Learner Centred Design in the Adventure Author Project

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Abstract. Involving stakeholders at an early stage of learning environment design enables researchers to base a system around the needs of learners. By working directly with learners, researchers gain insight into learners’ everyday problems when mastering difficult material, which complements their knowledge of educational theory. This approach is particularly fruitful when designing innovative systems which require new representations of complex concepts. This paper describes the development process of Adventure Author, an interactive story making environment for children. It focuses on the learner centred design methods used to develop a representation of interactive story structure for the user interface. Early consultation with our users around low and high-tech prototypes ensured that the representations we proposed could be comprehended and subsequently generated by children in the target age group.

Keywords. Learner centred design, children, interactive storytelling

INTRODUCTION

This paper describes the learner centred design process used to develop Adventure Author, a tool to facilitate interactive narrative creation in virtual environments. The software is intended to assist 10 - 14 year old children as they learn how to create interactive stories in computer game format. Desktop virtual environments or computer games are increasingly considered to have potential as an artistic and storytelling medium which goes far beyond the medium of linear written text (Murray 1998; Poole, 2000). As studies of children’s computer game playing habits indicate, children devote considerable amounts of their leisure time to playing games and greatly enjoy this medium (McFarlane, Sparrowhawk, & Heald, 2002). It is appropriate therefore, that children should be given opportunities both to study the artistic techniques used to create games, and to create their own stories in this form. By expressing interactive story ideas in a rich audio-visual environment, learners can explore non-traditional forms of literacy which do not rely solely on competency with written language. This is of great benefit for children who struggle with writing. Creating stories in an interactive medium may also foster general writing skills, such as audience awareness and plot development, which are relevant across media.
Adventure Author aims to support children as they build up complex, interactive story structures. This story making task is more difficult than the sort of classroom writing assignments in which children must devise a linear plot line with a beginning, a middle and a single ending. For example, the English Language curriculum guidelines in Scotland specify that for children aged between 12 and 14 years old, “the notions of openings, turning points, resolutions can be introduced” (SOED, 1991; p 47). In an interactive story, the idea of turning point is indeed central, but is rather more sophisticated. In composing an interactive narrative, the author must conceive of a spectrum of possibilities which could result from not one, but a series of turning points. The reader’s choice at one turning point can have a knock-on effect which will result in other choices being presented later in the story. As such, the story author must keep track of the consequences of a player’s possible choices within their interactive narrative. Given the potential complexity of an interactive story structure, a visual representation was required to enable the users to easily manipulate the relationships between the scenes in the story. Careful validation of the visual representation design was necessary to ensure that members of the target group could interpret it correctly, and that it would support them in developing a deeper understanding of the concept.

This paper describes the learner centred design process which was used to develop a visual representation for interactive narrative in Adventure Author. In the “Related Work” section, we place Adventure Author in the context of previous learning environments which were designed to support children’s narrative development. We also consider research into the educational benefits which can be gained from creating computer games. As this paper focuses on the learner centred design process employed in the Adventure Author project, a review of approaches used in the design of children’s technology is included. The section entitled “The Adventure Author Design Process” summarises the design work which has taken place so far on the project with various stakeholders including learners, teachers and game experts. Having established the context for the specific design challenge presented here – a visual representation of interactive narrative which is comprehensible by the target user group – a solution is described, followed by an account of two field studies with learners to validate the design. The paper concludes with some observations about the extent to which learners can contribute to the design of adaptive interactive learning environments which aim to support the acquisition of complex concepts.

RELATED WORK

Adventure Author is an environment designed to provide children with opportunities to create interactive stories in the form of a 3D virtual environment, drawing together elements of story authoring, narrative in 3D virtual environments, and computer game authoring. While the previous research projects described in this section have considered aspects of these, Adventure Author is distinct in bringing the elements together in a single strand. Indeed, the technology for enabling non-expert users to create 3D virtual environments with a high level narrative focus has only recently become available, for example in commercial tools such as Neverwinter Nights (Bioware, 2003). Previously technology has confined research into the educational benefits of computer games authoring to the creation of games with limited graphical capabilities, designed using textual programming languages. Such projects, although valuable for teaching learners problem solving skills, are not suitable for teaching higher level narrative concepts, as the author’s attention is necessarily focused on low level programming issues.
This section also considers design approaches which have been adopted in new technology projects, particularly in the domain of narrative learning environments.

**Narrative Interactive Learning Environments**

Two main themes can be identified in previous narrative learning environment research: environments in which learners can *create* their own stories, and those in which they can *participate* in stories, often in a virtual environment. Representative examples of such software are considered in turn in the following sections.

**Story Making Environments**

Digital storytelling opportunities for children have evolved from simple text creation environments to more sophisticated multimedia creation tools. Additionally, beyond the simple linear text creation tool of a word processor, more complex text-based interactive story making tools have been successful. For example, MOOSE Crossing (Bruckman, 1997; Bruckman & DeBonte, 1997) is a text-based virtual environment designed as a place for children to learn to program, and to practice reading and creative writing. It is a collaborative, constructionist online community populated by a few adults and many children in different geographical locations. The technology is based on MUDs (multi-user dungeons) and MOOs (MUDs object-oriented) but it has been specifically designed to make it easy for children to program. The children can build virtual rooms and objects and create new personas for themselves. This requires them to use a mixture of programming and creative writing skills. The examples reported by Bruckman (1997) demonstrate that the children’s descriptions in MOOSE Crossing can be imaginative and well written.

Audio-visual story authoring tools such as Kar2ouche (Immersive Education, 2006a) and Media Stage (Immersive Education 2006b) are currently popular in UK classrooms. Kar2ouche is a story authoring tool which enables children to create an audio-visual story by building up a storyboard consisting of a sequence of frames. The author can select a background picture for each frame and populate it with characters and props. There are also facilities for writing speech bubbles for the characters, and recording narration and sound effects. When a story is complete, it can be viewed as a Quick Time movie and shared with other learners. These learning environments appear to be particularly motivating to children, and initial findings suggest that they have potential for developing creativity and literacy skills appropriate to new media (Robertson & Good, 2003; Williamson, Dillon, & Owen, 2003). One important aspect of these environments are the audio recording facilities; children enjoy recording narration and dialogues for their stories. Similarly, the audio recording feature in the multimodal story creation environment POGO (Fusai et al., 2003) was used in creative ways as young children used a mixture of real world and digital tools to create, revise and perform stories. The value of audio recording is also noted by Ryokai, Vaulalle, and Cassell (2003) in their description of a story listening system in which young children can record stories in audio form while playing with a dolls’ house.

It is interesting to note that although audio-visual environments such as Kar2ouche offer a rich mix of media with which to create stories, they don’t support the creation of the types of structurally sophisticated plots which are possible with text-based tools such as MOOSE Crossing. A particular strength of MOOSE Crossing and other environments in which learners can create interactive story worlds is that they explicitly support the development of the important skill of audience awareness. By authoring an interactive story which contains several choices, and then watching a peer playing with
that story, the learner has an opportunity to directly observe an audience member’s reaction and develop his work accordingly. The Adventure Author project aims to combine the benefits of devising interactive stories with the motivational benefits of creating stories in a rich audio-visual medium.

**Story Participation Environments**

The development of desktop virtual reality technology has facilitated the development of interactive audio-visual learning environments in which children can participate in stories. Virtual role-play of this sort can be valuable both in terms of introducing the learner to an unfamiliar world (for example a historical setting), or by helping them to explore and evolve their attitudes in a more familiar world. By assuming the role of a character in a story which takes place in a believable environment, a learner can experience a situation from an alternative point of view.

Gjedde (2004) describes a narrative learning environment designed for children with multiple functional deficits based around a medieval theme. This software offers the learners an opportunity to experience an unfamiliar historical world. While exploring a frame story (an Arthurian legend) the children learn about various aspects of medieval life by watching video footage, making music, combining recordings of period instruments, and playing simple games. This environment offers a remarkably engaging multimedia experience, and has had a positive impact on its users’ quality of life.

Ghostwriter is a virtual role-play environment in which participants play the parts of characters in an interactive story which contains difficult ethical decisions and moral choices (Robertson & Oberlander, 2002). A (human) role-play leader plays the part of the other story characters, and in role, encourages the children to become emotionally involved in the story and discuss difficult decisions with each other. After the role-play session, and a discussion about the experience, the children write stories based on their adventures in the virtual world. Results of field studies with 10-12 year-old children showed that children are highly motivated by Ghostwriter and, as participants in the story, form relationships with each other and the game characters (Robertson, 2001; Robertson & Oberlander, 2002). The stories they write afterwards contain more portrayals of characters’ relationships, especially through dialogue (Robertson & Good, 2003; Robertson, 2001). Ghostwriter was positively received by the teachers and head teachers who saw it in use. The teachers could see the benefits of the activity on the children’s motivation and self-esteem, and noted that the experience seemed to have generally improved the behaviour of some of the children (Robertson, 2001). A collaborative virtual role-play environment with similar aims to Ghostwriter, but intended for younger children, is described in (Prada, Paiva, Machado, & Gouveia, 2002). In Teatrix, 7-11 year old children collaborate to create a story using a set of pre-defined scenes and characters which assume traditional Proppian folk tale roles such as villain or helper.

A contrasting virtual environment in which young people assume the role of a character in a narrative is Personal Investigator (Coyle, Matthews, Sharry, Nisbet, & Doherty, 2004), a 3D game designed for therapeutic interventions. Here the aim is to assist learners to change the roles they assume in everyday life situations. The user takes the role of a trainee solution detective who goes to detective academy to learn how to solve mental health related problems. The goals of the Personal Investigator game are structured to be analogous to the goals of a therapeutic approach known as Solution Focused Therapy in which the participants learn to tell new, more positive stories about their lives. An important aspect of Personal Investigator is the facility for users to share the experiences of other young people by watching videos in which the young people tell stories of how they tackled their problems. This therapeutic approach is also used in the Working Things Out resource (Sharry,
Brosnan, Fitzpatrick, Forbes, Mills, & Collins, 2004), a series of multimedia stories created by young people who wanted to share their stories about mental health problems to help other young people facing similar challenges.

Adventure Author incorporates elements of a story participation environment, in the sense that authors can invite their friends to experience the interactive stories which the children have created. However, as we have chosen to initially focus on supporting the author’s learning about interactive story structures, the resulting stories may be less engaging to participants than if they had been designed by expert game designers. Even so, observations in our previous studies in which children play each others’ games suggest that children do value the experience of playing a game which has been created by their peers (Robertson & Good, 2005b).

Children as Game Authors

In Kafai’s constructionist influenced work (Kafai, 1995; Kafai 1996), children learned how to program simple 2D graphical games using a text-based programming language. Her studies showed that the process appeared to foster transferable skills such as planning and problem solving. The multimedia content of the games which the children could produce were limited by their programming knowledge and the power of programming language itself; it was not feasible for novice programmers to use it to develop 3D virtual environments of the kind described above.

However, in the relatively short time since Kafai’s research, technology has evolved considerably. There are presently numerous 3D computer games available that feature not only impressive virtual environments but also readily available development tools which do not require detailed knowledge of programming languages. Free game editors of this sort are released with commercial games such as Unreal (Epic Megagames, 2006) or Half-Life (Valve, 2006). These tools enable end users to create 3D virtual worlds using an existing game engine; the task of designing a game level predominantly requires sophisticated graphic design skills rather than programming skills. Many of the currently available games creation tools require the user to gain considerable expertise in constructing 3D geometry, operating at a lower level than considering the gameplay experience as a whole. There are a few notable exceptions which are suitable for novices and can be adapted for educational use. Neverwinter Nights, considered in the “Adventure Author Design Process” section, is particularly suitable for this application, and has been successfully used in children’s game making workshops.

Custom-built educational games authoring tools have also been created to support specific research objectives. The Making Games project focuses on the educational and creative benefits which children can gain from creating their own computer games (Pelletier & Burn; 2005). In partnership with an educational software company, the researchers are using a child centred design approach to develop a computer games authoring tool for 11-14 year old pupils. An aim of the project is to explore the concept of “game literacy”, to study how the reading and writing of computer games may be taught in media studies classrooms. The current version of the authoring tool prototype places the emphasis on designing the gameplay – rules and boundaries of the game – rather than on interactive narrative aspects which are the focus of the Adventure Author research.

Habgood, Ainsworth, and Benford (2005) have explored the educational and motivational content of computer games created by forty children in the 7-11 age range. The children used a game authoring tool called Stagecast Creator to create educational games at an after school club over a period of eighteen sessions. The study explored the extent to which children created intrinsically
motivating educational games (having been provided with an example of such games), finding that the majority of the games contained either no educational content at all, or were extrinsically motivating. This illustrates the general difficulty of designing games with intrinsically motivating educational content, a problem which many adult edutainment designers face. Like the Making Games project, the emphasis on this study was on designing gameplay rather than on interactive narratives.

The roles of children in technology design

Adventure Author aims to support children in a complex task with which they likely have little familiarity. Therefore, it was important to involve stakeholders in the design process from the outset to reduce the risk of producing software which is unengaging or even unusable. In this case, as some of the stakeholders are children, it was necessary to consider the ways in which they could effectively contribute to the design. Druin (2002) describes the roles which children may play in the design of new technology, on a continuum from least to most involvement, as: users, testers, informants, and design partners. Until recently, it was common for the designers of children’s technologies not to directly solicit children’s opinions of products, instead relying on observations of their interactions with the technology. For example, in Conlon and Pain’s Persistent Collaboration Model for developing educational technologies in partnership with teachers, pupils are not directly consulted: teachers and researchers observe the children using the software and assess the impact it has on their learning (Conlon & Pain, 1996).

By extending the children’s role from user to tester, however, designers benefit from children’s comments and insights as they use prototype software, and take this feedback into account during the next iteration of the development cycle. When children collaborate with researchers as informants, they may be consulted before the testing stage. In the ECOi project (Scaife & Rogers, 1999), children were involved during the design of educational software in the domain of ecology. Among other activities, they identified problems they had with understanding the domain, suggested interface designs through low-tech prototyping, and worked with a designer on improving a mock-up interface. The researchers used what they termed an “informant framework”, which involved collaboration with teachers, software developers, graphic designers, psychologists and HCI experts. The informant framework recognises the expertise of a spectrum of professionals as well as the end user pupils. Scaife and Rogers reflected on the success of including children as informants and questioned the extent to which children’s contributions to the design of educational software are useful. They identified problems which arose during collaboration with the children, such as selecting and prioritising the large number of suggestions produced by children, encouraging children to focus on the learning goals of the software, and managing communication difficulties between children and adults. They also make the point that design suggestions from a particular group of children may not scale up to be generally useful for children in different age groups, learning styles or ability levels.

In Druin’s Cooperative Inquiry method, children take the role of design partners, collaborating regularly with adults in inter-generational teams over long periods (Druin, 2002). These teams work together on requirements capture, system specification, design and testing, and evaluation. Team members take part in activities such as observations and interviews of technology users, data analysis, and low-tech prototyping. As the teams work together over a long period of time, they develop techniques for successfully taking advantage of the skills of children and adults, and for managing the unconventional power relationship between children and adults.
Design processes involving children in the roles of informants or design partners have previously been employed in the development of environments to support story making activities. The Cooperative Inquiry approach has been used to design tangible collaborative storytelling environments (Taxén, Druin, Fast, & Kjellin; 2001), room sized story making kit for children (Alborzi et al., 2000), and storytelling robots in a paediatric rehabilitation context (Druin et al., 1999). StoryStation, an intelligent tutoring system which gives children feedback on their story writing skills (Robertson, 2002), was designed using the CARSS framework (Good & Robertson, 2006), a learner centred design approach which draws on elements of Co-operative Inquiry and Conlon and Pain’s Persistent Collaboration Model for designing intelligent systems in partnership with teachers (Conlon & Pain, 1996). An informant based design approach was used in the development of an online collaborative storytelling environment for a Canadian public service broadcasting corporation (Antle, 2003).

Given the success of these design methods in other projects in the domain, it was appropriate to consult stakeholders in the design of Adventure Author. We adopted a variety of consultation methods to inform different aspects of the design, including requirements gathering via interviews with teachers, children and expert games designers (Good & Robertson, 2004) and extensive observation of children using existing game authoring tools in order to identify strengths and weaknesses of previous approaches (Robertson & Good, 2005; Robertson, 2004).

However, to answer the central question of the research reported in this paper – whether children can understand and use a visual representation of interactive narrative in order to create their own stories in a story creation environment – we did not require children in the role of full design partners. Firstly, the researchers had a clear idea of the system to be designed, and the system fit within an ongoing research agenda. Having children take the role of design partners is most effective when the research agenda is more open-ended, resulting in more opportunities for children’s ideas to be incorporated into the initial design phases. Secondly, we knew in advance that the system to be built would incorporate a number of intelligent features to facilitate the process of story creation: expecting children to understand and/or contribute to the complex operations occurring behind the scenes is unrealistic given that they have little to no knowledge of artificial intelligence and computing. Nonetheless, we felt that children’s involvement needed to go beyond the tester role: given that the representations on which the system is based are, in and of themselves complex, it made little sense to design the system if children could not work with the representations. Therefore, we used a two-stage learner centred design process in which children acted as both informants and testers of a low-tech prototype, followed by an initial implementation of the system.

THE ADVENTURE AUTHOR DESIGN PROCESS

During the design of Adventure Author we consulted with various stakeholders: learners, teachers and expert games designers, to gather requirements for the tool. Although the main focus of this paper is on the low and high-tech prototype evaluation work which we conducted with pupils to validate the design of a visual representation for interactive narrative, a summary of our previous requirements gathering studies is useful to provide a context for the work.

A particularly useful requirements gathering activity has involved observing children in the target age group using a commercial game authoring tool called Neverwinter Nights to make interactive stories, and interviewing them about their opinions of the software. In one such study, a group of 10 young people took part in a four day summer holiday workshop in which they used art materials to
plan stories which were then realised in game form using Neverwinter Nights (Robertson & Good, 2005b). All participants found the overall experience to be enjoyable and rewarding, stating they would like to have further opportunities to make their own games in the future. Other results of the study were equally positive: the participants all displayed particularly high levels of motivation, and benefits were noted in terms of self-esteem, with the participants proud to display their games to one another and friends and family. A series of follow up studies involving 60 children in three hour long games creation workshops confirmed these impressions (Robertson, 2004).

In addition to the motivational issues described above, we were particularly interested in looking at Neverwinter Nights from an educational perspective in order to determine its relative strengths and weaknesses. Observations of the young people’s interactions with the tool, and analysis of the games which they produced suggest that Neverwinter Nights is an excellent tool, and the workshop participants learned to use it without difficulty. However, it was not designed to be an educational product, and consequently has a number of weaknesses in developing storytelling skills. One clear area of weakness is the representation of plot: the NWN toolset has no facility to allow the representation of multiple and distinct plot threads. This limitation was clearly evident in that the adventures created by the participants did not take advantage of the possibilities offered by the interactive medium, in other words, they contained little in the way of branching plot structure.

A further weakness is the facility for creating interactive dialogue. The dialogue is represented to the author in an expanding tree structure. This structure records the possible choices for the player during a conversation along with the replies which game characters give in response to player choices. The problem is that the impact of dialogue choices on the overall plot are not represented, making it difficult to keep track of the story threads.

A final area of weakness in the NWN toolset is the fact that it contains a number of features that make sense in the context for which it was designed but not in the educational context of Adventure Author. NWN uses game mechanics derived from the pen and paper Dungeons and Dragons genre, in which outcomes in the game are determined by rules governing interactions between characters, and are based on traits such as constitution, dexterity or strength. Hence, character creation in the toolset does not focus on the personality traits or motivations of characters, as would be appropriate in a story making environment.

Having established the strengths and weaknesses of an existing authoring tool, it was necessary to establish which features should be included in an interactive story authoring tool, both from a motivational and an educational perspective. To this end, we conducted in depth interviews with children, an expert teacher, and an expert game designer at which the interviewees played example games created by children during the Gamemaker workshops (Good & Robertson, 2004). The children’s perspective on the features which they enjoyed playing gave us insight into the aspects of games which children value; the teacher’s comments informed us as to the educational potential of various features; and the game designer shared his opinion on the attributes of games which contribute to its artistic merit. Interestingly, these three perspectives had common themes: choice and consequence were not only educationally important in the eyes of the teacher, but were considered as desirable from the point of view of the player; and the development of characters’ motivations in the story was also considered important.

Based on these previous consultation studies, the Adventure Author interface has the following requirements: to support children as they map out the structure of the story; to enable them to understand and manipulate choice points in the story; to permit them to work with multiple plot
threads simultaneously; and to allow them to reflect on consequences arising from choices. The visual representation of interactive narrative which meets these requirements is presented in the next section.

The development of Adventure Author is on-going. At the time of writing, a 3D prototype of Adventure Author has been evaluated by a group of children and adult experts in conjunction with NESTA Futurelabs (Robertson & Good, 2005a) but further technical development is required before a summative evaluation can take place.

A SYSTEM FOR THE REPRESENTATION OF INTERACTIVE NARRATIVE

Previous academic projects which aim to explore digital narrative forms have drawn inspiration from examples using other media. For example, Louchart and Aylett (2004) have used knowledge elicitation techniques with live role-play experts to inform them of the features of emergent narrative. Adopting a similar approach, we studied adventure game books, which are a form of interactive fiction, to assist with our conceptualisation of interactive narrative on the grounds that they tell branching stories in a relatively simple form and are aimed at children (see, for example the Lone Wolf books by Dever (1984)).

In an adventure game book, the reader assumes the role of a protagonist in a story. As with normal fiction, the reader is first introduced to the character and the setting at the start of the story; however from that point onwards the experience of adventure fiction is rather different. The story is not linear as in usual fiction, it is interactive and branching: the reader will often be presented with choices. The reader must consider the merits of each option, and then make a choice, with his choice then determining how the narrative proceeds. As such, all adventure game books feature a narrative that is split into numbered sections. Each section is a point in the interactive narrative, and each contains a description of the narrative circumstances, a number of choices and, occasionally, a picture illustrating the narrative. All of the choices are tagged with a number which tells the reader which section he should read next if he chooses that option. The adventure thus generally proceeds through a series of choices until a section of text is reached where the reader is told that his adventure is at an end, due to his success or failure.

On studying this form of narrative, it was noted that there were often two types of choice in adventure game books: choices which are open to all, and choices which are available only to those whose character in the fiction has acquired some status earlier in the adventure. An example of the first category (standard choices) would be choosing which direction to explore in an environment. The second category (status choices) refers to situations such as only enabling the player to climb down a mineshaft if he previously collected a rope.

After studying this form of interactive narrative, a system was developed that was compatible with the formal structure of an Augmented Transition Network (ATN), a derivative of a State Transition Network (STN) (Woods, 1970). An ATN was necessary over an STN due to its facility for global memory, something that would be required in modelling status choices.

An interactive narrative can be visualised as a series of connected ‘scenes’: there is a single start scene with multiple interim and end scenes, and multiple transitions between these scenes. Each scene must have a description of the narrative and a series of choices. These choices may be of the standard or status varieties, with status varieties only able to be chosen if the related status has been previously acquired. Designating the contents of each scene and then taking each scene as a state in an ATN, the representational system for interactive narrative was thus devised. Figure 1 shows an external
representation of a scene (of the type which the story author would see). Figure 2 is a representation of interactive narrative in the form of an Augmented Transition Network (ATN). Note that in this model, the interactive narrative is acyclic, i.e. the story cannot contain loops.

**Fig.1. A system state (or ‘scene’), annotated with content areas.**

**Fig.2. Interactive narrative represented as an ATN.**

We chose not to explore some aspects of the ATN formalism (such as computations on arc transitions) in the preliminary evaluation of the representation, as we wanted to evaluate whether members of the target user group could comprehend the more basic features of the formalism. Work on a more extensive children’s visual programming language for interactive storytelling is under way at the University of Sussex (Howland, 2005).
EVALUATION OF THE REPRESENTATION IN A PAPER-BASED MEDIUM

Having developed a representation of interactive narrative, it was necessary to examine whether the children of the target age group could understand it. This informal pilot evaluation was first conducted using a paper-based medium for two related reasons. Firstly, creating a paper-based medium to convey the system meant a significantly smaller development time and cost, beneficially allowing both immediate feedback and, if this feedback was negative, comparatively less wasted design effort. Secondly, initially deploying a paper-based medium was useful as a requirements capture exercise, enabling us to observe areas wherein the computer medium could aim to support users via intelligent help.

Materials

The first step in conducting this evaluation was the development of an example of interactive narrative devised using the system described above. Existing fictions for children were examined for compatibility with the idea of interaction, and a piece called ‘The Kindly Ghost’ (Hodges, 1991) was eventually selected. The story tells of Jiri, a boy who is abandoned in the desert by his brothers and is forced to survive by displaying kindness to the different characters he meets. Jiri is eventually rewarded with survival and a happy life. This story was particularly suitable for adaptation in that it contained many implicit choices made by the narrative’s protagonist. By making these explicit, and postulating alternate outcomes, an interactive narrative could be created in a straightforward way. Furthermore, the story’s implicit choices were not only of the standard variety with an immediate response, but also of the status variety where, because of an earlier action, Jiri’s status changes. This change in status entails future possibilities and consequences. As such, using this story for assessment allowed us a full demonstration of the capabilities of the representational system developed for interactive narrative.

The paper representation of the story was constructed in the following fashion. Each scene was a single A4 sheet which was structured following the scene content’s outline, thus containing a narrative description, choices and an illustration. These scenes were glued to a large roll of paper, and from each choice in a scene an arrow was drawn to the scene it led to, thus forming a connected network of scenes. Further following the stricture of augmented transition networks, end scenes were designated with a red border.

Participants

A group of six 10 year old children were asked to participate in the evaluation of this paper-based representation. The children were pupils at a state funded primary school in Edinburgh, where the researchers had worked on previous successful projects. Although it would have been preferable to determine children’s comprehension of the representation on an individual basis, it was necessary to carry out this exercise as a group, due to time constraints resulting from the children’s school day and researcher availability. The study took place in an open plan space in the school which is often used for creative projects.
Procedure

The evaluation proceeded through four phases. In the introductory phase, the participants played short, fun ‘getting to know you’ games to encourage them to feel comfortable with one another and the researchers, easing them into the experimental environment.

Following this, and in order to gauge the children’s understanding of interactive narrative, the participants were told a specially devised interactive story called ‘The Kindly Ghost’ as a group. The story was told orally to them by one of the researchers, scene by scene. At each scene the children voted to determine which choice was taken, and thus which scene in the narrative would come next. During the story they were asked to justify their choices in order to observe the degree to which they were engaged and motivated by the interactive narrative. The first author made notes during the interaction, including recording the votes cast by the children for each story choice.

Next they were shown the chart containing the visual representation and were asked questions such as “What would have happened if we had made a different choice at this scene?” and “What do you think the red boxes around these scenes mean?” The participants’ answers were noted by the researchers.

Finally they were asked to generate their own interactive narrative as a group, with the researchers facilitating the group interactions. The researchers did not provide story ideas, rather, their role was to help resolve group conflicts, and assist in secretarial tasks such as maintaining the scene numbering system. The group were asked to make an interactive version of a well known fairy tale (“Goldilocks and the Three Bears”) because they were familiar with the story, and it is suitable for conversion to an interactive story given its obvious choice points (e.g. which chair Goldilocks chooses to sit in). As this was their first introduction to producing interactive narrative, we decided not to ask them to construct a completely new story, which is a more difficult task than adapting an existing story. The children’s story was saved for later analysis.

Findings

The findings of this pilot field study are summarised below. As the purpose of the study was to inform the design of a high-tech prototype of Adventure Author, the emphasis was on exploring how the children reacted to participating in an interactive story, and observing the extent to which they could use the visual representation we had previously devised.

Participation in interactive narrative

While participating in the interactive narrative, the children clearly understood the genre, and were motivationally engaged by it. This was particularly evident as participants individually voted for their preferred choice: a number of deadlocks occurred with three children favouring one choice while the other three favoured a different one, and all participants vociferously championing their own preference. Perhaps the most passionate of these deadlocks occurred in considering the final choice: at the end of the story Jiri is in a position to wield power over his brothers who had abandoned him, and so the participants had to decide whether Jiri should forgive his brothers, banish them or punish them, provoking some clearly considered opinions:
Jane: “He should banish his brothers and not punish them because if he punishes them the eagle and the rat might think this is not the person who freed us and not be friends with him anymore.”
Jeff: “I think he should forgive them because if he punishes them or banishes them they would want even more revenge.”
Linda: “I don’t think he should forgive them because they’re his brothers. They’re his brothers and they just left him.”

The children seemed enthused by the story, becoming increasingly excited and voicing keen asides as the story proceeded to its climax. In addition, it was clear that the children understood the nature of interactive narrative: at the completion of the story, a participant immediately asked, “Can you go back and tell us what would happen if we did punish [the brothers]?” The other participants were also keen to do this, displaying comprehension of the idea of alternate outcomes and real eagerness at the prospect of exploring them.

Comprehension of visual representation

When questioned, the children immediately recognised that the paper chart contained a visual representation of the narrative and were able to use the chart to both plot the route they took through it and also determine what would have occurred at various stages in the narrative if they had chosen an alternative route. Participants were also able to correctly identify attributes of the system structure such as narrative end points. In addition, one of the children spotted that there was an unintentional error in the representation of the story, correctly pointing out that a transition was missing in the diagram. In discussion, the participants expressed that seeing the visual representation of the narrative assisted them in understanding the story.

Generation of interactive narrative using the visual representation

Provided with a stimulus of ‘Goldilocks and The Three Bears’ and with their experiences of the sample interactive narrative, the participants were able to work effectively as a group to devise an interactive narrative version of the story. The participants’ discussions demonstrated an understanding of the requirements of the genre, including multiple distinct threads and conclusions, as illustrated by the following exchange:

Researcher: “What happens when she goes into the house?”
Joseph: “On the table she sees some porridge.”
Jane: “Which one does she take?”
Edmund: “If she takes the daddy’s porridge it’s too hot and she runs out of the house and can’t get back – Game Over!”
Jeff: “Yeah, and if she takes the mother’s porridge she freezes and the bears find her!”

Ultimately the group developed an interactive narrative that featured all the narrative attributes of the ‘The Kindly Ghost’: multiple end and interim scenes, multiple outgoing transitions from a single scene, and status choices which would result in delayed consequences from a player’s choice. It is interesting that the children were able to collaboratively produce a story at least equal in complexity to the example story (see Figure 3). Interactive Goldilocks contained more scenes than the example story,
particularly end scenes, as the children enjoyed writing what they called “Game over” scenes in which Goldilocks came to a bad end. The subversive nature of this version of the fairytale is similar to Roald Dahl’s version of Goldilocks in “Revolting Rhymes” — the children were keen to include possibilities involving unexpected role shifts, such as the Three Bears enslaving Goldilocks. The Goldilocks story contains fewer status choices than the Kindly Ghost example. The explanation for this is not clear, although a possible explanation could be that the children found them difficult to reason about. In any event, it was decided not to include status choices in the next phase of the design due to time constraints so this issue requires further investigation.

The generation phase proved valuable in identifying tasks which Adventure Author should support, as a number of minor difficulties for the participants were observed. Thus, it was determined that Adventure Author should effectively manage scene data by numbering all the scenes created, ensure there are no slips in numbering the scene transitions, and ensure that the ultimate story structure is valid with respect to the specifications of the ATN driven formal system. This evaluation was a success: the group of participants were able to both understand and generate the visual representation of interactive narrative using a paper-based medium, and furthermore, they seemed to enjoy the experience. After working with the target user group, we had good reason to believe that it was worth implementing the visual representation in a high-tech prototype.

**IMPLEMENTATION OF A HIGH-TECH PROTOTYPE**

After establishing that members of the target user group could understand and use the visual representation of interactive narrative, the next stage was to create a high-tech prototype, AA2D. This would allow a user to create a simple interactive narrative similar in style to the “choose your own adventure” books, and subsequently share this story with her peers. AA2D can, as its name suggests, be used to create text and picture based stories rather than stories set in 3D game worlds. A later
version of the software which enables authors to create stories in 3D worlds is described in (Robertson & Good, 2005a).

The Scene Editor (Figure 4) enables the user to create, view and edit the attributes of scenes in a story, including the scene title, a textual description, an illustration and choices leading to other scenes. The right hand pane shows an overview of the structure of the interactive narrative, in the form of a directed acyclic graph. As the user creates and links new scenes, the story overview is updated to reflect the structural alterations to the story. The left hand pane shows the editable details of an individual narrative scene.

The Scene Editor interface also provides support for the issues identified in the paper-based evaluation: an automatic story checker is provided to validate the structure of a story, with intelligent feedback given to users when structural problems are uncovered. In addition, management of scenes and scene data is ensured, as each scene is visually represented and uniquely identifiable. AA2D also provides logging and monitoring facilities to allow detailed analysis of individual behaviour: all feedback given in response to structural errors is logged, and user interactions are time stamped.

Fig.4. The Scene Editor mode of AA2D.

Fig.5. AA2D’s Game Engine mode.
Figure 5 shows AA2D in Game Engine mode. In this mode, players/readers can participate in an interactive narrative previously created in the Scene Editor. The player reads the description of the scene and decides which action to take. She selects the button which represents the option she prefers. When the button is pressed, the display changes to represent the connected scene. When the player reaches an end scene, she is asked if she would like to play again in order to explore another path in the story.

EVALUATION OF A COMPUTER-BASED MEDIUM

The focus of this evaluation was to gain insight into participants’ understanding and use of interactive narrative in a digital form, and to explore the extent to which AA2D supported the learner in the task of creating an interactive story. By evaluating the visual representation and basic design for a story editor in an early prototype, we hoped to avoid including features in later versions of Adventure Author which the target user group found difficult to understand. Similar to the paper-based evaluation, the computer-based evaluation was designed to determine whether, firstly, participants could understand the interface for interactive narrative and, secondly, whether they could use AA2D to generate their own interactive narrative.

Materials

As with the paper-based evaluation, an example of interactive narrative was required to give the participants a model to which they could refer. Given the suitability of ‘The Kindly Ghost’, another work by the same author was chosen, this time a story called ‘Trapped in Time’ about a young boy who is led to a mysterious cursed town on the back of a friendly goose. During the story the boy is faced with a choice which can either release the town from the curse, or doom them to another century of the same fate. The first author created an interactive version of ‘Trapped in Time’ using AA2D and selected pictures to represent each scene.

Participants

AA2D was evaluated using the same six children who participated in the paper-based evaluation. We chose these children because they were familiar with the researchers, they had some experience of interactive narrative, and they would be able to inform us of pertinent differences in usability between the visual representation in paper form and its implementation in AA2D.

Procedure

This evaluation proceeded through five phases, with the first four similar to those of the paper-based evaluation. After an introductory ‘ice-breaker’ session, the children individually played through the interactive version of ‘Trapped in Time’ using AA2D’s Game Engine. They were then asked to complete a series of comprehension questions about the story. Following this, they examined the narrative’s structure using the Scene Editor interface and completed a worksheet to test their understanding. Next they were asked to generate their own interactive narrative, doing so individually using the Scene Editor in AA2D. The final phase, not present in the paper evaluation, was an interview
with the participants, in which they were asked questions about their experiences of using AA2D and how it compared to their experiences in the previous paper-based session. The researchers took notes while observing the participants using AA2D, particularly of the number and nature of questions asked. The interviews were audio recorded and later transcribed. The participants’ completed worksheets and AA2D story and log files were saved for future analysis.

Findings

Participation in Interactive Narrative

After the children played through ‘Trapped in Time’, they were each provided with a worksheet containing questions to ascertain their comprehension of the narrative. The first question simply asked what happened to them during the story - all were able to recall in detail the choices they selected and the consequences in the narrative. Interestingly all the responses to this question were written in the first person (whereas the AA2D story is written in the third person), saying things such as “I went flying with the goose” perhaps inferring engagement to the extent that the participants did feel personally involved in the story.

The second question asked the participants what made this story different to the ones they normally read in class. All the participants understood that it was choices that made them different. Notably one participant stated:

Jane: “It had options. The only books I ever read to do that were Goosebumps.”

This is a reference to the Give Yourself Goosebumps series, for example Stine (1995) of adventure game books, in essence similar to the Lone Wolf game books described above.

The third question asked the participants to consider what made the interactive narrative similar to stories they read in class. The participants appeared to find this question more difficult. Three answered that it was still a form of story, one cited “excitement” while another said “it took you on an adventure”. One participant did not answer.

The final question asked if the participants had enjoyed the story – one described it as “ok”, two said they liked it, one said it was “good”, one “really good” and one “excellent”. That the majority of responses to this question were clearly positive and none overtly negative arguably shows that the participants also found the narrative to be motivationally engaging. One participant with writing difficulties did not appear to enjoy reading the story as much as listening to the ‘Kindly Ghost’ on the previous occasion.

Comprehension of visual representation in AA2D

The children next examined the structure of ‘Trapped in Time’ using AA2D’s Scene Editor, receiving a worksheet questioning them about the attributes they observed. These questions had objectively right or wrong answers relative to the structural representation, with the first question directly asking what the Scene Editor was displaying. Five of the participants answered this question and of those all correctly identified it was a representation of the interactive story. One such response featured an astute analogy:
Jane: “It’s a path. You all started at the same point but may have ended at a different point. It is like a tree, Trunk – beginning, Branches – choices, Tips – end”

The story graph does indeed resemble a tree, it is in fact an almost exact formulation of a tree graph structure; suggesting that this child had a strong grasp of the concepts underlying the interactive narrative.

The five questions that followed this featured less room for expression, asking the participants to identify specifics of the representation: the endings, the start point, their route through the story, and what happened if certain choices were made. Overall, including the first question, the participants performed well: three participants got the maximum score of 6, two got 5, and one got 4. That all the participants had predominantly correct answers suggests that they possessed an understanding of the representation.

**Generation of interactive narrative using AA2D**

Once the researchers had ensured that participants could comprehend the sample narrative, the participants were asked to generate their own using AA2D. The group was first given a brief tutorial on how to use the AA2D Scene Editor. Two researchers were on hand to provide assistance if requested. Each request, including the participant’s name and question, were logged for later analysis. Every participant asked at least one question. The minimum queries per participant was 2, and the maximum was 6, with an average of 4.

The 25 total queries could be divided into four categories: recurring questions concerning important features of AA2D; questions concerning features not provided by AA2D; requests for confirmation; and questions with no direct relevance to the evaluation. The first category was the most pertinent, concerning features of AA2D’s interface that the participants did not satisfactorily understand. These questions suggest a need for better instruction in using AA2D and, in some cases, a redesign of certain features of the interface. The second category was of interest in determining additional features that AA2D might usefully provide. The two queries that fell into this category were the ability to add characters, and the ability to change end scenes to middle scenes after they had been created. The third category is not strictly a type of query, they were requests for confirmation and, as such, had more to do with confidence than with actual comprehension. The final category consisted of questions such as “Where do I find the quotation marks on the keyboard?” which had no direct relevance to the evaluation of AA2D. Although all the participants did need individual assistance in using the tool, this is common when children first encounter new software. No participant asked the same query twice and all participants produced some form of interactive narrative. Figure 6 provides an overview of the size and breakdown of the features of the story generated by each participant. It can be seen that each pupil successfully created an interactive story containing two or more alternative outcomes.
As illustrated in Figure 7, the pupils occasionally made mistakes when attempting to join scenes together (as logged by AA2D), but this did not present a major problem in this first session. Their errors were mainly the creation of orphaned scenes with neither incoming nor outgoing transitions. However, given that in normal classroom circumstances there would be fewer adults available to answer individual queries, this suggests that Adventure Author should be able to provide additional assistance to prevent children from creating stories containing structural errors.

Edmund appeared to find it easy to create his story, confidently producing a surreal adventure with many “game over” states in which the player could meet a sad end. He committed the largest number of structural errors, but he also produced the largest number of scenes. His teacher, on playing his adventure, was amused by his work and commented that he is an excellent, humorous writer in class. Jane, another pupil identified by the teacher as being an accomplished writer, took a good deal of care in writing each scene, with the result that her story contained fewer scenes than the other
children’s stories. In contrast, Jeff took a breadth first approach to scene generation, creating an overview skeleton structure for the story without writing very much text for each scene description. It would be interesting to investigate whether there is a relationship between generation strategy and error frequency: Jeff committed no structural mistakes using a breadth first strategy while Jane’s depth first strategy produced a more detailed story with an incomplete structure. The limited time the authors had to create the story is likely to be a factor here; it is probable that Jane would have produced a structurally complete story given more time, as her answers to the interview questions suggested she had a very good understanding of the concept. We cannot tell however, whether Jeff would have revised and extended individual scene descriptions if he had had more time or whether he would have preferred to write a fresh story. This issue would require further attention before devising a teaching approach for the classroom: is it better to advise pupils to use a breadth first strategy to produce a complete interactive story or a depth first approach to produce a story containing detailed scenes? At this point we would suggest that the former strategy would be more appropriate if the focus of the lesson was story structure as it would enable the authors to think at a higher level about interesting choices for the plot rather than lower level vocabulary details which could be addressed in other lessons.

During the final interview phase of the evaluation, all participants stated that they had enjoyed using AA2D and would be happy to do so again. The participants also had an opportunity to express ideas for improvements to AA2D. Three suggestions were put forward; an improvement to the way in which scene connections were specified in the interface, an automated tutorial on how to use the tool; and the ability to allow a user to record dialogue in audio form to be played during the adventure. The last suggestion is currently being implemented as it confirms our previous research with story authoring tools (Good & Robertson, 2004; Robertson & Good, 2004).

The participants then were asked whether they preferred AA2D to the paper-based medium they had used previously. Their responses to this were without clear consensus: two participants expressed no preference; two preferred the computer, with one saying that it was “easier”, another preferred paper because writing was “faster”. The final participant gave an inconclusive account of his preference saying AA2D was “easy to control” but “harder” than paper.

**Discussion**

Overall this evaluation was successful: all participants could individually both understand the system of visual representation for interactive narrative and use AA2D to generate interactive narratives of their own, and furthermore they seemed to enjoy these activities. The participants’ understanding of the representational system for interactive narrative is evident in that all participants correctly answered the majority of questions concerning AA2D’s interactive narrative representation. Each participant’s ability to generate systems of interactive narrative was evident in the fact that each did individually succeed in generating a system of narrative with multiple paths and multiple endings. Motivational engagement is suggested in a number of ways: all participants were able to recall in detail their path through the story describing it in the first person; all participants responded positively to the question about enjoying playing an interactive narrative, on the first worksheet; all participants explicitly responded that they enjoyed AA2D and would like to use it again, in the interview; and throughout participants provided thoughtful responses to questions concerning AA2D. The results of this evaluation should, of course, be interpreted with caution as the members of the target user group who used AA2D had previous training about interactive narrative from the first paper prototype study.
However, this situation is likely to be similar to that of actual classroom use; we anticipate that Adventure Author would be introduced to pupils after some initial groundwork in interactive storytelling. For example, the teacher could introduce the topic using a “choose your own adventure” story, or with an oral telling of an interactive story such as the one used in the first study.

This study also provided valuable feedback concerning how the prototype might be improved. The users had some queries about how to use the Scene Editor, and asked if it provided features which were not present, such as the facility to change a middle scene into an end scene. Valuable feedback was also provided in the interview phase where the participants were directly asked how they would improve AA2D, noting features of further interface improvements, tutorials, and voice recording that would be valuable to examine as further work.

In addition to the extra features mentioned above, it would be beneficial to provide assistance to the author to ensure that the structure of the story is coherent. It is important to do this because inconsistencies in the story structure could cause confusion to players and detract from their enjoyment of the experience. Structural checking can be achieved through analysis of the directed acyclic graph of story scenes. Firstly, loops in the story could be frustrating to players because they would be unable to progress further in the story. In some cases experienced authors might deliberately include loops to make some kind of artistic point, but it is likely that novice authors would introduce loops by mistake rather than design. By checking for cycles in the graph structure, Adventure Author could warn the author that the loop structure could be confusing to the player. Another potential structural problem is the presence of end scenes which are unreachable from other scenes. This could arise if the author took the creative approach of thinking of alternative resolutions to the main obstacle in the story at the beginning of the planning process but forgot to create the story path which would result in a resolution. Adventure Author could alert the author to the possibility that she has forgotten to make a path to an ending by analysing the graph for end scenes which have no incoming transitions. A related problem is the presence of normal scenes which have no outgoing transitions – this denotes a story path which has no resolution. Adventure Author could draw the author’s attention to this fact and suggest that she should add an end scene to resolve that branch of the story.

The evaluations of the visual representation as low and high-tech prototypes have been extremely valuable aspects of the Adventure Author design process. Taken in conjunction with the results of consultation with stakeholders on other aspects of the design, they indicate that the design is appropriate for the intended user group. This reduces the risk in later stages of the development of this innovative technology. In particular, the visual representation we have adopted seems to address the main concern identified with the Neverwinter Nights toolset (as described above). As the NWN toolset does not provide an overall representation of the interactive plot, including the consequences which will result from player choices, authors find it difficult to create stories in which the user’s choices alter the plot outcomes. The preliminary studies of Adventure Author suggest that the representation we have chosen enables authors to keep track of the choices they offer to users throughout the game, resulting in successful coherent interactive plot structures.

CONCLUSIONS

While our preliminary evaluations of AA2D were primarily intended to assist in our design process, it is possible to draw some initial conclusions about the skills which pupils are likely to develop from using this interactive storytelling software. The task of creating a story with branching choice points and multiple possible endings encourages authors to think through the consequences of a protagonist’s
actions within the story world. The interactive nature of the story also requires authors to consider their audience first and foremost, in order to create an adventure in which it is engaging for other children to participate. By the same token, this interactivity means that the author can try out the story for herself beforehand, checking to see whether various plot twists have the desired outcome.

In developing Adventure Author, we have adopted a range of methods in consultation with stakeholders. Interviews with children, teachers and expert games designers have instructed us about the sorts of games which children would like to produce, and the sorts of games which teachers and games experts would value. We have observed a large number of children using a similar commercial game authoring tool to establish its strengths and weaknesses for educational purposes. In the work presented here, we have validated a visual representation of interactive narrative through fieldwork with children in the target user group working in the role of informants and testers. We have found these methods to be useful and appropriate in the design of educational software which scaffolds children in the acquisition of a complex concept (interactive narrative).

We have not, however, found it appropriate to include children in the role of equal design partners on this project. Here, rather than involving children themselves in the creation of the visual representation of interactive narrative, trained computer scientists, cognitive scientists and educationalists created a design which was validated through field research with children. We would argue this may often be an appropriate approach in the design of AIED systems in which the aim is to support learners as they explore complex domain structures. The learners cannot assist in designing a representation of the domain if they are unfamiliar with that domain. In the case of Adventure Author, the children were initially unfamiliar with the concept of interactive narrative. They required a visual representation in order to develop a full understanding of the underlying concept, and could not therefore be expected to assist in designing such a representation. In many learning domains, adult designers will be required to assist child designers by teaching them about the new domain. The teaching strategies and representations which the adults use are likely to fundamentally shape the children’s mental model of the domain. Consequently it is unlikely that the children will propose innovative strategies or representations to be used in the software, although they may be able to suggest amendments. Furthermore, the design of intelligent educational systems necessarily comprises the use of sophisticated techniques to monitor student input and provide individualised feedback: it is unrealistic to suggest that children could, or should, be equal contributors to this process. While children have successfully contributed to the development of new technology in the role of design partners, there is a limitation to the roles we can expect them to assume in the design of adaptive interactive learning environments. Nonetheless, including learners, teachers and other stakeholders as informants and testers is invaluable if we are to produce high quality intelligent learning environments.

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