Adventure Author: a learning environment to support creative design

Judy Robertson
Mathematical and Computer Sciences
Heriot-Watt University
Edinburgh EH14 4AS UK
+44 131 451 8223
Judy.Robertson@hw.ac.uk

Keiron Nicholson
Mathematical and Computer Sciences
Heriot-Watt University
Edinburgh EH14 4AS UK
+44 131 451 8223
K.Nicholson@hw.ac.uk

ABSTRACT

Creative design tasks are both challenging and rewarding for learners. While it is exciting to design a new product of which one can be proud, there can be many frustrations along the way. This paper considers the challenges faced by young people as they create their own computer games. It describes an initial model of the creative process involved in game design and presents qualitative analysis of interview data from two field studies focusing on the source and evolution of young people's ideas. The theoretically informed model of the creative process, and the empirical results are used to inform the design of software scaffolding for an interactive learning environment called Adventure Author.

Keywords

Creativity; game design; children; software scaffolding

ACM Classification Keywords

D.2.1 [**Software Engineering**]: Requirements / Specifications – *user-centered design;* K.3.2. [**Computers and education**]: Computer and Information Science Education – *computer science education, curriculum, literacy;* K.3.1 [**Computers and education**]: Computer Uses in Education – *computer-assisted instruction (CAI).*

General Terms: Design, Human Factors.

INTRODUCTION

Creative design is a deeply satisfying activity in which individuals can express themselves by producing fascinating and beautiful works for others to enjoy. Creativity is prized in art, science and entrepreneurship and is considered within the education system as an attribute which should be fostered. However, learning how to deal with the challenges and frustrations of the creative process can be difficult. This is partly because creative design tasks are inherently difficult and are unlike many tasks which learners encounter at school. This paper considers the challenges faced by young people in creative design tasks in the context of making 3D computer games, and outlines the design for an interactive learning environment to scaffold the creative process.

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When undertaking creative design projects, such as computer game authoring, learners work within an environment which may be unfamiliar to them. Unlike other classroom projects which are designed to focus on a single curriculum area within a tightly constrained time scale, a project of this nature requires an integration of skills across a wide subject spectrum as well as meta-cognitive skills such as planning, reflection and self organization. Creativity requires some independence of thought and learning; as Koestler [8] observed, during the creative process the learner also plays the role of the teacher by assessing their own progress.

Design problems as characterized by Lawson [9] are open ended, and cannot be fully specified at the outset. The designer has numerous overall goals to satisfy, perhaps to create something useful or beautiful, using the tools available within a set time period. As the design progresses and the designer learns more about the problem, these goals may change. Furthermore, design problems typically have multiple possible solutions, the suitability of which can only be determined by subjective judgment. For this reason, the designer may never be completely satisfied with the solution – they may have to accept that the design is finished at the point when time runs out, even if they would have liked to refine it further. Not only do designs have multiple possible solutions, there are also multiple possible design strategies which may be successfully applied. An experienced designer is familiar with a range of design techniques and can judge when each technique is applicable to the problem. A novice designer, then, is grappling with an open ended learning environment in which there is no single correct solution, or even a single correct method. In contrast, in other common classroom tasks (such as solving an equation), the learner is asked to find a correct answer, and is guided to the solution by a prescribed procedure.

Within the context of the Adventure Author project, we are investigating how an interactive learning environment could support learners as they grapple with the complex process of design. We have chosen the domain of computer

game authoring as previous work has indicated that young people find it both motivating and challenging [12].

The paper begins by explaining more about the Adventure Author project and summarizing previous research in computer game authoring with children. We then present an initial account of the stages involved in the creative process of game design, derived from theories of creativity in other domains. Having proposed a model of the creative process in this context, we investigate aspects of it further by examining qualitative data from two field studies. Insight from this analysis about the sources and evolution of learners' game ideas is used to inform the design of software scaffolding to support children throughout the stages of the creative process.

BACKGROUND

The Adventure Author Project: Context

The Adventure Author project is investigating the domain and meta-cognitive skills which young people can learn through the creative process of game design. The project is using a design-based research methodology to develop a theoretical model of creativity in the domain of game design. Design-based research is a methodology used in the learning sciences to generate and test learning theories in a naturalistic context via systematic adjustments to a designed learning environment [15]. It is appropriate for projects in which the aim is "to directly impact educational practice while advancing theory which may be of use to others" [1].

Although we are currently analyzing evidence about the nature of children's literacy and meta-cognitive development through the game design task, the focus of this paper is on how novice game designers can be supported throughout the creative process via software scaffolding. By making a theoretical model of the creative process explicit in a software support system, it can be tested and revised through empirical work within a classroom.

An output of the project will be an interactive learning environment called Adventure Author. The software will consist of custom designed educational tools layered on top of a commercial game editing tool called Neverwinter Nights 2 (http://www.atari.com/nwn2/). The advantage of using a pre-existing game editor is that we can focus on the educational aspects of the learning environment while enabling the novice designers to create a state of the art 3D game. At present, we have a prototype version of Adventure Author which we used to explore appropriate visual representations for interactive storytelling [12]. This prototype was developed using the learner centred design process documented in [4]. Having conducted a series of field studies to inform us about aspects of children's creativity in game design, the next stage will be to further develop the Adventure Author software in conjunction with a child design team, before evaluating it in a further classroom field study. This paper documents the findings of recent field studies with respect to the creative process, and discusses how these findings have been incorporated into an initial design for the Adventure Author software scaffolding.

Game Design and Children

Kafai's ground breaking work in the 1990s first explored the educational benefits for children of game design. She investigated a constructionist pedagogical environment called "learning by design", in which children have control over their learning in the context of a challenging design task. Over a six month period, Kafai studied the progression of fourth graders' skills as they created educational 2D games using the textual programming language Logo. The learners developed a range of domain specific skills from the project, including increased understanding of computer programming and mathematical concepts, as well as the meta-cognitive skills required to plan and monitor such a challenging task. Kafai characterised the process of learning by design thus: "The students developed a piece of game software, the product, from the beginning to the end. In this context, they generated many ideas for their games but did not implement them all; they solved problems related to their programs, their game ideas, designs and fractions; they developed design strategies to deal with the complexity of the task at hand; and they modified and adapted their games in the ongoing development. Making games offers an example of how design can be brought into public education" [7].

Since Kafai's study games technology has moved on, and young people today are regular consumers of sophisticated 3D games. Fortunately, there are still opportunities for learners to produce games using this newer technology, although the focus of the game making task has evolved accordingly. There is less emphasis on understanding and writing low level code, and more emphasis on higher level game design concepts. It has recently become common for game editing tools to be released with commercial titles, such as the Unreal, Quake or Half Life families. The game developers' purpose in releasing their development tools is to encourage the user community to develop their own content, as so to keep them interested in the title even after they have finished playing the original adventure. Game editors typically enable users to build and texture the geometry of 3D worlds, and script the behaviour of entities within that world. Such environments can be difficult for beginners to use; specialist training is often required to master 3D concepts, for example. However, some commercial 3D game design environments have been designed for complete novices. In particular, we have extensively studied young people's use of the Neverwinter Nights Aurora Toolset, which can be used to create computer role-playing games [12] (see Figure 1).

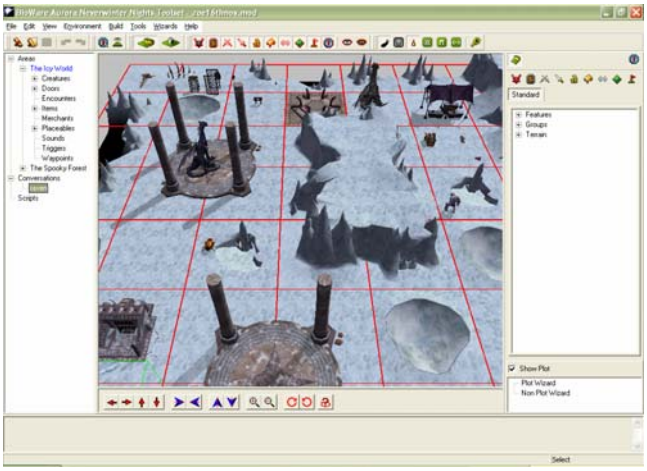

Figure 1. The interface to the Neverwinter Nights Toolset

In a series of community education workshops with around three hundred children aged between 10 and 16, we have examined the educational potential of this software in terms of motivational and learning affordances [3]. The workshop participants enjoy the opportunity to express their story ideas in game form, and appreciate sharing their games with friends or family members. In particular, we have explored how Neverwinter Nights can be used to create interactive stories in which the outcome of the plot can be influenced by the player. The young people are able to comprehend and manipulate the complex structure of branching dialogue, and are often motivated to write lengthy conversations between the player and story characters [14]. Szafron et al. [18] have also had success in using a modified version of Neverwinter Nights as a way of teaching creative writing to young learners while Pelletier and Burn [11] have explored educational game authoring from the perspective of developing new media literacy. Howland, Good and Robertson review children's game scripting environments from the perspective of developing programming skills and describe a visual programming language called Script Cards which will be integrated with Adventure Author [6].

The Creative Process

In order to develop software scaffolding in Adventure Author which will support learners effectively, it is necessary to have a theoretical model of how the creative process of game design progresses.

Various authors have identified stages in a general creative process (for a review see [2]). There is some commonality between stages in different models, and recognition that there are "loops" or overlaps between these stages. As game design is a multi-disciplinary task, we have drawn upon models from various fields, including commercial games development [10], software development, creativity theory [2][16], and Sharple's characterisation of writing as design [17]. Observations and analysis from the community education workshop series integrated with current theoretical understanding of creativity in these domains have provided a preliminary model of the creative process of computer game authoring.

We propose that the creative stages of the game design process are exploration, ideas generation, game design, game implementation, game testing and evaluation. The designer can progress through these stages in order, but it is common for designers to return to previous stages as their ideas evolve.

Exploration

The designer discovers and experiments with features of the game design software, to determine its capabilities and how it could be used to express ideas.

Idea Generation

The designer engages in a cycle of generating ideas and evaluating their merit. They will eventually select a scheme of related ideas, which can then be refined into a coherent game design. Novice designers often get started by adapting concepts from their favourite commercial games, and good ideas which do not fit with the emerging theme of the game can be saved for later projects. The designer may have to move back to the exploration phase several times to establish the feasibility of an idea.

Game Design

The designer expands upon the selected ideas to create a full game design – this includes detailing major characters, forms of gameplay, content of game levels, and the progression of the narrative.

Game Implementation

The designer implements their design as a working game, involving a variety of technical and artistic skills depending upon the authoring software. Implementation activities are interleaved with cycles of redesign and testing. Problems or gaps in the game design may become apparent, prompting a revision, while repeatedly adjusting and testing complex game elements may be necessary before they will work correctly.

Game Testing

The designer plays through the game themself, to identify problems with low-level game elements. This allows them to locate and fix bugs and to balance the gameplay.

Evaluation

The designer invites a member of the target audience to play the game. They will observe difficulties which the player encounters, their emotional reactions to characters and narrative, and their general experience with the game. The designer will ask the player for their general opinion, suggestions and criticisms, and may decide to return to earlier phases in the process to alter the game according to this feedback.

EMPIRICAL WORK

In order to investigate how young people's ideas evolve in the context of game design, we have conducted two field

studies in contrasting settings. To understand young people's creativity in a flexible, informal environment, we ran week long Gamemaker workshops as a summer holiday activity supported by the local authority. In this setting, young designers can create games as they wish without the requirement to meet any particular educational objectives. However, as it was also important to explore how a formal classroom setting would impact on children's creative processes, we opted to conduct a realistic classroom study in a typical UK school. In this case, we had to justify how the game making activities mapped to the English language and IT curricula used by the school.

Community Education Field Study

The first field study took place in August 2006 during two week-long summer holiday workshops for teenagers aged between 12 and 16 years old. The first workshop was open to anyone, while the second was advertised as for girls only. Ten boys between the ages of 12 and 15 and nine girls between the ages of 12 and 16 attended. The workshops each lasted for 2 to 3 hours over a period of five days. At the end of every day, copies of the young people's games were saved in order to track their progress, and a short interview reflecting on the day's learning was recorded with each participant as they filled in a design diary. At the end of the workshop, participants each discussed their experiences of the creative process of game design, in a series of semi-structured interviews lasting around 20 minutes each. The interviews were transcribed for later analysis.

Classroom Field Study

The second field study was based in a state funded school over eight sessions between August and November 2006. Thirty Primary 6 pupils (10 year olds) took part with their classroom teacher, a specialist IT teacher and three researchers. Each child had 40 minutes per session to use the software, and participated in 20 minute introductory and plenary class discussions on each occasion. Throughout the project the pupils were asked to write down their game ideas on slips of paper (decorated with pictures of gems) and store them in a small cardboard "treasure chest" which they decorated with coloured pens. At the end of the project they were asked to indicate which of the ideas from the treasure chest they incorporated in their games, and which they discarded. The children's games were saved after every session to provide a record of their progress, and they were asked to complete pre and post study questionnaires about their experiences with games design. In addition, six case study children (three boys and three girls) were selected on the basis of their interest in games during the initial session, their curriculum attainment in English language and advice from the teachers. Two children were selected from each of the low, medium and high ability groups. The case study children took part in a ten minute semi-structured interview about their game ideas at the end of the project. The interviews were transcribed for later analysis.

Qualitative Analysis Findings

This paper will focus on the findings from qualitative analysis of the interviews transcripts with the nineteen community education workshop participants and the six case study children from the primary school study. The purpose of the analysis was to examine the interviewee's perceptions about the sources of their game ideas, and how their ideas evolved during the design process. The analysis was conducted with a thematic analysis method [5] using NVivo 7.0, a qualitative analysis tool.

General Observations

Before examining the young people's thoughts on creativity specifically, it is helpful to briefly summarise the results of the studies in general. Most importantly, the young people and teachers who participated in the project greatly enjoyed the experience and considered it to be worthwhile. The game designers showed great commitment to the project, working and concentrating hard. The games they produced were interesting and considered to be fun by their peers. The participants mastered the complex software quickly, although naturally the primary school children found it more difficult to learn than the teenagers. In contrasting the two settings it became clear that the informal nature of the community education study enabled the participants to spend more time in useful exploratory play. On reflection after four weeks of the school field study, the researchers realised that the children's games were suffering because the designers had not had enough time to simply explore the features of the toolset, and get used to the style of the game. Once this was rectified, the pupils' games became more imaginative and distinctive. This illustrates that it is important that the playful aspect of game design should not get lost under the pressure of meeting classroom educational expectations.

A positive aspect of the classroom situation was the opportunity for sharing discussion about the games in introductory and plenary sessions. We used the introductory time to illustrate how to use the toolset, to demonstrate example games and to showcase good features of the children's games. The plenary time enabled the children to talk about what they had achieved and the difficulties they encountered. The pupils were avid to learn more about the software, particularly those who played games a lot at home. Their questions demonstrated that they could reason about the features which were likely to be available in the toolset, based on their experience of playing games. They had high expectations for their own games because of their prior knowledge as gamers, and they were eager to learn the skills necessary to meet their expectations. The class also hypothesized about the causes of unexpected behaviour within the games they had created, and shared suggestions about how to fix problems.

With respect to the challenges of open ended design tasks, the flexibility of the informal community education setting was helpful. The sessions were loosely structured, giving

the designers freedom to discover which method of working suited them. The adults were in the role of facilitators rather than instructors, and there was a high enough ratio of adults to participants to provide help as it was needed. There was little formal instruction, and interview transcripts reveal a range of strategies for coping with the design task. In contrast, flexibility in the school setting was constrained by timetable, resources, learning objectives and to some extent the existing classroom relationships between pupils and teachers. It can be difficult to promote within teachers and learners the attitude that learners should make creative decisions for themselves without being told the "correct" answer by the teacher. However, the pupils did make some progress in identifying that there were alternative methods of achieving the same outcome within the software. They were pleased to share tips, shortcuts and alternative methods that they discovered. They also realized through peer evaluation sessions that there are many different opinions about what makes a "good" game and that although designers can choose to take advice from others, they can also choose to stand by their creative decisions in the face of criticism. They learned to accept that they would not have time to implement all of their ideas, and that their games might have to remain unfinished.

Sources of Ideas

The young people occasionally found it difficult to explain where they got their ideas from, as is to be expected. It is often hard to identify the source of an idea, especially after a period of time has elapsed. In a small number of cases, the interviewees seemed to be uncomfortable about acknowledging that their ideas had been influenced by outside sources, perhaps in case they were accused of copying. To reduce these problems, we structured the interviews around their design notebooks or treasure chests in order to discuss particular ideas. If a prompt was needed, the interviewer explained that often game designers would get inspiration for their ideas from books, films or other games, and that this was acceptable and useful behaviour.

The sources of ideas fall into three main categories: other creative products, social influences, and exploration of the game toolkit. The young people spoke of getting ideas from existing public creative products over a range of media: books, films, TV, cartoons, paintings and interactions in online communities. Of these, games and films were the most common influences. The young people chose to adopt features of commercial games which they particularly liked, rather than attempting to faithfully copy particular episodes within their favourite games. For example, Calumn (aged 14) explained that "Yeah, my game's based, well a little bit, on World of Warcraft, the part where you can go around and do what you want." One of the main themes he investigated while creating the game was the extent to which his player could freely explore his game world without being required to experience events in a particular order. Another feature from commercial games which is popular is a sidekick or helper character, and this was adopted by several children. For example, Ben (aged 9) said "I like the game Sonic Heroes, because like the fights are easy and it's easy to move about when you're working in a team of three. So that's why I had the idea to make them [his game characters] follow you."

Current book-film cross-overs were popular, such as "Lord of the Rings", "Narnia" and "Eragon". Interestingly, the young people were also inspired by their own creative work, or that of their friends. Andrew (aged 12) mentioned that "I'm writing a story at home, and that gave me an idea for the Little Buddy character." He went on to explain how he had adapted ideas from his story to suit the game medium, and candidly offered the following advice to other game designers: "If you are reading any books then just steal ideas from them". Alice (aged 13) described how she was inspired by a story a friend had written: "My friend is interested in writing, and she was telling me about this book that she's trying to get published, and …it was a circus tent full of mirrors, and I decided to put that in my game."

The game designers also mentioned social influences, including asking advice from friends or family, playing games made by other participants, and making characters or situations based on real life. The girls tended to mention these influences more often, particularly giving more thought to how the player would experience the game, e.g. "[I chose] mainly just what other people would enjoy." Another girl explained that she didn't play games very often so the group discussions were an important source of advice for her: "Just listen to what other people in the group are talking about, and change them to suit your own game and your own interest" The younger children seemed more influenced by playing their peers' games than the teenagers, mentioning features of the games which they had adopted such as "I found out that, when I played my friend's game she had something like a pit in it, and I put a pit in mine".

Another influence on ideas came from using the toolset. Ideas emerged from the possibilities inherent in the software, and sometimes from the limitations of the software: "It's just… what I come across when I'm putting things in [within the toolset]. Like the dragons: I didn't really plan to put them in, but then I found out that they were good … and they helped you get rid of the monsters, so I made that into part of the game... then I made up my own story depending on what I can do, or can't be done [within the toolset]." An example of exploiting serendipity comes from Marcus (aged 15) whose game ended up as a comedy incorporating various well known characters: "Originally I just had the army and just a normal human commander. But then I thought "oh, it'd be funny…" Like, I had a dwarf in the army, and as he's small… I changed the colour of his skin [to green], 'cos I hadn't realized that

you could change the colour of skin… And I thought; why not make Yoda?"

Lastly, an important point to note is that participants often recognised that new ideas can come from the juxtaposition of other ideas from various sources, as illustrated by this comment by Sam (aged 14): "I could get a lot of my ideas from other games and sort of mix them up a bit". This demonstrates a relatively mature understanding of creativity, rather than the misconception that ideas arrive wholly formed in the minds of gifted individuals.

Evolution of Ideas

The evolution of the children's games ideas was very much influenced by their interactions with the toolset in both negative and positive ways. The toolset often acted as a constraint on putting their ideas into practice either because an idea was simply not possible within the toolset (e.g. "Some of [the ideas] might have been really hard to do anyway, like, cos you can't ride dragons in Neverwinter Night"), or because it was perceived as too difficult (e.g. "So for a quest to finally open up and stuff there's a lot of script and stuff, so I changed my ideas a bit to try and make it easier for… me to do". The toolset also acted as a stimulus for ideas, or as a method for exploring possibilities for authors who preferred not to plan too much in advance. Sam commented: "Yeah, like, originally I was going to make it that you were in a forest, and, like, you went through all these levels and had a big showdown in the castle. But I, like, sort of changed my mind, and just… made it up as I went along, really. Just, like, put levels in that I thought suited it, not that I thought had to be there." Discovering emergent features of the game while playing it also acted as a catalyst for some designers, including Stella (aged 13) who described how she decided to hide a gemstone in an arena because she had noticed how the unexpected behaviour of the dragons she had placed there would make it tricky for the player to find.

Game designers would discard ideas if they got too complicated: "I just thought it would be better if you didn't really need it, because it just makes it more complex". A designer who attempted an ambitious design which had to be scaled back offered the following advice for other designers: "Just try not to be too complicated with your ideas. Then, if you want, when you've finished it you can try and put some more complicated bits in". In contrast, another designer explained that her ideas got more complex as her skill grew: "[The ideas] changed quite a lot. I think it was partly cos, like, I was getting more experienced". In general, the girls in the community education workshop were less ambitious with their initial plans than their male counterparts and tended to grow their games based on early successes. As a result, they were more likely to complete their games within the week.

Another reason given for an evolution in ideas was related to the internal consistency of the game. The designer would realise that the original disparate ideas needed a connecting theme, or that the game structure might not make sense to the player. Indeed, some children noted that they changed their ideas after observing a peer play their game and finding it too difficult, thus demonstrating that they were successfully adapting to their audience.

A very common reason for discarding game ideas was that the designer was facing time constraints and had to prioritise. They may have liked to include an idea, but simply did not have time to implement it. Some of the young people explicitly mentioned a strategy for spending time effectively: "I wanted to make the levels that I had really good". Calum (aged 13) slightly regretted spending too much time on a single level: "I just wish I'd got a little bit further. I think I spent a bit too much detail on the elf camp, cos it's really… everything is in the right place. I think I spent a bit too much time on that, and went over … so I think I spent a bit too much time making it good." However, he was pleased that the time he invested made his game different to the other participants' games; the uniqueness of his game was important to him.

From the perspective of supporting children during the creative process, two particular points emerge. Firstly, initial ideas which the designer liked were not incorporated in the game simply because he or she forgot about them and did not refer back to the designer notebook or treasure box to rediscover them. Secondly, the designers were often reluctant to discard work they had done in the toolset, even if the final product would be better and more coherent without it. However, some designers were able to reject ideas at a planning stage if they realised they would not fit in with the other selected ideas or game theme. This suggests that the tool should support designers in storing ideas and prototype implementations for future reference, even if they do not make it into the final game.

SUPPORTING CREATIVITY IN ADVENTURE AUTHOR

To aid novice designers, we aim to explicitly support each stage of the creative process through software. Much of this scaffolding will be embodied in the "Designer's Notebook", an evolution of a paper-based system used at workshops to allow users to keep track of their ideas, designs and progress.

Exploration

In our classroom sessions, it was thought that the children were not given enough time to simply explore the toolset, and as a result would continue to do so throughout design and implementation. They were also reluctant to get rid of work once they had created it, and the combination of these factors could lead to a lack of focus in the finished product.

Following on from this, the initial exploration phase will be supported by providing a 'scrap area' for the free exploration of toolset features and game content. As they can play around with this area throughout development, they can feel free to try things out as they go, exploring the limits of what they can achieve without feeling bound to the results. If designers are particularly pleased with

something they have developed here, they can export it to their actual game.

To encourage adventurous exploration, the software will monitor and react to each designer's use of the toolset. For example, it will suggest features that they haven't tried yet, and if required provide help on how to use them.

Ideas Generation

The software will allow users to record ideas using a simple visual metaphor: ideas as balloons. A visual interface such as this can make the abstract process of idea generation more engaging. It can encourage designers to partake in dry but worthwhile activities by providing 'visual rewards': for example, categorising your ideas will result in a more colourful collection of balloons.

The metaphor can be easily extended: if you decide you don't like an idea, pop it with a pin. If you're stuck for an idea, the balloon seller can offer one donated by another child, or generated by the software. Generated ideas can guide users towards what is achievable in the toolset – for instance, expansions of game design or narrative which are well-supported by the art resources available. It can also suggest the use of plot or character archetypes through their presence in popular children's entertainment. For example: "In Star Wars: Revenge of the Sith, flawed hero Anakin undergoes a 'character arc' that turns him into a villain. How could you use this idea in your own game?" In general, this aims to give designers an initial impetus for creative thought, rather than providing them with ideas they will necessarily use.

Design

Children tend towards ambitious designs which are not always easily achievable, as they not only require complex scripting and programming work beyond their abilities[6], but also the intellectual discipline to think through every aspect of the design. By providing wizards that directly scaffold specific designs tasks, we can help the user to clarify their designs until they are in a workable state. Supported tasks will be chosen based on requests from children, and will also focus on areas that teachers indicate an interest in, such as writing interactive dialogue.

Implementation

As with the design phase, the software will provide implementation wizards to support many of the most requested implementation tasks – for example, the ability to create a 'sidekick' character. These aim to reduce the extent to which users have to scale back their design ambitions. Most powerfully, the software will scaffold scripting, simple programming and the use of branching plotlines in a way that is easy for young users to work with (for an early prototype, see [13]). This will enable them to create a rich game world that responds to player choices.

Testing

The software will populate a simple 'to do list' of tasks and bug-fixes based on the user's feedback about their design plans. This information will be integrated with the toolset Save system, so that progress can be tracked from session to session, and represented visually for users and teachers.

Evaluation

The evaluation screen will record constructive criticism from teachers and play-testers. The software will generate its own recommendations based upon automated analysis of game content - for example, "Your starting area is quite small, but has many hostile characters – combat could be very difficult for most players."

Designers will be supported to 'Accept' or 'Reject' feedback, as long as they give a reason. Cropley has argued that the ability to think independently is key to creativity [2], but this is difficult with young children who are used to being told the 'right answer'. Here they will be able to learn from constructive criticism, while also asserting their creative independence by justifiably rejecting it.

The software will support one of the key aspects of creativity in game design by aiding players to move freely between the creative stages. The support tools will be available throughout development, and users will be encouraged to return to them: for example, recording an idea in the "Designer's Notebook", then testing it out in the scrap area. However, as some users may prefer to let a game design evolve naturally through exploration, the software will not force them to do extensive planning.

FUTURE DIRECTIONS AND IMPLICATIONS

The initial version of the "Designer's Notebook" is under development. This will be used as a starting point for a six month learner-centred design process with a team of six 11 year old designers at a local primary school. On previous projects about authoring tools, we have noticed that children find it difficult to grasp that they are being asked to design a tool which helps other people to design an artifact. They often interpret the task as simply to design an artifact. It is therefore necessary to give the young members of the design team plenty of time to play with the current version of the software and encounter some of the difficulties with it in the present form before moving on to design activities. In addition, analysis of the domain and meta-cognitive skills demonstrated by participants in the school field study is ongoing.

The software scaffolding to support the creative process as described above naturally has aspects which are specific to game design. However, as we believe that there is much in common between computer game authoring and other design tasks, the software has applications elsewhere. For example, the features to support ideas generation and evaluation could easily be adapted to support creative writing. An interactive learning environment of this sort can be used not only to support learners, but as a research tool to gather data with the aim of refining theories of creativity. By logging learners' interactions with features in the "Designer's Notebook", and associating these with independent ratings of the creative output, it may be

possible to identify successful patterns of activity throughout the creative stages and discover which teaching interventions are most helpful to different learners.

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