playwriting techniques […]"*

The authors of [18] also argue that drama is not exclusively related to theatrical performances and they use the term *dramatic media* to cover *"[…] media that display characters performing live actions, such as theatre, cinema and videogames."*

To further investigate the expressive power of Fables we created a number of different stories, some inspired by the actions of characters in children books, others based on the typical daily life of historical characters. We found quite possible to express instructions (for recipes for instance) in the form of Fables, and in those cases we took advantage of the branching to cover alternative storylines with typical errors and their consequences. Finally, in Sect. 5 we discuss how the evaluation of F4BL3s

(the web-based tool implementing Fables) also shed light on the expressive power of Fables.

The main limitation we can see in Fables is that rooms are immovable and must be the same in every slide. Therefore, game-like scenarios in which rooms or locations are created and/or destroyed dynamically as the game progresses will be impossible to express. Even a Fable where a room only exists in a slide but not in all others would be impossible; furthermore, all rooms must be present and the same in all slides also across all alternative branches of the same Fable. In our brainstorming sessions and experiments with Fables we have not found this a major limitation; moreover, the kind of dynamic narrative that we are excluding is perhaps mostly found in digital games, while Fables focuses on interactive scenario-based stories, which are naturally more *static* (like the game/novel by Moore [7]).

Another problem we encountered is with the current terminology we adopted for Fables; for instance, consider a fairy tale with a talking wolf as a character. In Fables the wolf could be represented by an element of type Person or Thing, depending on whether the wolf is an active character or a passive item in the story. Being the wolf an animal, some Fable authors might find it illogical to associate the Person type to it; situations like this (e.g. stories involving robots, magical animals or animated objects in general) led us to consider a possible renaming of all categories of elements in Fables. **Room** seems so far a general enough name, which is clearly related to theater, movies and computer games, so it could be left as is. However, **Person** and **Thing** might be changed to **Character** and **Prop** (or perhaps **Item**), adopting a more theatrical metaphor for Fables. This change in terminology is still under discussion, and might be implemented in a future version, provided evaluation by our users (both teachers and pupils) supports its usefulness.

4 Extended Implementation

A new version of the online Fables tool F4BL3s has been implemented and used in the tests. The main new features of this version of F4BL3s are:

- possibility for the authors to associate custom images to the characters in their Fables (i.e. *skins* for Fables),
- better visualization of Fables in the playback page,
- and export function to convert fables into Twine stories and Microsoft PowerPoint compatible slides (PPT for short).

4.1 Skins and the New Playback Page

A *skin* is a collection of small, icon-like images that the author of a Fable can upload in her Fable via a special page of the F4BL3s web tool. The images, if present, will be used when the Fable is played back, in the playback page of F4BL3s. In the current implementation rooms have a static background image associated with them, but the author can customize the image representing any person or thing (see Fig. 3, created with free icons from www.flaticon.com).

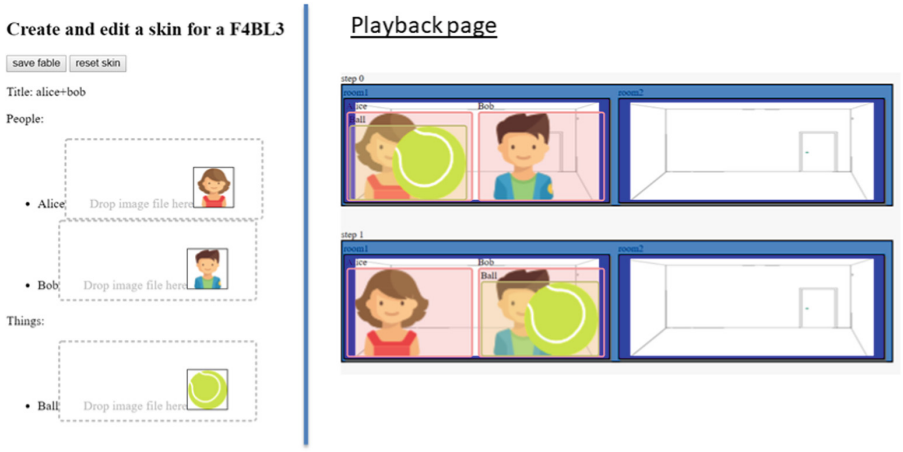

Fig. 3. Skin editor (on the left) and playback page for the Alice and Bob Fable (right).

Technically the image is loaded in the webpage via an input file-upload HTML element; the image is then transferred to a temporary canvas and converted in a string using base64 using the standard toDataURL method. Since the F4BL3s tool is a serverless web application, and all data is stored locally using localStorage, also the skin is stored in localStorage, in the same object that is associated to its Fable. This is done via the standard JSON API, therefore only small images can be used in the current version, up to 20 kilobytes per image.

4.2 Exporting to Twine and PPT

Twine file format is HTML-based with special tags, and it is well documented, so we simply implemented a Javascript library that saves a text file in the right HTML format, with data representing a textual rendition of a Fable. The file can be saved locally and uploaded via the free Twine online editor (at http://twinery.org/2). Once the exported Fable is opened it the Twine editor shows a bubble for each slide in the Fable, and clicking on a bubble it is possible to edit the contents. A bubble (i.e. a passage in the Twine jargon) can contain text, HTML tags and images; the exported Fables use HTML DIVs to represent the nesting of rooms, people and things in each slide. Navigation in Twine works by defining buttons with links that connect all passages into a graph. Taking advantage of this, we simply map the actions that each slides of a Fable can have (with up to three actions out-going from each slide) into Twine button-links. Twine users can then click on the play button and navigate interactively through the slides, in the same way the playback page in F4BL3s allows to interact with the Fable. We also implemented non-deterministic choice in our export function: in case multiple actions with the same label lead away from a slide in a Fable (for instance in Fig. 1, the two *hitBall* actions), the corresponding Twine button-links are automatically replaced

by a short *Harlowe* script[3] that rolls a die to randomly jump along one of the possible alternatives. And this is exactly the same that happens in the playback web-page of F4BL3s.

We also wanted to export to Microsoft PowerPoint slides, since they are a commonly used format for school teachers, and it was in our requirements for F4BL3s to interoperate well with PowerPoint and Google Sheets. For the creation of PPT files from Javascript we adopted the PptxGenJS library, which has simple commands to:

- create a presentation from within a webpage,
- save it as a PPT file, by downloading it
- create and a slide to the presentation,
- add shapes, text and hyperlinks to a slide at specific coordinates.

The resulting PowerPoint presentation is still editable and behaves exactly as a manually created presentation would, allowing teachers and pupils to further alter their exported Fable. Our implementation exports a Fable to a PPT file by creating an initial PowerPoint slide with the title of the Fable and three lists of elements in the Fable: rooms, people and things. Then for each Fable slide a PPT slide is generated, with a visual rendition of the tree of elements. More details about the layout of the slides can be found in the next subsection about visualization. The actions (which represent jumps from slide to slide, in a Fable) are converted to PPT hyperlinks: during presentation, these hyperlinks can be clicked like buttons and will make the PowerPoint presentation jump to a new slide, hence implementing the semantics of our actions. Contrary to the Twine export, we could see not simple way to implement non-deterministic choice for multiple actions with the same label (such as the two *hitBall* actions in Fig. 1), therefore, we decided to map each action directly to a PPT hyperlink. The user interacting with the PowerPoint presentation will have to decide manually which of the multiple hyperlink with the same label to click. Finally, we believe that having a PPT export file supports printing, cutting and tinkering with a paper version of a Fable, hence, it fits very well with the activities in the typical Danish primary classroom.

4.3 Visualizations

Most new features in F4BL3s have to do with better visualization of Fables. For the new playback page and for the export to PPT we explored many possible visualization styles. Figure 4 shows the best three visualization styles, that we call *nested sticky notes* version 1, version 2 and *fixed minimal size* (respectively the second, third and fourth column in Fig. 4). The problem of rendering a Fable closely resembles that of creating a responsive layout for a webpage, where scaling works automatically across a large range of possible dimensions and number of elements in the page; however, especially for PPT export, we could not rely on style sheets (such as CSS), so we decided to develop custom layout algorithms.

[3] Twine's internal scripting language.

Fig. 4. The first column from the left is the textual representation of Fable slides; the second column is the rendering according to nested sticky nodes version 1, and the next two columns are rendered according to version 2 and the export to PPT layout algorithm.

For *nested sticky notes version 1* we used the following rules:

- if a room has *n* room-type children, then each room-child takes up (100/n) percent of the parent area (e.g. in Fig. 4 first row and second column, *room1* in slide 1 is the only child of *world*, so it takes up 100% of *world*)
- if any item present:
  - items take 30% of their room's area; items are vertically stacked, with nesting if it is the case
  - sub-rooms equally share the remaining 70% left

Nested sticky notes version 2 uses simpler rules:

- place rooms before persons and things (left-to-right),
- divide horizontal space equally among children.

Nested sticky notes version 2 is used in the playback page of F4BL3s, as visible also in Fig. 3 on the right; this visualization style works best when there are few rooms, and limited nesting, which is typically the case with a Fable.

Both versions of the *nested sticky notes* layout algorithms display a problem: as visible in Fig. 4 the same item (for example the ball) changes size significantly from slide to slide, in the second and third column. We call this problem **variable scale problem** and we found that it is distracting and somewhat confusing for our users, as well as being aesthetically unpleasing. To solve this problem and also to explore more natural-looking layout methods, we developed a completely different layout for the PPT export, called *fixed minimal size*.

The idea is that for each slide:

- all rooms are arranged first, recursively. At each level of the rooms' tree, a grid is defined, as *square* as possible. For example 3 rooms at the same level will be arranged in a 2-by-2 grid, with a bit of space left over.
- then for each room: all persons and things are arranged (i.e. placed and resized).

To avoid the problem of variable scale present in the other two layout methods discussed above, we compute the first step (i.e. arranging all rooms) in order to discover the size of the smallest room in our rendered slide, and we call that *minimal size*. Then we define the size of all persons and things to be fixed at 1/6 of the minimal size, in all rooms of the slide: this offers a nice visual consistency for persons and things, as visible in the Fig. 4, last column.

4.4 Existing Tools and F4BL3s

During the development of F4BL3s we investigated various related tools, and we focused on Twine and Ren'py [9] since they are most commonly and widely used. As discussed in [8] Twine is a free web tool for authoring hypermedia and it is aimed at non-technical people as well as game developer. The main mechanism of Twine is the definition of paragraph of text that can be connected to other paragraphs by labeled links. Since each paragraph can contain text, images and audio, the created games can be quite sophisticated. Twine also has a scripting language called Harlowe to support more complex behavior by the part of the game, than simply allowing the player to navigate the paragraphs, e.g. score can be kept or certain links might only work after the player has collected some specific item. Another similar tool is Ren'py [9], a visual novel engine that runs on computers and mobile devices; it allows authors to use text, images and audio to create tell interactive stories such as visual novels and simulation games. Ren'py uses Python scripting to program the behavior of potentially large and complex novels and games. Interestingly in [10] an e-learning tool based on Ren'py is defined, and some limitations of the use of Ren'py are discussed.

Contrasting F4BL3s with tools like Twine and Microsoft PowerPoint, we find that F4BL3s offer more semantic support to create scenario-based, interactive and spatial stories. Fables have both *visual* and *spatial* semantics, where a story is constructed of actors like rooms, people and things; the author of a Fable works explicitly with an ontology (the palette in the F4BL3s tool), where actor roles are clearly defined. For instance rooms do not move during playback, while people move from room to room, and things move when picked up by people. We modeled these roles on natural ways of describing stories exhibited by our informants, and formally on type systems for mobile ambients (as discussed in [17]). In comparison to Ren'py, F4BL3s does not support scripting but instead it leverages on direct manipulation and definition of structured data, such has rooms and items. However, there are similarities: for example a Fable can be played as a interactive visual novel, and the visual aspect of a Fable are customizable in F4BLs, by defining a skin.

5 Evaluation: Method and Results

This study is conducted via a research through design approach [14], aimed at gaining new knowledge on the needs of teachers regarding how new digital tools could support them in expressing their creativity and arranging new e-learning experiences for their pupils. Our analysis focuses on functional, experiential and informational values, in order to evaluate how Fables could concretely fit within the e-learning ecology. However, being engaged in a research inquiry, we see the design of F4BL3s as a design exemplar, embodying our understanding of the inquiry at hand [14]. Moreover, through our inquiry we have conducted a participatory design process, rooted in findings from previous studies (see [1]). Hence, our idea of Fables emerged from previous studies and from the knowledge we gathered on how Danish teachers were responding to the digitization of learning. In accordance with the participatory design agenda, our goal is to empower our user groups [6], leveraging on their skills and desires for their practice.

As it is typically done with research through design and participatory design, we are integrating our design process with ethnographic methods [20], such as observations and situated interviews with potential users. All the sessions were video-recorded, with permission from the participants, so that we could analyze their needs and responses to our concept. Moreover, we are conducting an iterative design process [20], in which prototypes are made to foster creative thinking within our creative team and in the users. We started from low-fi prototypes [11]: simple, semi-interactive visualizations to imagine the interface and the interaction. Currently we are at the second iteration, and this time our F4BL3s prototype is moving towards a hi-fi prototype, as the key features have all been implemented and most of the graphic interface is functioning. Since F4BL3s is a tool addressed to teachers and pupils to develop interactive stories, we found it challenging to rely on paper-based prototypes, as we feared that the users would be confused and expect a pre-made simulation or another PowerPoint-like application. For this reason, we started testing our prototype only when it could communicate its purpose, an agile technique usually called *minimum viable product*.

At this stage we have conducted a preliminary evaluation with a focus-group of 3 teachers from a local primary school in Odense. It was our goal to conduct a test with a small group of teachers and their classes, however, we decided together with the teachers that we will involve their pupils with a more mature version of the prototype, that incorporates teachers' suggestions.

5.1 Discussion and Results

We conducted our evaluation with a group of three primary school teachers. The participants included two male teachers, one teaching Danish language and literature, geography, and social sciences, the other teaching mathematics and history. A female teacher was also involved and she was teaching Danish language and literature, English, mathematics and physical education.

The evaluation involved a shared semi-structured interview (a technique discussed in [19]), during which we showed our prototype. We both took ethnographic notes and video-recorded the interview, so that we could store their comments for the design of the new prototypes. The interview took place inside a meeting room at the school and

we planned it to be centered around three main themes: to find out if they saw a purpose for F4BL3s in their classes, possible future scenarios of use that they might see in our prototype, and possible desired or missing features.

We started by presenting ourselves and our concept, showing our prototype on a large wall-mounted television from our laptop. In order to effectively communicate the use of F4BL3s, we live-edited three different stories, which were supposed to act as demos, fostering ideas on possible use and features for the tool. During the start of the interview the teachers seemed confused on the nature of F4BL3s. We hoped that after we explained the scenario we had in mind and after having shown the stories we edited, the teachers could take control of the prototype, trying to edit the existing stories or creating a new one. However, they did not seem confident in doing that, so we continued an open conversation on how the prototype could be improved. We planned about 30 min for the test, and instead as the conversation went on we actually used about 1 h.

We identified three main themes in our analysis of the video recording: technical functionalities, learning applications, and multimodal communication. These three themes emerged one after the other during the interview. During the first 15 min circa, the teachers tried to make sense of how F4BL3s worked technically and its purpose, with the Danish language male teacher taking the lead in their dialogue with us. Afterwards the teachers tried to figure out how our prototype could contribute to their own teaching practices. Hence, we all shifted into a shared brainstorming which lasted for the rest of the time, on possible applications and on which functions could be useful in concretely supporting their teaching practice. During this brainstorming, the teachers expressed their desire for more support for multimodal communication.

Regarding the technical functionalities, the male Danish language teacher commented on the interface: "We would like to have coding in other classes than just sciences and this looks like block coding!" and then he asked more about how he was supposed to relate to the interface. All the teachers had previous experience with coding workshops held for their pupils by external instructors, who showed systems like MIT Scratch and they could identify similarities with our tool. As we explained that it might look like *block coding*, but that the interface is mostly inspired by PowerPoint and Unity and centered on drag-and-drop actions, they seemed to have understood that coding was not central in our case. Then the male Danish language teacher said: "I see, so it resembles block coding, but its meaning is subjects-based!" This comment provided a needed clarification for the teachers and created a more relaxed atmosphere. From an ecological perspective, the teachers were concerned about which changes F4BL3s would introduce in their evolving e-learning practices and how it fitted with their own needs, more concretely the teachers seemed worried that we were going to "sell them" yet another application for learning coding, which they did not want. Hence the teachers showed a different attitude: in the start they appeared very focused and quiet, leaning forward on their chairs, but as it became clear that F4BL3s was not a coding tool they leaned back and smiled. They became also eager to share their ideas, freely intervening in conversation and interrupting us.

Regarding possible applications, the teachers discussed how a tool like ours could be fruitfully used to demonstrate in class mathematical calculations step-by-step in the form of a multiple choice story, showing which mistakes can be made and how to avoid

them. Other interesting applications were discussed, like the representation of historical events and the articulated process through which laws are being passed in a democracy. The focus shifted then to the pupils' as makers of Fables for assignments in class and at home. The feature of automatic generation of Fables from a written text was particularly appreciated by the female teacher, who suggested a possible task in which the pupils would have to convert a script, from a story or theatre piece in English or Danish, into a Fable and enrich it with details and branching.

These comments suggest to us that the teachers have correctly framed the tool, in terms of supporting the creation of exemplars (as in Schön [3]) through mini projects, which the pupils can solve in their assignments. Moreover, our prototype, although at an early stage, was seen as a reflective tool, potentially enriching the current flow of information between teachers and pupils. In this regard, the teachers readily expressed their desire for more support for multimodal communication; in particular they would like to be able to include sound and video footage, instead of just image and text.

Open questions must be addressed in relation to how correctly frame the interaction between teachers and pupils and how can F4BL3s contribute to it. Moreover, we need to investigate how F4BL3s fit within the other tools which are used in the school, if it can be part of a valuable tool chain, hence enriching expressive opportunities. Therefore, it is our plan to incorporate the teachers' suggestions in a new version of our tool and test this with the same teachers and their pupils during actual classes in the coming months.

6 Conclusions

Fables were introduced to explore ways to simplify digital game design and game programming for primary school teachers and their pupils. In this paper we refine our concept of Fables, by providing a more formal definition; furthermore, we discuss the second iteration in the development of the F4BL3s web tool. In F4BL3s an author can create a Fable (i.e. an objectified version of Schön's exemplars), starting from a textual description as well as by directly manipulating the rooms, people and things that appear in the Fable. The Fable can then be *run* as a digital, interactive scenario-based story, exemplifying abstract concepts or step-by-step problem-solving processes, for instance in mathematics. F4BL3s effectively allows Fable authors to create interactive digital media without coding, a need that was expressed by the teachers we cooperated with in previous studies [1].

In the present study, we approach e-learning as an information ecology [12], in which teachers and pupils are engaged in sharing information on learning content, subjective understandings, individual challenges, and feedback. This exchange of information is mediated through a series of analogue and digital tools. In recent years, Danish schools have been engaging in a digitization of learning practice, hence emphasizing the role of digital tools within the ecology. Teachers are actively contributing to this process exploring the learning affordances offered by existing digital tools, such as Kahoot, Google Docs, Microsoft PowerPoint and others. Through this process, teachers and pupils are becoming increasingly competent in communicating through digital tools, to edit simple stories, presentations, and paper-based games. In

ecological terms we see this process as a form of co-evolution, a complex dynamics affecting our teachers and pupils engage and experience their daily practices. Issues emerge when teachers and pupils wish to create interactive media, like games or interactive animations, as these require coding skills. In our experience it is not realistic to expect primary school teachers to learn to program digital games, especially teachers with non-technical backgrounds. The responses we gained from the teachers participating to our study confirmed our expectation that they did not want another coding tool, but they welcomed the idea of evaluating a tool targeting their subjects, and in fact we designed F4BL3s to contribute to the ongoing co-evolution in e-learning ecologies, offering new affordances for existing storytelling, scenario-based learning practices.

In conclusion, although our prototype is still in the form of a minimum viable product and for this reason it could not be tested with pupils yet, it was nonetheless positively evaluated by teachers. More specifically the teachers responded positively to our envisioned scenario where Fables empower teachers and pupils and let them communicate and learn by creating their own digital scenario-based stories. They also liked the fact that Fables can easily support subject-related narratives, without imposing coding in the class, but actually mirroring the roles of teachers and pupils in their daily mediated interaction. From what we know now about the needs of teachers and pupils, we consider interoperability with other standard tools (such as Twine and PowerPoint) a key element in the acceptance of the Fables tool. Finally, building on the data gathered so far, future work includes an improved visual editor for F4BL3s, and we are considering importing standard file formats, such as those used in Microsoft PowerPoint or Google Docs. This will allow our users to work full-cycle, starting from whatever tool they find best, and finishing their Fables within the F4BL3 tool-chain.

References

1. Marchetti, E., Valente, A.: It takes three - re-contextualizing game-based learning among teachers, developers and learners. In: Connoly, T., Boyle, L. (eds.) Proceedings of the European Conference on Games Based Learning, pp. 399–406. Academic Conferences International (2016)
2. Simon, H.A.: The Sciences of the Artificial. MIT Press, Cambridge (1996)
3. Schön, D.A.: The Reflective Practitioner: How Professionals Think in Action. Ashgate, Farnham (1986)
4. Sangiorgi, D., Valente, A.: A distributed abstract machine for safe ambients. In: Orejas, F., Spirakis, P.G., van Leeuwen, J. (eds.) ICALP 2001. LNCS, vol. 2076, pp. 408–420. Springer, Heidelberg (2001). https://doi.org/10.1007/3-540-48224-5_34
5. Love, S., Gkatzidou, V., Conti, A.: Using a rich pictures approach for gathering students and teachers digital education requirements. In: Little, L., Fitton, D., Bell, B., Toth, N. (eds.) Perspectives on HCI Research with Teenagers. HCIS. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-33450-9_6
6. Björgvinsson, E., Ehn, P., Hillgren, P.A.: Participatory design and "democratizing innovation". In: Proceedings of the Participatory Design Conference, pp. 41–50. ACM (2010)
7. Moore, C.: Map It: The Hands-On Guide to Strategic Training Design. Montesa Press (2017)

8. Friedhoff, J.: Untangling twine: a platform study. In: Proceedings of the 2013 DiGRA International Conference (2013)
9. Rothamel, T.: Visual novel engine Ren'Py. https://www.renpy.org/. Accessed 1 Feb 2019
10. Prastowo, B.N.: Design and implementation e-learning system using Ren'Py based visual novel. Doctoral dissertation, Universitas Gadjah Mada, Yogyakarta (2017)
11. Valente, A., Marchetti, E.: Fables – exploring natural ways of expressing behavior to create digital simulations. In: Marcus, A., Wang, W. (eds.) DUXU 2018. LNCS, vol. 10919, pp. 110–126. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-91803-7_9
12. Nardi, B.A., O'Day, V.: Information Ecologies: Using Technology with Heart. MIT Press, Cambridge (1999)
13. Marchetti, E.: Occupational therapy and RPG games: a playful, ecological approach to healthcare education. In: ECREA 2018, the 7th European Communication Conference, Digital Library, Lugano, Switzerland (2018)
14. Zimmerman, J., Forlizzi, J.: Research through design in HCI. In: Olson, J., Kellogg, W. (eds.) Ways of Knowing in HCI, pp. 167–189. Springer, New York (2014). https://doi.org/10.1007/978-1-4939-0378-8_8
15. Latour, B.: Reassembling the Social. An Introduction to Actor-Network-Theory. Oxford University Press, Oxford (2005)
16. Benamar, L., Balagué, C., Ghassany, M.: The identification and influence of social roles in a social media product community. J. Comput. Mediat. Commun. **22**, 337–362 (2017)
17. Barbanera, F., Bugliesi, M., Dezani, M., Sassone, V.: Space-aware ambients and processes. Theoret. Comput. Sci. **373**(1–2), 41–69 (2007)
18. Lombardo, V., Battaglino, C., Pizzo, A., Damiano, R., Lieto, A.: Coupling conceptual modeling and rules for the annotation of dramatic media. Semant. Web **6**(5), 503–534 (2015)
19. Drotner, K., Iversen, S.M.: Digitale Metoder. At skabe, analysere og dele data. Samfudslitteratur (2017)
20. Kensing, F., Blomberg, J.: Participatory design: Issues and concerns. Comput. Support. Coop. Work (CSCW) **7**(3–4), 167–185 (1998)
21. Hook, A.D., Bodell, S.J., Griffiths, L.: A pilot project of the learning experience of undergraduate occupational therapy students in a three-dimensional virtual environment in the United Kingdom. Br. J. Occup. Ther. **78**(9), 576–584 (2015)
22. Bennet, S., Rodger, S., Fitzgerald, C., Gibson, L.: Simulation in occupational therapy curricula: a literature review. Aust. Occup. Ther. J. **64**, 314–327 (2017)
23. Breaky, K.M., Levin, D., Miller, I., Hentges, K.E.: The use of scenario-based-learning interactive software to create custom virtual laboratory scenarios for teaching genetics. Genetics **179**(3), 1151–1155 (2008)
24. Broadbent, J.: Comparing online and blended learner's self-regulated learning strategies and academic performance. Internet High. Educ. **33**, 24–32 (2017)
25. Marchetti, E., Valente, A.: A tangible digital installation in the classroom: role play and autistic children. In. Munkvold, R., Kolås, L. (eds.) Proceedings of the 9th European Conference on Games Based Learning, pp. 346–353. Academic Conferences and Publishing International (2015)
26. Gros, B., García-Peñalvo, F.J.: Future trends in the design strategies and technological affordances of e-learning. In: Spector, M., Lockee, B., Childress, M. (eds.) Learning, Design, and Technology. An International Compendium of Theory, Research, Practice, and Policy, pp. 1–23. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-17727-4_67-1