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Authoring and Delivering Personalised Simulations – an Innovative Approach to Adaptive eLearning for Soft Skills

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Abstract: This paper examines the personalization of online training simulations which are a key modern approach in computer aided education. More specifically it focuses on the difficulties involved in authoring personalized training simulations. The composition of such systems is very difficult which has hampered their wide spread adoption [Joolingen, 03]. Presently adaptive training simulations can only be authored by programmers working closely with subject matter experts. One of the key ways for adaptive simulations to increase their popularity in online eLearning [Wade, 09] is to reduce the effort and technical skills required by authors in their development. We argue that personalized online simulations need to be composed by subject matter experts, inexpensively and quickly. This paper details the twin challenges in composing content for both educational simulations and personalization. It also describes ACTSim, a new and unique composition tool that supports the rapid development of personalized training simulations. In particular ACTSim focuses on situational simulations for inter personal dialogue, so called soft skills. This paper concludes with a series of evaluations of the composition tool and of courses developed using the composition tool.

Keywords: simulation, soft skills, authoring, adaptive
Categories: I.6.8, J.7, L.2, L.3.0, L.5.0

1 Introduction

Personalization is the one of the major innovations taking place on the internet at the moment [MacComascaigh, 09]. It has been particularly successful in the area of online education where it has improved the effectiveness of online eLearning [Brusilovsky, 96; De Bra, 00]. However, a key area of learning where personalization has not been widely adopted is simulations. Educational simulations tend not to be adaptive and usually incorporate a *"one-size-fits-all"* approach to teaching [Brusilovsky, 00]. Simulations do not incorporate personalization due to the challenges involved in their development [Grigoriadou, 06]. Educational simulations are extremely difficult to compose even without the consideration of personalization. They are complex and time consuming to author [Brigas, 03] as they must adhere to

pedagogical principals as well as incorporate a genuine interpretation of the real world. Situational simulations are particularly difficult to compose as the author must capture human behaviour and interaction in logical sequential models.

The process of authoring educational simulations is complicated further with the introduction of personalization which brings with it its own set of difficulties in composition [Brusilovsky, 98]. Typically adaptive courses are composed using tools that are only accessible by those with a technical background [Dagger, 05]. The few tools that have been designed for non-technical experts to author adaptive courses are not commercial but are prototypes which have only been used within third level or formal learning.

In order for simulations to become widely adopted within the eLearning community they must incorporate personalization. Development of adaptive simulations must be supported with tools and techniques which reduce the complexities involved in composition [Cristea, 05]. Composition tools should allow authors to develop the models upon which the simulations operate, apply pedagogical principals and assign areas where personalization should be applied. This will allow authors to compose training simulations that are realistic, educationally sound and which adapt to each individual learner.

This paper builds on the previous publications by the authors and provides a much more comprehensive review of several different aspects of research. It includes a more detailed state of the art survey with an examination of adaptive courseware authoring tools. The paper also presents a more refined authoring process than described in previous publications. A more detailed description of the design of ACTSim and its evaluation is also included this paper.

Section two of this paper begins with a detailed description of soft skill simulations including an examination of their advantages and key impediments. Section three then describes a state of the art survey which includes an outline of the key requirements which needed to be addressed in development. Section three describes the action based research approach employed in the development of the ACTSim composition tool and a comprehensive overview of its design is detailed. Section four describes the numerous evaluations that were completed at different stages of ACTSims development. The ACTSim authoring tool was evaluated with non-technical users that did not have any prior experience with personalization. The users were domain experts and developed several courses related to soft skills. Section five of this paper describes the conclusions of the research.

2 Soft Skill Simulations

There are four categories of educational simulations; *physical*; *iterative*; *procedural*; and *situational* [Alessi, 01]. The first two categories of simulations, *physical* and *iterative*, are *"teaching about something"* simulations. The focus of these simulations are the objects with which the learner interacts. The second two categories of simulations, *procedural* and *situational*, are *"teaching how to do something"* simulations. The focus of these categories is the *way* in which the learner interacts with the simulated objects.

This research focuses on educational simulations which are part of the *situational* category. Situational simulations, or soft skill simulations as they are more commonly

known within industry, are used to teach skills based on interpersonal relationships. They are set in a social situation where the learner takes on a particular role and is taught through interaction with a simulated person or people. These situational simulations are the most complex type of simulation to develop as they teach and model human to human interaction. They are typically used to teach communication skills such as leadership, marketing and sales. The focus is on *how to* communicate with others so the dialogue within a simulation becomes particularly important. Soft skill simulations are typically delivered online and tend to use a combination of media with high end simulations employing short video clips which can be interacted with using multiple choice options.

The main advantage with soft skill simulations is that they are educationally very effective [Adams, 08]. The learner is an active participant and is *"taught-by-doing"*. Simulations offer the learner an opportunity to repeatedly practice the skills they are being taught. They are free to make mistakes without suffering from any of the negative real world consequences. The use of video and audio in soft skill simulations ensures that the simulations maintain a high standard of fidelity which is crucial for them to be effective [Mayer, 05]. Another key benefit of using online simulations is that they can be very successfully incorporated into a blended learning solution. A learner can quickly and easily develop their interactive dialogue techniques with online simulations.

While soft skill simulations are educationally effective and an economical choice compared to real world alternatives, they are very expensive to develop relative to other eLearning solutions. Educational simulations often need to be developed by large teams of personnel which also increases the time and cost of authoring. Development teams may include computer programmers, educational strategists and subject matter experts.

Educational simulations, particularly those used to teach soft skills, also tend to be non-adaptive. Educational simulations have been slow to incorporate adaptivity due to the complexities involved in authoring adaptive systems which must be added to the existing difficulties of composing simulations. Some authoring tools have been developed that allow non-technical subject matter experts to compose adaptive courses but they are very limited and have not been widely used [Cristea, 03; Dagger, 04; De Bra, 10].

The main benefit of personalized simulations is the improvement in educational effectiveness. Personalized simulations gain in relevancy, contextualization and lower cognitive barriers for the learner. Furthermore, personalization also reduces the burden of composition by decreasing the number of similar simulations that need to be authored. This is accomplished by allowing the author to compose a single simulation model and applying adaptivity across it to produce several titles.

3 State of the Art Survey

After an extensive search to identify a representative sample of authoring tools for adaptive soft skill simulation was conducted, the authors concluded that no such tools currently exist. Therefore the authors divided the state of the art review into two sections. The first section is a review of a representative sample of soft skill authoring

tools and the second a review of a representative sample of *"traditional"* personalisation course authoring tools.

3.1 Survey of Soft Skill Simulation Authoring Tools

3.1.1 SimWriter

NexLearns SimWriter [NexLearn] authoring tool is a commercial application used to develop soft skill simulations. SimWriter allows non-technical authors to develop situational simulations without needing to write code or create complex rules. It employs a graph representation of the simulation models and incorporates a rigid authoring process.

SimWriters strongest feature is its representation of the dialogue that occurs within the simulation. The dialogue models that are created by the author show decision points within the simulation. These models are used to execute the simulation and are represented in the *'map'* display of SimWriter with the use of nodes and edges which form a graph (branching visualization). SimWriter also incorporates a clear and concise authoring process which employs a very useful pedagogical framework (steps that allow the author to describe how the simulation will be educational). The authoring process is divided into three phases; mapping the dialogue model; writing the content; and designing the front end of the simulation.

SimWriter does however suffer from a number of frailties as an authoring tool. The most notable of these is that while the concept of employing a graph in the *'map'* view is intuitive, it is poorly designed and executed. The display is restrictive and limits how the simulation model can be structured. The *'map'* view also employs several different element types in order to model the dialogue. While this is suitable for short simple simulations it is not practical for larger and more complex models which would be more typical of a real world dialogue. The authoring process also has its weaknesses. It is, for example, rather slow and does not allow rapid development to occur.

3.1.2 Experience Builder

The Experience Builder [ExperienceBuilder] composition tool is another commercial application. It is a web based tool and is used to compose soft skill simulations which can be authored by non-technical personnel. Experience Builders most compelling characteristic is its authoring process. This process is central to the composition tool and focuses on modelling the dialogue that occurs in the simulation. The development of these models is the most important aspect of soft skill simulation development as they capture the logic behind the educational experience.

Model development is supported in the authoring process with a pedagogic framework. This is a framework which supports the author in creating an educationally affective simulation. This is accomplished by allowing the author to describe the learning outcomes they would like the learners to achieve. The authoring process also includes steps that allow the authors to select from a set of predefined screen appearances for the simulation. While this allows the author to influence the front end of the simulation they are allowed to focus their efforts on developing the dialogue models.

The major criticism of Experience Builder is that there is no graphical representation used to visualize the dialogue models that are developed [Gaffney, 08a]. The author is offered no clear representation of the dialogue segments or how they are connected. With even relatively short simulations the models involved become impossible to comprehend [Emmendorfer, 09]. Simulations are not scalable and development is very slow.

3.2 Survey of Adaptive Courseware Authoring Tools

3.2.1 MOT

My Online Teacher [Cristea, 03] is an academic adaptive hypermedia composition tool. It is a web based authoring system used for on-line adaptive course production. MOT is based on two frameworks; an adaptive authoring framework for adaptive hypermedia systems; and a framework implemented using a Common Adaptive Format (CAF) which integrates with LAG, a layered view on adaptation functionality.

MOT employs an effective approach to representing and authoring course content. A hierarchical format of concepts is intuitive and would be easily understood by subject matter experts. Relating different concepts is also an idea that authors would be comfortable with. MOTs most innovate feature is that it allows the authors to create the rules which will adapt and personalize the course.

MOT however has not been used commercially and is only really accessible by those with a technical background. The difficulty with MOT comes with the conception and implementation of the personalization. While the manual refinement of the lessons is easy to follow the application of adaptivity is rather technical. An author needs to be familiar with adaptive hypermedia principals to effectively and efficiently apply personalization.

Another criticism of MOT is that it is basically a modelling tool which does not directly produce an educational course. Instead, the models that are developed in MOT rely on external adaptation engines to deliver its course such as that which is used in the AHA! system [De Bra, 2003].

3.2.2 ACCT

The ACCT [Dagger, 04], Adaptive Course Construction Toolkit, was developed in Trinity College Dublin and is another academic adaptive hypermedia authoring tool. The ACCT was designed for a non-technical course developer to create adaptive and non-adaptive activity-oriented courses based on sound pedagogical strategies. It incorporates a graph representation of the author's concept space and provides a real-time course test and evaluation environment.

The ACCT strongest feature is the use of a graphical interface which allows the author to easily and quickly develop the course concept space. The author is provided with a clear and concise space for composing their course which is easily accessed by non-technical subject matter experts. The ACCT also provides a course developer with such tools as a custom narrative builder, content package assembler and learning resource repository. These features create a tool that allows the author to develop an entire course from beginning to end. ACCT was successfully trialled and evaluated with secondary school teachers and other domain experts.

The ACCT's weakest feature is that it does not allow the author to create their own rules of adaptivity; instead the personalization is predefined and fixed. There is also a poor representation of process flow within the concept space. The concept space is also rather lightweight and lacks the robustness of a true domain model.

4 Key Requirements

Through analysis of the state of the art presented in this paper and previous research [Gaffney, 08a] several key requirements for composing adaptive soft skill simulations were identified.

4.1 Model Representation

Most eLearning authoring tools, such as the MOT system, do not provide any graphical representation of content. The authoring tools that do employ graphical representation, such as the ACCT, do so in a manner that is unsuitable for capturing the specific requirements of simulations. Traditional eLearning composition tools are not expressive enough to represent the models upon which simulations operate. Educational simulations require a very new way of thinking about content [Aldrich, 04] which must be accommodated in the tools used for their development. Simulation authoring tools must represent content in a manner which allows the author to capture the intricate relationships that exist within the simulation models.

The models upon which soft skill simulations operate are based on the dialogue that occurs within the simulation. Soft skill simulation authoring tools must therefore represent the dialogue in an intuitive and user friendly manner. SimWriter, Experience Builder and most other soft skill simulation authoring tools implement designs based on similar principals. They decompose dialogue into smaller more manageable components and allow authors to map routes that will be available to the learner. Although there are subtle differences between their designs different authoring tools employ a uniform approach to dialogue.

In order to represent dialogue models upon which soft skill simulation operate a graph visualization should be incorporated; nodes and edges indicating the possible paths available to the learner. This approach can be seen in some soft skill simulation authoring tools and dialogue management systems [Luz, 00]. It allows an author freedom to describe and capture a dialogue. The models used to describe soft skill simulations require very expansive models [Emmendorfer, 09]. The models that are generated in these systems are however typically very complex. Mapping all the possibilities of a real dialogue, even within a relatively confined subject area, results in many components intricately interconnected.

4.2 Adaptivity Application and Representation

Most traditional adaptive courseware composition tools are unsuccessful at satisfactorily representing adaptivity [Paredes, 09]. Content is typically presented as text within these authoring tools and adaptivity is based on tagging this content; tagged content presented only as text with no other graphical representation is very difficult to follow and understand. It therefore becomes difficult for an author to view

where and how adaptivity might occur within the adaptive course as they can only view small segments of the course at any one time. Traditional adaptive courseware composition tools also typically require the author to compose complex rules or commands based on process languages. In order for adaptivity to become accessible to non-technical subject matter experts authoring tools need to incorporate a graphical approach to expressing personalization.

This research has identified two approaches to adaptivity within the domain of soft skill simulations; tagging and triggers; each of these are described in the following paragraphs.

Tagging: The first approach to adaptivity is manipulating the dialogue model so it becomes relevant to each individual learner. This is accomplished by pruning the model so only particular sections or sub-dialogues become available to the learner in the simulation.

Dialogue inclusion/exclusion is indicated in the model by tagging the dialogue elements with values which will describe the nodes. If the nodes are found to be relevant to the learner (match properties in the learner's user model) the nodes will be included in the simulation; if the nodes are found to be not relevant to the learner the nodes will be excluded. Tagging should be based on properties that are appropriate to soft skill simulations and that are relevant to both dialogue and the learner.

This approach to adaptivity allows the author to control personalization in the simulation without the need to compose complex rules or write any code. The author can indicate relevance and scope of the dialogue through tagging. By incorporating multiple adaptive dimensions [Wade, 09] (adaptivity axes/characteristics) and multiple properties for each of those adaptive dimensions an author can implement very sophisticated personalization.

This strategy results in a very flexible system which can adapt models at multiple levels. Personalization may result in any combination of nodes in a dialogue model being included or excluded. Adapted simulations may differ by a single node, multiple sub-dialogues or any variation between.

The model should generally not present a visual indication of tagging to the author to reduce the complexity of the model. However, the authoring tool should incorporate a feature that allows the author to view tagging within the model which they can turn on and off. The author should be allowed to highlight sections of their dialogue model that have been tagged with a particular value or combination of values. The graph visualization and highlight function would allow the author to view how a model might be adapted. Such visualization of tagging used in adaptivity would not be possible in composition tools that employ a simple text presentation to describe their content.

Triggers: The second approach to personalization identified within this research was to adapt the learning experience based on educational principles that are triggered within the simulation; this is an occurrence or event that fires when a learner reaches a particular point in a simulation. Triggers are based on assessment, feedback and reflection [Quinton, 06]. A learner, for example, may navigate to a particular node within a simulation. This node has been associated with a feedback trigger so the learner would be presented with data pertaining to their progress in the simulation, percentage of the simulation completed for example.

In a traditional simulation triggers would occur at the same navigated point for each learner and deliver identical content. The approach employed in this research personalizes the triggers so they *only* fire within a simulation if relevant to the learner. Furthermore, the content delivered in these triggers is personalized to the learner based on their route through the simulation or the learner's user model.

Within the composition tool triggers should only be allowed to be placed *within* the dialogue nodes to indicate their occurrence in the simulation. This approach ensures triggers do not increase the complexity of the dialogue model by being directly connected to dialogue model; i.e. triggers can not be embedded in the dialogue model. Furthermore, this approach means that triggers can be easily moved or deleted. To indicate their inclusion or exclusion within a simulation it should be possible to tag triggers in a similar manner that components of the dialogue model are tagged. Tagging should also be based on characteristics that are appropriate to the soft skill simulations and the learner.

Adaptive Dimensions: The characteristics that are used in tagging both the dialogue nodes and triggers should be relevant to soft skill educational simulations. They should be easily accessible to non-technical authors that do not have previous experience with adaptive hypermedia; i.e. the concepts encapsulated by the adaptive dimensions should be easily explained to the authors. The author should be provided with short concise list of dimensions to select from; an exhaustive list of adaptive dimensions may cause the authors to be confused and overload. The authors should not be allowed to create their own adaptive dimensions; this again creates an easy to use authoring environment that will not confuse the authors. The system should however be designed in such a way that it can be easily extended to include other dimensions that may identified at a later date. This research has identified the following adaptive dimensions which meet the required criteria; the *role* of the learner; *learning outcomes* the learner is to achieve; relevant *categorisation* of dialogue nodes; and related *subjects* that are relevant to the learner.

4.3 Authoring Process

ELearning authoring tools, particularly those used to compose educational simulations, require a clear and concise authoring process. The authoring process is an outline or blueprint that an author follows while developing eLearning solutions. The composition of adaptive soft skill simulations must include several aspects in its authoring process which cover both simulation development and adaptivity.

The authoring process should be an iterative step-by-step cycle which focuses on composing the dialogue models upon which the simulations operate. All other steps within the process should support the development of these models. The authoring process should also include a pedagogical framework. This is a schema that allows the author to determine learning outcomes and a pedagogical approach. Dialogue models are typically very large with 100 to 200 connected nodes. The author should be allowed to create and connect the dialogue nodes quickly within the authoring process.

4.4 Additional Requirements

There are three other requirements that a successful adaptive soft skill simulation authoring tool must also include. The first additional requirement is the inclusoin of aids to assist the author in navigating the large complex models that they develop. These could include a map, search functionality or other features to reduce the complexity of the model.

The second additional requirement addresses the need for an eLearning composition tool to include functions that provide a pedagogical framework. This allows the author to determine the pedagogical approach and learning outcomes they wish the learners to achieve. The pedagogical approach is an abstract view of the teaching and dialogue style that runs intrinsically throughout a simulation, for example; the simulation may be highly interactive or incorporate a more informative style of dialogue; it could be confrontational or passive. The learning outcomes are however a much more concrete expression of what the learners should achieve. The learning outcomes, once created by an author, can be explicitly related to the dialogue model. This insures a model that is educationally sound while also acts as documentation of the model that is developed. Learning outcomes can also be used in personalization.

The third additional requirement addresses the need for functionality used to validate that dialogue models are suitable for publishing. This includes automated inspection that verifies that content has been entered and that learning outcomes have been addressed within the model. Functionality should also be included that allows the author to view sequencing of components in the authored model to insure they create a meaningful and coherent dialogue.

5 Design of ACTSim – A Toolkit for Authoring Personalised Simulations

The ACTSim composition tool was developed in Trinity College Dublin in cooperation with the Department of Psychiatry as part of the ADAPT project [ADAPT]. As part of the ADAPT project a delivery system was also developed that allows authored titles to be created as standalone web courses or integrated into existing Learning Management Systems.

ACTSim was designed to be used by non-technical subject matter experts to compose adaptive soft skill simulations. ACTSim was developed using an iterative rapid prototyping approach. This began with a detailed examination of the key requirements previously described in this paper and other publications [Gaffney, 08a]. The design of ACTSim is presented in the following sections in relation to each of its key requirements.

5.1 Model Representation

The dialogue that occurs within a simulation is decomposed into small components known as Dialogue Elements. Dialogue Elements are represented graphically as nodes within the composition tool. They are primarily composed of a *'statement'* and *'response'* which occurs within the simulation, the statement which can be chosen by

the learner and appropriate response of the simulated person. The Dialogue Elements are connected with directed edges which indicate the possible paths the learner can take within the simulation. The connected Dialogue Elements form a graph known as a Dialogue Model, as seen in the largest section of the ACTSim composition tool in Figure 1. Once the Dialogue Model has been completed and fully scripted the video clips can be recorded and associated with the appropriate Dialogue Elements.

There are many authoring tools that employ a simple text interface to describe the simulation model such as Experience Builder and Knowledge Dynamics KDSimStudio [KDSimStudio]. While this is adequate for describing simple simulations it does not allow the author to develop large authentic simulations and is insufficient to capture the complexities involved in describing the various paths available to the learner. The graph based approach to representation is far more intuitive and user friendly than the use of text to describe the simulation models.

The manner in which the ACTSim composition tool represents dialogue and allows the author to construct the dialogue models is similar to the ACCTs approach to representing learning content. The use of nodes and edges to represent dialogue and speech can also be found in many dialogue management systems [Churcher, 97] such as the CSLU toolkit [Sutton, 98] and GULAN [Gustafson, 98]. However, while these systems incorporate an intuitive representation of dialogue they are not used for composing adaptive educational simulations. They do not incorporate the same functionality as ACTSim such as determining a pedagogical framework, applying adaptivity or describing an authoring process that supports the author in creating the simulation and dialogue model.

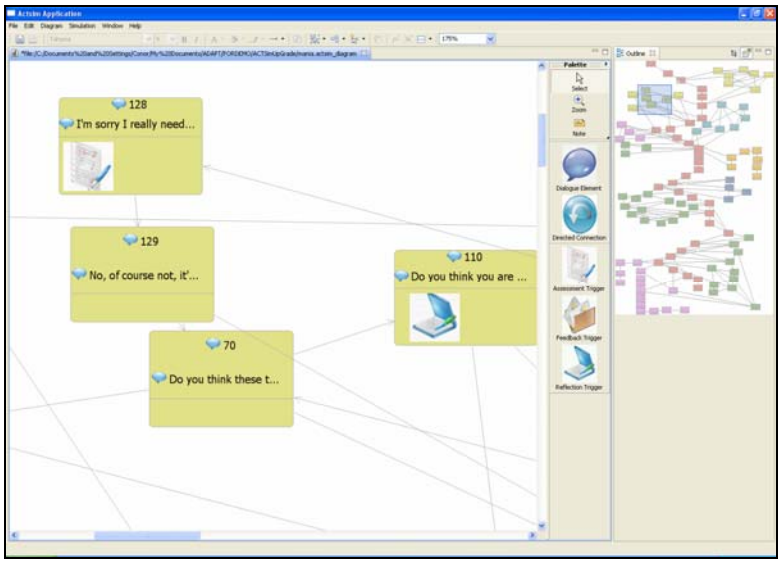

Figure 1: ACTSim Composition Tool

5.2 Adaptivity Application and Representation

ACTSim employs two approaches to composing personalized simulations. The first of these allows the author to develop simulations which adapt the dialogue of the simulation to the needs of the learner. This concept is similar to that of adapting the content of courses in traditional eLearning systems. ACTSims approach incorporates a methodology of tagging the Dialogue Model but importantly does not require the author to compose complex rules or commands. Tagging is easily completed by the author in the graph representation of the dialogue model. Authors can tag Dialogue Elements individually or apply tagging to a selected set of Dialogue Elements. The composition tool also allows the author to highlight sections of the model to view how and where adaptivity might occur. Personalization of the dialogue can be based on role, learning outcomes, related subjects and related categories.

Unlike the ACCT authoring tool, ACTSim allows the author complete control over the personalization that can take place within the simulation. The MOT tool allows the author such control but requires the author to have a technical background in adaptive hypermedia to incorporate the adaptivity. The ACTSim composition tool incorporates the best of both the ACCT and MOT; the author completely controls the adaptivity but does not need to create complex rules to define the adaptivity.

The second approach to personalization is based on adapting the educational principles of assessment, feedback and reflection. These are personalized triggered events within the simulation and are only fired if properties in the learner's user model are matched the property tags of the Triggers. Furthermore, the content delivered to the learner through triggers is dynamically adapted to the learner. This is based upon several aspects of the simulation at run-time such as the route the learner has navigated through the dialogue or learning outcomes they have achieved. Triggers are represented as nodes in the ACTSim composition tool which are placed in the Dialogue Elements to indicate their occurrence in the simulation. In Figure 1 an example of an Assessment trigger can be seen in Dialogue Element 128 (correct exam paper icon) and an example of a Reflection trigger can be seen in Dialogue Element 110 (writing pad and pen icon).

The concept of employing separate nodes to represent different components within a soft skill simulation model is not uncommon. For example, SimWriter incorporates many different types of nodes within its model representation. These non-adaptive nodes not only represent the dialogue that occurs within the simulation but also indicate the occurrence of such things as learner reports and directed feedback. SimWriter and other soft skill simulation authoring tools link these components directly with the components that are used to describe the dialogue. This approach immediately adds to the complexity of the authoring the simulation and also makes the flow of the dialogue difficult to follow. By separating the adaptive triggers from the dialogue and not embedding them into the simulation model the authoring complexity is reduced and the model becomes easier to read. Furthermore, by placing the adaptive triggers on the Dialogue Elements instead of embedding them into the model they can be easily added, deleted and moved from one Dialogue Element to another without affecting the model that has been developed by the author.

5.3 Authoring Process

The authoring process employed by ACTSim is an iterative step-by-step cycle as seen in Figure 2. Its focus is the development of the Dialogue Models which have been to describe adaptivity that can occur within the simulation. Developing the Dialogue Model an iterative step in itself within the authoring process and it is the area where an author will invest most of their time. Describing the dialogue, defining the learning outcomes, determining the pedagogical approach and evaluating/verifiying the model are all steps which support the development of an affective Dialogue Model used in soft skill simulations. Tagging the Dialogue Model and developing tagged Triggers are steps that address the adaptivity within the authoring process.

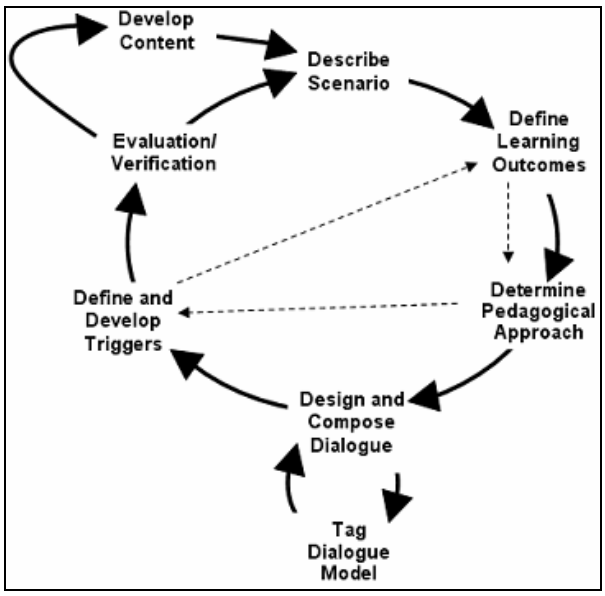

Figure 2: ACTSim Authoring Process

Each authoring step is explained in the following paragraphs.

Describe Dialogue: the author begins the authoring process by naming the scenario and describing its purpose. The author can also develop tagging properties at this stage of the authoring process.

Define Learning Outcomes: the author defines all of the learning objectives that could be achieved by a learner within the simualtion.

Determine Pedagogical Appraoch: the author determines the dialogue and teaching style that will be used in the simulation.

Design and Compose Dialogue: the author designs and populates the Dialogue Model upon which the simualtion will operate. Previous steps support the author in this complex task. The simulations description, learning objectives and pedagogical approach all influence different aspects of the Dialogue Model. Such is the

complexity that an author will need to redesign, develop and expand their model through many iterations.

Tag Dialogue Model: the author may tag individual Dialogue Elements as they are created or they may tag large sections of the Dialogue Model (sub-dialogues) once they have been completed.

Define and Develop Triggers: the author creates Assessment, Feedback and Reflection Triggers, populates them and places them at appropriate points within the model. As the author creates Triggers they are tagged appropriately.

Evaluation/Verification: the author evaluates and assesses the iteration of the authoring process they have completed. The results of this evaluation are used to improve the Dialogue Model and adaptivity of the simulation in the following iteration. The author can also use verification tools to aid them in their evaluation.

Develop Content: once the Dialogue Model has been completed content (typically audio or video) is developed and associated with the model. This step in the authoring process is only completed at the end of development.

A soft skill simulation is developed over multiple iterations of the authoring process. An author may not address every step in each iteration. Further details of the authoring process can be found in previous publications [Gaffney, 07].

5.4 Additional Requirements

To assist the author in navigating the complex models developed ACTSim includes a map of the dialogue model, zoom functionality and an arrange feature. ACTSim also allows the author to define Learning Objectives and associate them with groups of Dialogue Elements. This not only insures that the simulations developed are educationally sound but can also be incorporated into the adaptivity. In order to validate the dialogue model ACTSim also allows the author to select sequences of Dialogue Elements and script the dialogue as it would appear to the learner in taking a particular route through the simulation. The author can also validate the existence of statement and responses within the dialogue and once a video has been recorded the author can validate that segments of video have been associated with the model.

6 Evaluations

ACTSim has been rigorously evaluated throughout its development, a necessity with user based applications [Shneiderman, 92]. Many iterations of design, implementation and evaluation have taken place with results of each evaluation feeding into the following cycle [Dix, 04]. The evaluations have been user centric and several kinds of evaluation techniques have been employed at different stages of ACTSims development [Preece, 94]. The goal of the evaluations has been to gather data about the usability of ACTSim and improve effectiveness, efficiency and user satisfaction [Jokela, 03]. In particular the evaluations performed have included predictive, interpretive and usability evaluations. These evaluations are described in detail in the following sections.

6.1 Predictive Evaluation

The first evaluation employed within this research was a cognitive walkthrough [Rieman, 95]. This is a predictive evaluation [Preece, 94] which does not require a prototype. Instead a specification and storyboard of the ACTSim design were developed using the requirements previously described. These allowed tasks to be completed cognitively which highlighted issues and allowed them to be detected very early. Typically a cognitive walkthrough involves expert reviewers but due to the innovative nature of the research the walkthroughs were completed with expert users with previous experience of developing soft skill simulations. The predictive evaluations were initially completed with all non-adaptive requirements and at a later stage of development with the adaptive requirements. These evaluations allowed prototyping of ACTSim to begin very quickly.

Figure 3 illustrates one of the story boards used for the first cognitive walkthrough. These storyboards were used to examine the non-adaptive requirements of the composition tool such as the basic functionality for authoring dialogue and related authoring process. The storyboard displayed in Figure 3 was used to evaluate the zoom functionality and map that were incorporated into the design. The second cognitive walkthrough occurred at a later stage of development and was used for the initial evaluation of the adaptive features of the composition tool. The results of the predictive evaluation were qualitative in nature and assisted in determining required functionality and interface layout.

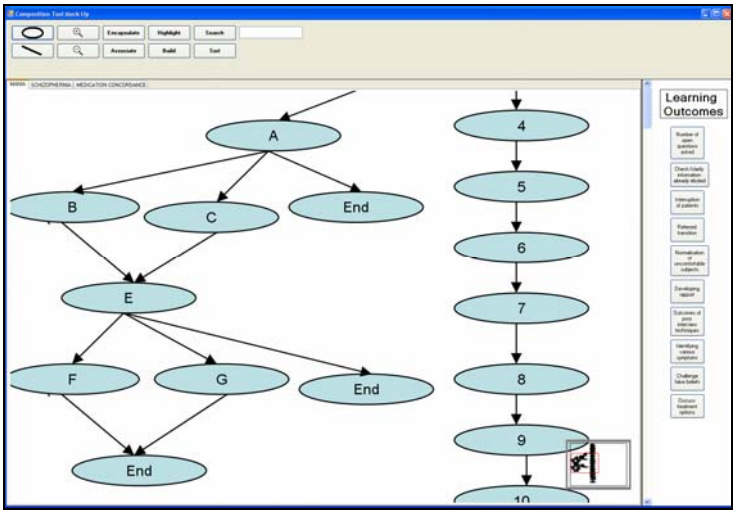

Figure 3: Storyboard - Use of the Zoom-In function with a map of the Dialogue Space in the bottom right corner

6.2 Interpretive Evaluation

The evaluation techniques used most frequently within this research have been interpretive based. Interpretive evaluations assist the understanding of complex interactions that occur in natural settings [Walsham, 93]. They are a formative target driven [Preece, 94] approach which can be completed quickly. Contextual interviews [Holtzblatt, 93] in particular were employed as they complement the cooperative inquiry research methodology used to develop the ACTSim composition tool. They allowed users to effectively and efficiently influence design decisions which resulted in rapid prototyping.

Interpretive evaluations were employed at many stages of development and were completed with users from several different domains. These included healthcare, customer care and education. In particular contextual interviews were conducted with soft skill experts from the Department of Psychiatry in Trinity College Dublin. Elements of usability evaluations [Preece, 94], such as questionnaires and recorded semi-structured interviews, were also included within the contextual interviews. These were used to further analyze feedback, make selections between alternative designs and to confirm evaluation metrics were being followed. They were designed to be short and less comprehensive than complete usability evaluations.

Some of the results of the contextual interviews are apparent when comparing the original storyboards from the initial cognitive walkthrough to a recent screenshot of ACTSim, figure 4. These highlight some of the design aspects that have remained in ACTSim such as the approach to dialogue representation and zoom functionality. They also illustrate how some of the features have changed over the course of the development due to the contextual interviews that have taken place. For example the location of the palette, location of the map and the design of the learning outcomes display.

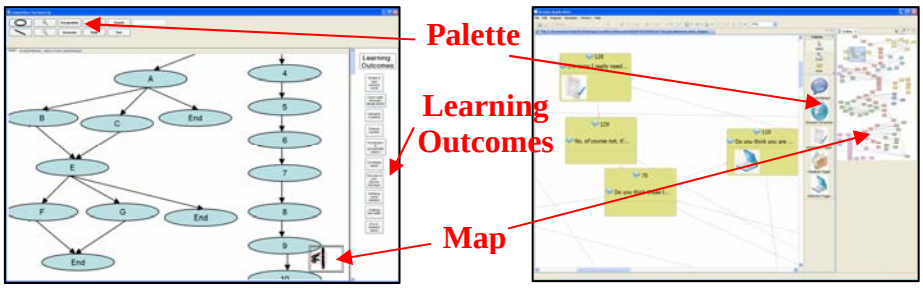

Figure 4: Comparison of storyboard (Figure 3) and ACTSim (Figure 1)

Short questionnaires and semi-structured interviews were incorporated within the contextual interviews to examine several aspects of the composition tools development. For example, a feature for encapsulating sections of the dialogue (sub-dialogues) was considered as part of the ACTSim design. The aim of this feature was to reduce the complexity of the dialogue models and enhance its ease of comprehension by the author. Two designs were developed and implemented, a tabbed approach and a compartment approach. A group of users within healthcare were asked to complete several short tasks with each design and their opinions were

collected with a short questionnaire. 100% of users found the compartment approach more intuitive and user friendly than the tabbed approach. This feature was however later removed from the design. The initial evaluations employed users that were experienced with dialogue representation and so easily understood the concept of encapsulation. Subsequent evaluations employed a larger set of less experienced users who found the concept to be to be confusing.

6.3 Usability Evaluations

Two usability evaluations [Tyldesley, 88] were completed during the development of the ACTSim composition tool. Usability evaluations were employed far less frequently than interpretive evaluations as they require a great deal of time and resources to design and complete. Usability evaluations are however necessary within the development of a user based application as they provide subjective quantitative and qualitative data [Preece, 94]. Experimental evaluations such as these are the most powerful methods of evaluating a design or an aspect of design [Dix, 04].

Both usability evaluations completed were designed on user based trials and were completed in a controlled environment. Evaluation metrics were derived from application requirements [Preece, 94]. These metrics were then used to develop tasks [Macaulay, 95] for the users complete. Data for the first usability evaluation was gathered with questionnaires. Data for the second usability evaluation employed several techniques including questionnaires, video analysis and an examination of the user's comprehension of the ACTSim system by testing their memory retention and understanding.

Tasks were carried out by each user in order to achieve a work goal which closely examined an aspect of ACTSims design. Once the users had finished all the tasks the data was collected and could be examined to ensure planned levels of usability were achieved.

The first evaluation examined many of the non-adaptive aspects of design such as basic functionality, model representation and navigational aids. The results of this evaluation were very positive. The design and implementation of the dialogue representation was particularly important in the first usability evaluation. Users found the approach employed in the ACTSim tool to be *'intuitive'* and *'effective'*. It was however found in the first usability evaluation that navigational aids were not effectively evaluated. Results were inconclusive as authors composed models that were not large enough for users to utilize appropriate functionality.

Further information regarding the first usability evaluation can be found in previous publications [Gaffney, 08b]. The following section describes in detail the second evaluation that was completed.

6.3.1 Second Usability Evaluation

The second usability evaluation focused on the adaptive aspects of design such as tagging the Dialogue Model and adding Triggers. This evaluation also examined the authoring process and re-examined the usability of the navigational aids.

This usability evaluation employed users from a number of different backgrounds including psychiatry, psychology and health care. In order to evaluate adaptivity within ACTSim it was necessary for the users to have previously developed a

Dialogue Model that contained no adaptivity; i.e. the models were not tagged and no Triggers had been added. Employing a pre-developed Dialogue Model in the usability evaluation allowed users to apply adaptivity to a model that they were familiar with.

All users initially completed a short period of training. This was followed by a test that ensured that they had reached a sufficient level of competency to complete the evaluation. The evaluation consisted of two major tasks. The first task required the users to complete several iterations of the authoring process with the Dialogue Models that they had previously developed. This task included the following steps; examine and evaluate the model; create suitable tagging properties (users were allowed to choose from role, subject or category; which ever property they felt was most suitable to their simulation); apply the tagging properties to sections of their Dialogue Model; add at least one of each of the Trigger types to the model; edit each of the Trigger's properties appropriately. Employing a step-by-step approach to the task allowed users to evaluate their model, apply adaptivity and ensured they followed ACTSim's authoring process. A final step in the first task required users to independently complete a full iteration of the authoring process.

The purpose of the second task was to evaluate the navigational aids used in ACTSim. The second task employed a different Dialogue Model to the first task. The Dialogue Model employed in the second task was a model that was unfamiliar to the users. The users were required to locate specific Dialogue Elements based on determination within the model, specific tags and statement properties. The second task was presented in series of steps with each step associated with a separate navigational aid. Employing a Dialogue Model that the users were unfamiliar with ensured that users were not predisposed to the location of any of the Dialogue Elements so requiring them to correctly use each navigational aid.

Evaluation Objectives: The first objective of this usability evaluation was to establish that the user found tagging to be an effective approach to creating a personalised simulation. Specifically, users could easily understand the principals of tagging a dialogue model to create a simulation that would be adaptive. Furthermore, users could efficiently tag their dialogue model in a user friendly manner. Specifically, could users both create tagging properties and apply them to a dialogue model quickly and easily.

The second objective was to establish that users found the principals involved with triggers to be an effective approach to incorporating adaptive assessment, reflection and feedback into an educational simulation. Specifically, could the user easily understand how the triggers would effect the end simulation and how they would create a personalised simulation for the learner. Furthermore, the evaluation was to determine if the Triggers could be efficiently added and manipulated within the Dialogue Model in an efficient and user friendly manner. Specifically, could the user easily and quickly; add triggers to the compartments of the dialogue elements; move them from one compartment to another; delete the triggers; and access/edit the triggers properties.

The final objective was to re-examine aspects of the first evaluation that did not meet the required success criteria. This included a re-evaluation of some of ACTSims navigational aids such as the search, arrange and zoom functionality. The authoring process was also re-evaluated with respect to its effectiveness, efficiency and ease of

use. Could the users easily follow the authoring process and did it aid them in creating an effective adaptive soft skill simulation.

Highlighted Evaluation Results: A short test was used as one of the methods of evaluating the effectiveness of tagging. The users achieved a mean score of 70.83% in the test. While this is a high score it did not reach the required predefined success criteria determined before the usability evaluation (80%). This slightly low mean score initially indicated the users did not understand how tagging would effect the final simulation. However, users may in fact have misunderstood the question in the test as the questionnaire, which was also part of the evaluation, found that 80% of users agreed or strongly agreed that it was easy to see how tagging would effect the final simulation. Other aspect of the effectiveness of tagging all scored within the predetermined success criteria. The efficiency of tagging also performed within predetermined success criteria as did the user satisfaction. For example, the average time for creating a tagging property was 13.2 seconds (well within the success criteria of 30 seconds) and 100% of users agreed or strongly agreed that they found it easy to tag a group of dialogue elements with properties that they have created.

The effectiveness of the triggers was also evaluated using both a test and questionnaire. The users achieved a mean score of 83.3% in the test, within the success criteria of 80%. The questionnaire however indicated that while the concept of incorporating triggers into the dialogue model was effective that they were not represented adequately. This may simply be due to the icons incorporated not being distinct enough from one another. The efficiency of adding and manipulating triggers was also found to fall within acceptable parameters as was the user satisfaction with the interface. For example, the average time for a user to add and update a Feedback trigger was 24.4 seconds (well within the success criteria of 60 seconds) and 100% of users found it easy to access the properties of the triggers.

The re-evaluation of the navigational aids determined that the search, zoom and highlight functionality were effective, efficient and easy to use. However, the arrange function was proven to be rather less useful with users finding its results confusing. The authoring process was also shown to be effective, efficient and easy to follow with 80% of users agreeing that it allowed them to quickly compose a well supported dialogue model.

6.4 Evaluation of Courses

To date the simulations developed in ACTSim have been used by medical students in several universities including Trinity College Dublin, the University of Edinburgh and Imperial College London. ACTSim has also been successfully employed to develop corporate simulations in a large well known multinational company. A number of evaluations of these simulations have been completed, the results of which have been very positive. For example, 68.4% of students agreed they had acquired new skills or improved existing ones because of the simulations. 84.2% agreed that they will be able to apply what they have learned from these simulations to the real world. 68.4% believed the simulations used in the course were an effective method of education. These evaluations and strong uptake of the courses illustrate that the simulations composed using ACTSim are an effective and valuable tool.

7 Conclusions

Educational simulations are an effective and efficient form of eLearning. They are however difficult to compose and typically do not incorporate any kind of adaptivity. This paper shows that educational simulations can be adaptive and that they can be personalized in a sophisticated manner. Furthermore, this research also demonstrates that technical personnel can be removed from authoring process and that these systems can be composed by subject matter experts.

These innovations are illustrated in ACTSim, a composition tool that allows the rapid development of adaptive soft skill simulations. It is the first authoring tool of its kind and employs a unique approach to adaptivity which is easily accessible to those outside of the adaptive hypermedia community. Developed and evaluated with soft skill experts ACTSim puts the power of adaptivity in the hands of authors in the real world.

References

[Adams, 08] Adams, W. K., S. Reid, et al.. A Study of Educational Simulations Part I - Engagement and Learning. Journal of Interactive Learning Research. 2008

[ADAPT] ADAPT. http://kdeg.cs.tcd.ie/node/61

[Aldrich, 04] Aldrich, C. Simulations and the future of learning : an innovative (and perhaps revolutionary) approach to e-learning. San Francisco, Pfeiffer. 2004

[Alessi, 01] Alessi, S. M. and S. R. Trollip. Multimedia for learning : methods and development. Boston ; London, Allyn and Bacon. 2001

[Brigas, 03]Brigas, C. and M. Marcelino. Authoring-Tools for Web-Based Simulations. International Conference on Computer Based Learning in Science. 2003

[Brusilovsky, 96] Brusilovsky, P. Methods and techniques of adaptive hypermedia. User Modeling and User-Adapted Interaction **6**: 87-129. 1996

[Brusilovsky, 00] Brusilovsky, P. Adaptive Hypermedia: From Intelligent Tutoring Systems to Web-Based Education**:** 1-7. 2000

[Brusilovsky, 98] Brusilovsky, P., J. Eklund, et al. Web-based Education for All: A Tool for Development Adaptive Courseware. Computer Networks and ISDN Systems. 1998

[Churcher, 97] Churcher, G., E. S. Atwell, et al.. Dialogue Management Systems: a Survey and Overview. Technical report, University of Leeds. 1997

[Cristea, 05] Cristea, A. Authoring of Adaptive Hypermedia. Educational Technology & Society. 2005

[Cristea, 03] Cristea, A. and A. de Mooij. Adaptive Course Authoring: My Online Teacher. LTTF International Conference on Telecommunications. 2003

[Dagger, 04] Dagger, D., Conlan, O., et al. Developing Adaptive Pedagogy with the Adaptive Course Construction Toolkit. Authoring of Adaptive and Adaptable Hypermedia. 2004

[Dagger, 05] Dagger, D., V. Wade, et al. Personalisation for all: making adaptive course composition easy. IFETS journal of Educational Technology and Society. 2005

[De Bra, 00] De Bra, P. Pros and Cons of Adaptive Hypermedia in Web-Based Education CyberPsychology & Behavior **3**(1): 71-77. 2000

[De Bra, 03] De Bra, P., A. Aerts, et al. AHA! The adaptive hypermedia architecture. Proceedings of the fourteenth ACM conference on Hypertext and hypermedia. 2003

[De Bra, 10] De Bra, P., Smit, D. et al GRAPPLE: Personalization and Adaptation in Learning Management Systems in ED-MEDIA. 2010

[Dix, 04] Dix, A. J.Human-computer interaction. Harlow, Pearson. 2004

[Emmendorfer, 09] Emmendorfer, J. Teach Soft Skills With e-Learning. from http://www.ame-learning.com/revolution/wp-content/uploads/softskills.pdf 2009

[ExperienceBuilder] ExperienceBuilder http://www.experiencebuilders.com/.

[Paredes, 09] Paredes, P., Ortigosa, A., et al. TOGETHER: an Authoring Tool for Group Formation based on Learning Styles EC-TEL: Authoring of Adaptive and Adaptable Hypermedia. 2009

[Gaffney, 07]Gaffney, C., D. Dagger, et al. Supporting Personalised Simulations: A Pedagogic Support Framework Summer Computer Simulation Conference. 2007

[Gaffney, 08a] Gaffney, C., D. Dagger, et al. A State of the Art Survey of Soft Skill Simulation Authoring Tools. Hypertext and Hypermedia. 2008

[Gaffney, 08b] Gaffney, C., D. Dagger, et al. Evaluation of ACTSim: a Composition Tool for Authoring Adaptive Soft Skill Simulation. Adaptive Hypermedia and Adaptive. 2008

[Grigoriadou, 06] Grigoriadou, M. Papanikolaou, K. Authoring Personalised Interactive Content. Semantic Media Adaptation and Personalization, IEEE Computer Society 2006

[Gustafson, 98] Gustafson, J., P. Elmberg, et al. An educational dialogue system with a user controllable dialogue manager. International Conference on Spoken Language Processing. 1998

[Holtzblatt, 93] Holtzblatt, K. and S. Jones. Conextual Inquiry: A participatory technique for system design. Participatory Design: Principles and Practice. D. Schuler and A. Namioka. 1993

[Jokela, 03] Jokela, T., N. Iivari, et al. The standard of user-centered design and the standard definition of usability. Latin American conference on Human-computer interaction, ACM.2003

[Joolingen, 03] Joolingen van, W. R. and T. Jong de. SimQuest: authoring educational simulations. T. Murray, S. Blessing and S. Ainsworth. Dordrecht. 2003

[KDSimStudio]KDSimStudio. http://www.kdsimstudio.com/

[Luz, 00] Luz, S. State-of-the-art survey of dialogue management tools. Technical Report. 2000

[Macaulay, 95] Macaulay, L. Human - computer interaction for software designers. London, International Thomson Computer Press. 1995

[MacComascaigh, 09] MacComascaigh, M. and W. Andrews. Leading Websites Will Use Search, Advanced Analytics to Target Content. Gartner RAS Core Research Note. 2009

[Mayer, 05] Mayer, R. E. The Cambridge handbook of multimedia learning. Cambridge. 2005

[NexLearn] NexLearn http://www.nexlearn.com/.

[Preece, 94] Preece, J. Human-computer interaction. Wokingham, Addison-Wesley. 1994

[Quinton, 06] Quinton, S. A brief critique on the future of learning (Assessing the potential for research). Contemporary approaches to research on learning environments: Worldviews.

[Rieman, 95] Rieman, J., M. Franzke, et al.. Usability evaluation with the cognitive walkthrough. Conference companion on Human factors in computing systems, ACM. 1995

[Shneiderman, 92] Shneiderman, B. Designing the user interface : strategies for effective human-computer interaction, Addison-Wesley. 1992

[Sutton, 98] Sutton, S., R. A. Cole, et al. Universal Speech Tools: The CSLU Toolkit International Conference on Spoken Language Processing. 1998

[Tyldesley, 98] Tyldesley, D. A. Employing Usability Engineering in the Development of Office Products. The Computer Journal: 431-436. 1998

[Wade, 09] Wade, V. Challenges for Multi Dimensional Personalised Web (Invited Keynote). User Modeling, Adaptation, and Personalization. 2009

[Walsham, 93] Walsham, G. Information Systems in Organizations, Wiley&Sons. 1993