Fostering engaged and directed learning by activity foregrounding and backgrounding

Katy HOWLAND[1], Benedict DU BOULAY and Judith GOOD
IDEAs Lab, Department of Informatics,
University of Sussex, UK

Abstract. We propose a design model for guiding learning in exploratory environments through representational choices. Selecting the appropriate representations at the correct granularity can foreground the salient activities and background the irrelevant.. We demonstrate how this model can be applied via learner-centred design to ensure that the engaging factors of an environment are preserved whilst the learner is guided towards the development of specific skills.

Keywords. Learner engagement, external representations, writing skills development, learner centred design.

Introduction

A long standing question, with which all designers of intelligent tutoring systems and interactive learning environments must engage, is how to ensure that the tasks and activities undertaken will help learners develop the desired skills. Setting learners tasks based around the target domain does not automatically guarantee that they will develop skills in that domain, no matter how advanced the cognitive and emotional modelling. For example, when using Logo, a groundbreaking programming microworld which aimed to teach mathematical and computer science concepts and skills, learners often failed to develop the higher-level conceptual skills which the designers hoped could be fostered [1]. With the increasing interest in learning environments based around games and simulations this issue has become even more pertinent. Games and other exploratory environments can be highly motivating and engaging, but are users learning what designers hope they will learn?

The highly challenging task which designers face is encouraging learners to do the cognitive work necessary to learn the hoped-for skills. This means gaining attention, focus and engagement from the learners in undertaking tasks which involve working at the right conceptual level. Failure to achieve this can leave the learner engaging with material at too superficial a level, engaging with material in the wrong context, or not being able to see the wider relevance of what they have learnt.

The interface is crucial in any educational system. It is the main point of communication and interaction with the learner and defines how the domain is represented to them. The mode of representation is particularly important in exploratory environments where the system does not control or closely direct the

[1] Corresponding Author: IDEAs Lab, Department of Informatics, University of Sussex, Falmer, Brighton, BN1 9QJ, UK; Email: K.L.Howland@sussex.ac.uk.

learner by setting tasks. Representational support can focus the learner's attention and cognitive effort more subtly so that they tackle the activities thus made more salient and engage with concepts at the desired level. Representations and tools can allow users to move beyond their individual cognitive limits. This can be very important when the skills a system aims to develop are more complex than the individual could work at alone. For example, a calculator can enable novice mathematicians to work with large numbers beyond their arithmetic capabilities, allowing them to tackle more realistic problems or more advanced mathematical concepts than they otherwise could. Equally however, the desired skills could be lower level. If a system aimed to teach basic arithmetic skills it would not be beneficial to provide a calculator as learners would need to carry out calculations themselves in order to learn the skills in question. In this way we can see that choices about representations and tools provided in an interface can *foreground* elements which are to be learnt and *background* those that are less important depending on the educational aims of the system designer.

However, altering the structure of tasks in this way, and possibly removing assistive support, runs the risk of the user losing motivation if the foregrounded tasks are too laborious or uninteresting to the user. This is particularly true if it is clear to learners that there is an easier way of completing the task and achieving an overall goal. This is problematic, because it is not enough to simply get a learner to carry out a task; they need to fully engage with it to achieve the best learning.

This paper presents a model which highlights key issues to consider when designing for guided and engaged learning in exploratory environments, and provides a case study to show how these factors can be applied in practice. The next section outlines the technique of foregrounding and backgrounding in the context of key theories and existing work on interface design principles for educational software. The following section explains potential motivational problems when adopting these techniques. This is followed by a case study which shows how learner-centred design can help avoid these problems. Finally, conclusions are made and we outline the further work planned in this area.

1. Foregrounding and backgrounding activities to support skills development

Educational software interfaces have to support learning as well as ensuring that interaction is straightforward and intuitive. The choice of representations is particularly important as it defines the tasks and concepts which are brought to the foreground and those which are left in the background. It is generally accepted that a single representation is not sufficient to represent all aspects of any complex entity. The match-mismatch hypothesis [2] states that where a representation highlights a certain type of information, tasks using that type of information will be easier to perform than those requiring other types of information. Where required information is implicit in a representation and needs to be inferred, the task will be harder than if the information were presented implicitly. If working at the desired level of activity involves the need to hold complex mental representations in working memory, this can be problematic [3]. It can place a large cognitive load on the user and may understandably lead them to focus on other aspects of an environment which are better supported.

Making a task achievable by providing explicit representation of the required information is beneficial. However, making a task as easy as possible should not be the aim; easier is not always better when it comes to educational tools [4]. Norman

distinguishes between experiential and reflective cognition [5], and expresses concern that using multimedia learning environments can encourage experiencing when one should be reflecting. Experiential or 'reactive' cognition does not require deep thought and is event driven with automatic reactions following from input. Reflective cognition requires much deeper thought and tends to be slower and more laborious. It also requires the ability to store temporary results and use those results in further thought processes. For this reason external representations can facilitate reflective cognition by assisting more complex chains of reasoning to be built up, providing further evidence that representational support should be given provided for complex composition tasks such as structuring a narrative.

Choice of representation and means of interaction can completely alter the mode of cognition used in a task. Most work in this area has focussed on *direct manipulation* and its use in problem solving tools and tutoring systems. Svendsen [6] concluded that whilst direct manipulation interfaces can be very user-friendly they can hinder problem solving if they are supportive of thoughtless action. A number of other studies have also indicated that direct manipulation interfaces are not always desirable in educational applications [7-10]. This effect has been explored in relation to assistive interfaces which externalise task relevant information in an attempt to improve usability (e.g. greying out inappropriate menu options) [11]. This research indicated that such representational assistance can be counterproductive where the goal is learning, and led the authors to suggest that designers of educational systems consider intentionally making interactions 'more difficult' or 'less assisted'. So, whilst it is important to represent the relevant information over the irrelevant, it is also crucial that tasks are not made too easy through representational support; the learner needs to engage in considerable reflective cognition in order to develop the desired skills.

Although most work in this area has focussed on direct manipulation, it is really only a specific case in a more general model of how interfaces can guide learning. In each of these studies it is not direct manipulation itself which is the problem, but the tendency for direct manipulation interfaces to encourage unreflective approaches to problem solving, such as trial and error. In each example the direct manipulation elements of the interfaces allow users to rely on interface feedback to achieve tasks, placing them in a reactive mode indicative of experiential cognition rather than the deep thought mode required for reflective cognition. However, this is not a necessary characteristic of direct manipulation. In fact, it is the *level of granularity* at which the direct manipulation takes place which is key. Svendsen's study uses a command line tool as the non-direct manipulation condition, but an onscreen keyboard tool which allows characters to be dragged in one-by-one could allow typing in a command line through direct manipulation. However, because the level of granularity would be so low, the user would be unlikely to adopt the unreflective trial and error approach which hindered the problem solving (although the interface would clearly be problematic in a number of other ways). So, it is not direct manipulation itself which encourages an unreflective approach, only direct manipulation at certain levels of granularity.

Sedig et. al. [12, 13] challenged the sweeping view of direct manipulation by making a distinction between direct *concept* manipulation and direct *object* manipulation and reported that educational interfaces which support direct manipulation of concepts encouraged deeper reflection and better learning.

Our 'foregrounding and backgrounding' model of the influence of representation in learning tools centres on the idea that when designing a tool to teach a given set of skills, it is important to ensure that reflective thought is directed at the activities which

will help learners to develop the desired skills. Representations should show information most relevant to the intended skills development, with other types of information placed in the background. The level of granularity of the interface and the skills to be developed are important. The interface should not hide the complexity involved in an activity where the learner needs to understand complexity at that level. However, where the targeted skills are at a higher level, additional representational assistance can help foreground these skills. The lower level skills can be backgrounded and attention focussed on reflective engagement with the higher level skills.

2. Motivational factors in designing for exploratory learning environments

In the previous section we outlined a model for guiding learning by using representational choices to foreground the skills to be developed. A key aspect of this approach involves recognising that learning requires extensive cognitive effort, and as a result making interface design choices which effectively make some tasks harder in order to encourage reflective cognition. This goes against established wisdom in designing interfaces to some extent, as it runs the risk of making the system more difficult and less pleasurable to use. When applying these techniques to exploratory environments, such as game based environments, this is of particular concern because one of the key reasons people use environments such as these is the power they have to motivate and engage users. The benefits of these environments are lost if in the course of trying to guide learning we lose the engaging elements.

However, making tasks harder does not necessarily make them less motivating. Popular games are invariably challenging and games which are too easy are certainly not motivating for long. It seems clear then that designing an environment in which users have to work hard at pertinent points should not be incompatible with designing a motivating and engaging experience. The crucial issue is being aware of what the motivating factors actually are in practice and aligning these with the desired learning activities so the two aspects are integrated rather than competing.

The following section describes a design activity which forms part of an overall redesign of a game authoring tool to support the development of multi-modal writing skills. Computer game creation has good potential as an activity for improving writing skills. Creating a successful game involves creating realistic characters, developing interesting plotlines and writing compelling dialogues, as evidenced in game design handbooks [14-16]. Existing game creation tools, such as the Neverwinter Nights 2 toolset described below, make the activity possible for children without technical skills, but fall short of supporting writing skills development because the interfaces focus attention on non-literary aspects of game creation. According to the model presented above, there are a number of ways in which the interface fails to support skills development. For example, when trying to write an interactive story users of the toolset have to keep an internal representation of the (often very complex) branching plot in their minds. This can place a huge load on the user and may understandably lead them to focus on other aspects of game creation which are better supported.

Consultations with domain experts revealed the potential for a wide range of skills to be developed through the activity (for a more detailed account see [17]). Of particular note was the consensus that the activity had good potential for teaching composition skills (such as narrative structuring, language variation, using imaginative vocabulary, audience awareness and considering what the reader (player) needs to

know), planning, drafting and reflection and understanding how meanings are changed when texts are adapted to different media. It was noted that these aspects would need to be brought to the forefront of the game creation activity as the existing interface did not highlight the importance of these skills to the process. We were advised that existing writing elements such as dialogue composition should be emphasised and opportunities for writing extended so that learners move from a stilted form of writing to using it in a wider variety of contexts. Suggestions included written introductory flash screens, and giving users the opportunity to write descriptive text to appear on the game packaging.

The case study below describes the re-design of the character creation tool in the toolset with reference to the model outlined above and input from domain experts. It illustrates how foregrounding and backgrounding can be applied whilst maintaining motivational factors. A learner-centred design process with target users was adopted to ensure that the finished tool would be useable, and motivating and engaging to use.

3. Case Study

A number of aspects of the interface will be redesigned based on domain expert input:

- New representation of overall branching plot structure
- Character creation tool
- Augmented map view showing key story points
- Game box and manual creation studio

This case study focuses on the *character creation tool* and shows how the model of foregrounding and backgrounding can be applied to the re-design of this element of the tool interface to help bring about the required skills development by including activities recommended by domain experts.

Analysis of current interface provision: The commercially available toolset contains a number of 'blueprints' or generic versions of characters, objects and scenery items. To create a character currently the user selects a blueprint name from a list and moves the mouse into the 3D map view to see a 3D view of their chosen character. They can then choose either to place that character in the world or to cancel the operation and choose another blueprint. After the user creates a character they can, if they wish, open a properties window with over a hundred editable fields and customise the character. However, salient fields like those which define traits, skills and the character's disposition towards the player fade into the background alongside a variety of obscure fields which users are unlikely to understand or want to change. Creating a character is an important skill in narrative creation, but the toolset currently makes this seem an insignificant process. It is very easy to create ('drag in') a generic character, but this is only 'made easy' by hiding the complexity needed to develop skills in creating specific characters. The user has no opportunity to practice developing a well-rounded character, or to reflect on the character's motivations or back story.

Learner-centred design sessions: Two girls and two boys aged 11-12 were asked to help design a new character creation tool. They had used the existing game creation tool as part of a creative writing exercise in class for approximately *6-7* hours over a four week period. They were asked to build a paper prototype of a new tool which would help them to create more interesting characters for their stories. The prototypes created by the participants, along with transcripts of the activities and additional

interviews with the children were analysed. A number of key themes which gave suggestions for important design characteristics were prevalent:

- Participants liked customizing characters in some detail, including appearance and information about the characters skills and strengths and weaknesses, and were very keen that once created, characters should persist and be reusable. Personality and back story of characters were seen as important, but these must have a noticeable impact in the game such as affecting how other characters react to them.
- When it is not clear how an element will make a difference in the game participants reported that they skip straight past it.
- Prompts can be useful when creating a character. The existing random name generator is cited as a good starting point which can help fire up their imagination.
- Participants liked the idea of having the whole tool on a single view, reporting that it was hard to remember where options were if they had to switch between screens.

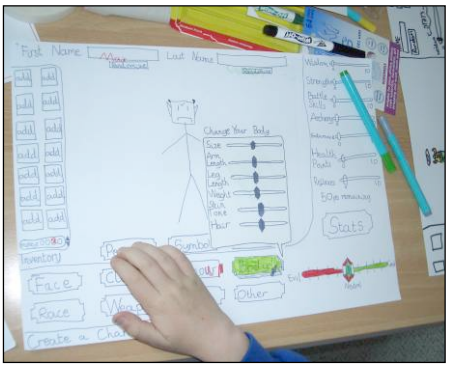

Figure 1. Paper prototyping session

Re-designed interface: The character creation interface was redesigned according to the principles of foregrounding and backgrounding highlighted in Section 1. Input from domain experts informed the target skills and some suggested activities, and input from target users informed usability and motivational considerations. The process for creating a main character now takes place using a wizard (less important characters, or 'extras' can still be added in the old way). The wizard is navigated through labeled buttons rather than 'next' and 'back' buttons to make it easier for users to find the option they want to change. The process has been transformed from one which can be done thoughtlessly to one which requires reflection. Crucially the users are not asked to carry out activities which have no noticeable effect on the finished game. The strengths and weaknesses screen allows the user to pick from a variety of descriptive phrases which define details about the character's personality, characteristics, physical appearance, strength and skills, as well as special feats they can perform. These are all linked to back-end character properties. The user can expand these description cards to see how a given description will affect the character's experiences and behaviours in game. Users can also define new descriptive phrases and define the back-end meaning for them. The descriptions screen allows the user to enter

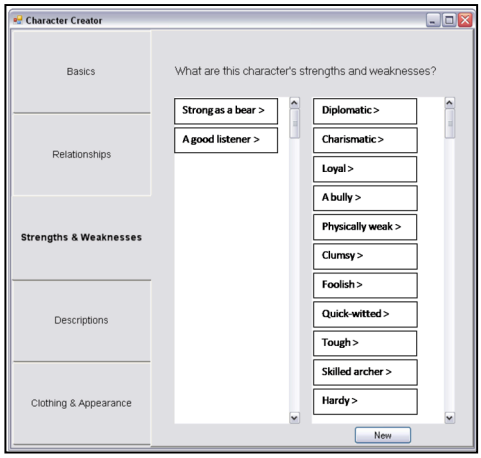

Figure 2. Strengths & Weaknesses screen

two important pieces of text about the character. The first is the description that the player will see in-game (unless the character under creation is the player character) which can provide extra hints or information, or simply mirror what may be deduced from the character's physical appearance and dialogue. The second description is for use in the add-on which allows users to design the box and manual for their game.

The redesigned interface brings to the foreground the elements of character creation which are important for developing multi-modal writing skills and removes the multiple unrelated elements which the user previously had to wade through to customise a character. The writing and description selection elements were included based on the input from domain experts who reported that as well as developing vocabulary and composition skills writing helped to ensure that learners reflect on the process of character creation rather than making arbitrary choices. Learner centred design sessions indicated that users were likely to skip over elements which would have no effect in their game world. Therefore, all activities were designed so that they had a clear relevance to the game. In this way the learning activities were aligned with the motivating factor for the users: the quality of their finished game.

4. Conclusions and future work

Games, simulations and other exploratory environments can be very motivating to users and can encourage them to put in considerable effort. Harnessing these features for learning systems has long been of interest to educators. There is much learning going on in all good games, as argued by Gee [18], but many educators would like to guide learning in these environments towards specific skill sets. It is possible to guide and direct learning in exploratory environments by foregrounding salient activities through representational choices. We have presented a model which describes how representations chosen and the level of granularity at which tasks are carried out can influence the level at which a learners attention is focussed. However, there is a risk that altering activities in this way could detract from engagement. By involving target users in a learner-centred design process it is possible to reduce this risk. In the case study presented, input just from domain experts could have led to the implementation of a descriptive writing activity which had no relevance to game. By working with users it became clear that such an activity would be completed in a cursory and unengaged manner as it would have no relevance to their own personal goals.

Any environment which motivates children to put in extensive effort has won their 'buy in' in some way. They have goals which they want to achieve and they are willing to work hard and complete laborious tasks to reach those goals. In a game the fantasy element often brings the buy in. Users are role-playing as a character and want to gain achievements and rewards as that character. With game creation the buy in comes from learners creating a game which they feel ownership over and which they are proud to share with their peers. Any additional guidance added through representational choices or other means must be aligned with the motivating factor rather than competing with it. In each situation the learner's goals must be investigated to avoid losing the incredible intrinsic motivation which these environments can offer. Learner centred design activities offer a powerful way of exploring these goals with the target users.

The next stage will be testing the effects of the redesigned interface on learning and engagement in a comparative study. In the longer term, the wider applicability of

this model will be investigated by applying it to other learning situations where the technique of foregrounding and backgrounding is likely to be of benefit

References

[1] Pea, R., E. Soloway, and J. Spohrer, The buggy path to the development of programming expertise. *Focus on Learning Problems in Mathematics*, 1987. **9**(1): p. 5-30.

[2] Gilmore, D.J. and T.R.G. Green, Comprehension and recall of miniature programs. *International Journal of Man-Machine Studies*, 1984. **21**(1): p. 31-48.

[3] Mayer, R.E. and R. Moreno, Nine Ways to Reduce Cognitive Load In Multimedia Learning. *Educational Psychologist*, 2003. **38**: p. 43-52.

[4] Brna, P., R. Cox, and J. Good, Learning to Think and Communicate with Diagrams: 14 Questions to Consider. *Thinking with Diagrams*, 2001.

[5] Norman, D.A., *Things that make us smart*. 1993: Addison-Wesley Pub. Co Reading, Mass.

[6] Svendsen, G.B., The influence of interface style on problem solving. *International Journal of Man-Machine Studies*, 1991. **35**(3): p. 379-397.

[7] Golightly, D. Harnessing the interface for domain learning. In *Proceedings of CHI '96: Conference Companion*. 1996: ACM New York, NY, USA: p. 37-38

[8] Holst, S. Directing learner attention with manipulation styles. In *Proceedings of CHI '96: Conference Companion*. 1996: ACM New York, NY, USA: p. 43-44

[9] Rappin, N., et al. Balancing usability and learning in an interface. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 1997: ACM New York, NY, USA: p. 479-486

[10] Trudel, C. and S. Payne, Reflection and goal management in exploratory learning. *International Journal of Human-Computer Studies*, 1995. **42**(3): p. 307-339.

[11] van Nimwegen, C., et al. The paradox of the assisted user: guidance can be counterproductive. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*. 2006: ACM New York, NY, USA: p. 917-926

[12] Sedig, K., M. Klawe, and M. Westrom, Role of interface manipulation style and scaffolding on cognition and concept learning in learnware. *ACM Transactions on Computer-Human Interaction (TOCHI)*, 2001. **8**(1): p. 34-59.

[13] Sedighian, K. and M. Westrom, Direct Object Manipulation vs Direct Concept Manipulation: Effect of Interface Style on Reflection and Domain Learning. *People and Computers*, 1997: p. 337-358.

[14] Bateman, C., *Game Writing: Narrative Skills for Videogames*. 2007, Boston: Charles River Media.

[15] Handler Miller, C., *Digital Storytelling. A Creator's Guide to Interactive Entertainment*. 2004, Burlington: Focal Press.

[16] Ince, S., *Writing for Video Games: A Scriptwriter's Guide to Interactive Media*. 2007: A&C Black.

[17] Howland, K., *A Game Creation Tool which Supports the Development of Writing Skills: Interface Design Considerations.* , in *Narrative Interactive Learning Environments (NILE)*. 2008: Edinburgh, UK. p. 23-29.

[18] Gee, J.P., *What Video Games Have To Teach Us About Learning and Literacy*. 2003, New York: Palgrave Macmillan.