# Supporting Personalised Simulations: A Pedagogic Support Framework For Modelling And Composing Adaptive Dialectic Simulations

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**Abstract**

Personalisation in Simulations for eLearning is a novel approach which requires a high level of designer support. This support not only involves the model complexity of the simulation but more importantly the complexities of integrating educational development best practice. This paper describes an approach to supporting personalised simulations in eLearning. This is achieved by providing a pedagogically informed support framework for modelling and composing adaptive dialectic simulations. Presently this research is being extensively evaluated in the School of Medicine at the University of Dublin, Trinity College

## 1. INTRODUCTION

Simulations are widely used in many aspects of science, industry and business for a multitude of tasks. However one of the key obstacles facing simulations is they can be extremely complex and costly to develop and require significant expertise to author. When applying simulation to domains where it is important to allow domain experts to build simulations them selves e.g. for training purposes or education, it is perhaps the key to empower the domain expert themselves so they are able to author and personalise the simulations.

The key problem with incorporating simulations is their composition [Page et al, 1999] and allowing non-technical domain experts to compose simulations. Generally, simulations are expensive and very time consuming to produce [Waziruddin et al, 2003]. This is particularly true where the simulation is designed to provide an educational basis. For example, higher educational establishments do not have the teams of programmers needed to write simulations for educational purposes. Typically they must outsource the required simulations because of a lack of technical know how or limited resources.

It is often the case with educational simulations that many need to be created which are similar but incorporate subtle differences. For example, training simulations for a doctor and nurse would be very similar with the doctors needing to be more in depth but for both of these roles a separate simulation would have to be produced. The differences between simulations are usually dependent on the end learner engaging the simulation or the context which they take place. To reduce the necessity of composing multiple similar simulations there is a need to maximize their usage so as to be applicable across a range of scenarios. A particularly important example of this is being able to adapt to different types of learners.

This adaptivity could be based upon the different roles or different experiences of the learners. For example, a simulation for training pilots could adapt to a learner based upon previous simulations that he/she has engaged in. As the learner improves and gains greater experience the simulation would adapt to offer them a greater challenge. The personalisation of simulations to the learner makes the simulation more relevant for them and improves the efficiency and effectiveness of the learning.

The particular type of educational simulations focused on within this paper are dialectic based simulations (instructional social simulations or soft skill simulations). This paper describes the design and implementation of a tool to support the authoring by non-technical people of dialectic based simulations which are adaptive to users based on role or prior knowledge in particular.

This paper begins with an examination of educational simulations. This is followed by a survey of existing dialectic based simulation composition tools which includes their current limitations. Through examination of these limitations, improvements to both the simulation design process and features of composition were identified. An improved design process, which includes pedagogical methodologies, along with a case study of an application developed is examined in the sections to follow. The paper concludes with a summary and outline of future work in this area.

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## 2. EDUCATIONAL SIMULATIONS AND DIALOGUE

Simulation is the science of creating a representation of a process or system for the purpose of experimentation and evaluation [Gogg & Mott, 1993]. It provides the user with a safe and realistic environment in which to interact and engage. Educational simulations can be categorised based on what they represent and how the user controls them [Alessi & Trollip, 2001], such as; **physical simulations** were real world objects/phenomenon are modelled which the user can continuously manipulate to observe changes in simulation state; **iterative simulations** which are similar to physical except the user only defines initialisation parameters and then observes the simulation output; **procedural simulations** which are similar to the first two categories except the objective is to learn about a process more so than the modelled objects of the simulation; and **situational simulations** which are similar to procedural but also includes behaviours and attitudes of people and organizations to increase the element of randomness of the simulation.

Main stream eLearning since the mid 90's has begun to focus more on the notion of constructivism i.e. learning by doing. There has been a move away from the more traditional passive approach of learning towards more learner centric solutions with students' inquiry, activity and engagement as key requirements to be satisfied [Mayes & de Freitas, 2004].

As previously mentioned, dialectic based simulations are the focus of this paper. These are simulations generally used for teaching, in particular communication skills where the learner is taught through the process of interacting with simulated people and scenarios through dialogue. The learner takes on a particular role and interacts with the simulation, from which they learn from their situation and can construct their own understanding, controlling the dialogue with the choices they make. Dialectic based simulations are typically used to teach communication skills within the domain of business, such as customer care, interviewing skills and sale process simulations. Examples of these dialectic based simulations are SkillSim Simulations [SkillSoft] and ForceTen 4.0 [Eedo]. The knowledge models that dialectic simulations depend on are dialogue based, the visualisation of which needs to be graphically represented for composition, displaying the features and attributes of communication between two or more people.

There are many advantages of using dialectic based simulations. From an educational point of view dialectic simulations are very effective. It has been argued that serious learning only occurs if it takes place in the social and physical context in which it is to be applied [Brown et al , 1989]. Dialectic simulations also have advantages over the real world alternatives of either employing actors to take on the roles or allowing the learner to participate in real scenarios. These include:

- Cost: Dialectic simulations can be reused so are a much cheaper option compared to that of constantly employing actors.
- Convenience: Compared to the use of actors, dialectic simulations are far more convenient. They can also be easily saved for replay, removing the necessity of recording equipment.
- Time: Time within a dialectic simulation can be decelerated which is not possible if training with the use of actors. This could for example allow the learner to actively reflect during their simulation.
- Safety: Dialectic simulations are often used to replicate situations where if mistakes made by the learner in the real world would have an adverse affect. For example a learner sales representative losing a valuable client.

Although being examined in particular are semi-structured dialogues such as conversations and interviews, the modelling of these types of simulations are considerably complex [Allen et al, 1996]. While there have been many different approaches to modelling human-to-human dialogue; such as Chat Circles [Viégas & Donath] and Comic Chat [Kurlan et al, 1996], a complex task in itself; ensuring pedagogic appropriateness adds further to the development complexities. Dialectic based educational simulations not only have to be authentic simulations but they must support serious learning (the idea that learning in a highly interactive environment is not something appended to the side of the experience but something that flows implicitly within the experience).

## 3. SURVEY OF EXISTING DIALECTIC BASED SIMULATION COMPOSITION TOOLS

This section surveys three dialectic based composition tools. While two are used in the composition of dialectic based simulations, one is a dialogue management system (DMS) which shares many similar features as dialectic based simulation composition tools.

### 3.1. VISIOn

Virtual Interviews for Students Interacting Online was developed in Trinity College Dublin with the goal of teaching communication skills in psychiatric settings. Part of this project being the development of a dialectic based simulation composition tool [VISIOn]. VISIOn supports the construction of very intricate and complex models; the interface is user friendly allowing the designer to place simulation dialogue elements anywhere on the canvas in any way they see fit. However the models that are produced do become very large and difficult to navigate and while the VISIOn composition tool does provide zoom functionality, it alone is not enough aid the designer in their navigation of the dialogue model.

Another issue with this composition tool is its lack of explicit design process. The effect of this is that designers will tend only to compose based on a previous course design experience. Educational theory does not get clearly defined which leads to limited formal pedagogical influence within the simulation.

The VISIOn system also provides very little scope for reuse of model elements. Meaning, each time a designer wishes to compose a simulation, they must make a fresh start. This is particularly frustrating given that the dialogue models created can be very similar.

### 3.2. SimWriter

SimWriter is a commercially based composition tool developed by NexLearn which allows for the composition of dialectic based simulations (social simulations) [SimWriter]. It provides a well structured development process taking the designer through three phases of simulation construction; construction of dialogue models; composition of content; and design of final interface. The canvas used for dialogue development is very restrictive, only allowing the designer to add each dialogue element to the canvas in a series of rows provided. The sequencing of dialogue elements in this manner is very controlling and while this is effective with small simple dialogues it becomes very limiting if the designer tries to compose large expansive models. For example, models consisting of 30 sequences or more. There are also no navigation features provided for such large spaces.

SimWriter does however perform well with the reuse of resources allowing the designer to use templates provided, upload edit scripts, reuse elements and media files. While simulations can be created quickly, there is still the need to produce many simulation models. While this process of composing the simulation is very explicit, there is surprisingly no formal documentation of educational imperatives, for example learning outcomes or assessment metrics. Basic pedagogic elements such as these are requirements now to insure pedagogically sound simulations.

### 3.3. CSLU Toolkit

The CSLU toolkit was developed in the Centre for Spoken Language Understanding to provide a framework and tools for the composition and investigation of interactive language systems [CSLU]. This is a dialogue management system (DMS) and although not developed specifically for the composition of simulation, it does provide some interesting parallels. These parallels are particularly evident while examining its dialogue canvas space. This dialogue canvas space allows the designer to place elements in a free and expressive manner, not restricting the placement of elements with rows or columns. The designer is however presented with a number of different types of dialogue elements from which to choose, increasing the probability that he or she will become confused, especially with the graphical similarities between each type of element. While these dialogue elements do promote reuse of resources it is limited within each model composed.

Although not designed to develop large dialogue models, the CSLU toolkit actually performs this task surprisingly well. This is due to a sub-dialogue element that the designer can use, which allows them to decompose their dialogue into smaller sections which are easier to manage. As the CSLU toolkit is a DMS it was not designed with pedagogical imperatives in mind but simply as a tool for modelling dialogue. However the addition of educational imperatives may be suited to this application.

An examination of each of these applications highlights the need for improvement in dialectic based simulation composition. In particular, there are four limitations that need to be addressed. These are complexity of development, reuse of resources, scalability and integration of educational imperatives which are now examined more closely.

### 3.4. Current Limitations in Authoring Dialectic Based Simulations

This subsection takes the four areas identified in the survey and describes more specifically what challenges they actually entail.

**Complexity of development: t**here are two aspects to be considered in the complexity of development which are the development process and the construction of simulation models. The development process is the procedure the designer follows in composing a simulation which not only include steps to insure the authenticity of the simulation but should also follow proven educational methodologies. The construction of simulation models is the process the designer followed to produce the dialogue models. It is these dialogue models that dictate all possible interactions that a learner can engage in within the simulation. While the development process can ensure that the simulation is pedagogically sound, it is the correct authoring of these models that creates authentic simulations.

**Reuse of resources:** the creation of simulations has often been a “one-off” undertaking [Robinsona et al, 2003], whereby the resources used are so unique to their context that efficient reuse has proven very difficult if not impossible. This however should not be the case with dialectic based simulations as conversation across various situations share similar characteristics which can facilitate their reuse. The application of adaptivity can utilise reuse of a single model for multiple scenarios.

**Scalability:** in the authoring of full and concise simulations there is often a need to compose models with large amounts of content. Authoring tools should be able to cope with such large amounts of data, presenting it to the designer in a clear intuitive manner.

**Integration of Educational Imperatives:** While the composition of dialectic based simulations is complex and their design process difficult, there is also a need to integrate educational imperatives into the design process In the context of this paper educational imperatives refer to educational design best practice, constructive alignment and pedagogic influence. This is to insure the simulations produced contain educational merit. For example, being able to identify learning outcomes and align such desired outcomes with activities being simulated and end user behaviour being formally or informally assessed. Composition tools should allow the user to compose their simulation and educational models simultaneously, moving seamlessly from one to the other.

While these limitations are recognised as to not cover all the limitations within composition of dialectic based simulations they have been identified to be the most important. This is particularly true of the integration of educational imperatives and complexity of development as they are most unique in the domain that combines both simulations and eLearning.

While certain tools address some of these limitations adequately, there is no one tool that addresses all of them, as seen in Figure 1. The most notable feature, lacking in each application, is a design process which encompasses educational imperatives. While SimWriter does provide some structure in building an educational simulation it does not allow the designer to explicitly state what they wish the learners to be taught. In these composition tools, enforcing the educational correctness is left for the domain expert designer to add habitually rather than explicitly. While all composition tools described are wanting in terms of educational imperatives they did contain features that aided the composition of dialectic based simulations. Of particular note were features highlighted in the complexity of development such as the CSLUs sub dialogue functionality and VISIOn's dialogue representation. In the following sections, there is an examination of an educationally sound design process followed by a case study of an application that all functionality desired in a composition tool.

| | Complexity of development | | Reuse of resources | Scalability | Educational Imperatives |
|---|---|---|---|---|---|
| | Development process | Construction of simulation models | | | |
| Vision | | ✓ | | ✓ | |
| SimWriter | ✓ | | ✓ | | |
| CSLU | | ✓ | | ✓ | |

**Figure 1, Table comparing existing dialectic simulation composition tools**

## 4. PEDAGOGIC SUPPORT FRAMEWORK FOR MODELLING AND COMPOSING ADAPTIVE DIALECTIC SIMULATIONS

Typically dialectic based simulation have been used for education purposes. A key finding in previous educational simulations and multi-media content in general, is that just developing the simulation alone without embedding pedagogical support and best practice may provide an entertaining and informative experience, but rarely produces experiences where key competences are actually obtained. As seen in Figure 1, dialectic based simulations often have no educational imperatives embedded. A methodology needs to be applied, not just for building a simulation but also to include a certain methodology that will ensure a pedagogically sound simulation. To fully understand why this pedagogy is necessary there is a brief examination of learning theory as applied to simulations.

### 4.1. Simulation Educational Theory

Constructivism [Fosnot, 1996] [Duffy & Cunningham, 1996] sees learning as a dynamic process in which learners construct new ideas or concepts based on their existing knowledge and their current educational context. It implies that learners do not passively absorb information but create knowledge through mental construction and engagement. Based on this premise, instructional and pedagogical novelty is required to address the issues of more traditional and static online education (eLearning).

In order to build a pedagogic support framework for composing adaptive simulations, an understanding and appreciation must be had of best practice educational design principles and alignment.

Education involves the activities of instructing, teaching, facilitating and supporting in knowledge transfer/acquisition and learning. Educational development typically involves the detailed process of identifying base requirements and forecasting further demands on learners at all levels. In the case of formal education, this process can be captured in an educational/training development plan or syllabus.

An educational development plan may be used to describe such things as educational focus, educational prerequisites, performance objectives, accreditation criteria, evaluation mechanisms and conceptual scoping [EDP]. A core concept in an educational development plan is termed "Constructive Alignment".

### 4.2. Constructive Alignment

A key aspect of any eLearning development process is alignment. This involves aligning the stated **learning outcomes** with the **teaching methods** used to achieve the outcomes and the **assessment metrics** used to measure the success of the teaching methods at achieving the desired outcomes [Mayes & de Freitas, 2004]. Figure 2 illustrates this cyclical process of alignment.

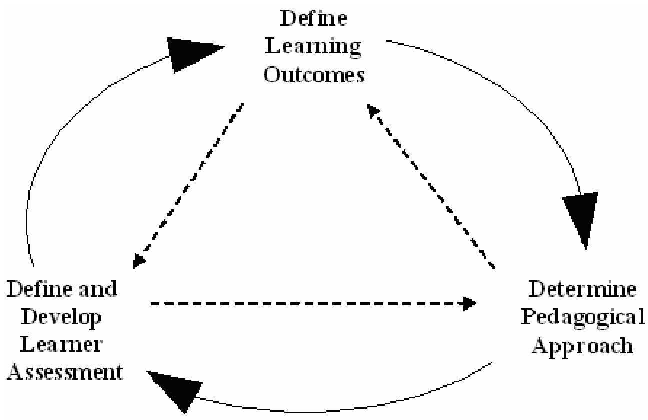


**Figure 2, Constructive Alignment**

Alignment is a cyclical process involving the identification and description of three different steps. The first step being the definition of the learning outcomes. These define what the learner should know at the end of their learning experience. The next step it to determine the pedagogical approach, which defines the teaching strategy to be incorporated to achieve the outcomes. The final step is to define and develop the learner assessment, which describe the ways the learner should be assessed so as so demonstrate what they have learnt.

### 4.3. Alignment and Simulation Development

The development process is at least iterative and at most rapid development. It must balance the incremental effort in designing a simulation and the necessary evaluation and feedback from subject expert and potential learner. Therefore the design process suggested is an incremental agile process in which iteration of the design cycle may need not necessary tackle each design step. It is only through continual iterations of the process and evaluations of the composed course that all design steps become fully satisfied. The balance is between the complexity and effort in executing each design step and the time taken to perform an iteration of incremental value.

The steps, illustrated in Figure 3, consist of the following processes:

- Describe Scenario: this is a high level description of the simulation which includes the context of the simulation and the different roles that it contains. This leads into the description of Learning Outcomes and Pedagogical Approach which can be defined accordingly.
- Define Learning Outcomes: These are the basic cognitive competences to be demonstrated, which are knowledge, comprehension, application, analysis, synthesis and evaluation [Mayes & de Freitas, 2004].
- Determine Pedagogic Approach: The educational strategies and instructional methods that are best suited to achieving the stated Learning Outcomes.
- Learning Outcome Assessment Metrics: The methods and metrics applied to assess the learner's acquisition of the stated learning outcomes of the experience.
- Design Dialogue: this is the design and definition of the dialogue models. This is an iterative step within itself, whereby the designer specifies all possible conversation they wish the learner to be able to participate in and control.
- Implement Simulation: the next step is for the designer to implement the simulation so the models constructed can be verified and tested. This step then leads back into learner assessment which is redefined accordingly.
- Evaluation: as with the educational development, the simulation development is an iterative process, as illustrated in Figure 3. To insure that each iteration is successful, the final step, before beginning the cycle again, is an evaluation of the development process that has just been completed.
- Script Content: On the final iteration of the development process, once the designer is satisfied that all educational and simulation models are completed the content is scripted. This is only completed in the final iteration as it is usually a costly and time consuming process not to be repeated in every cycle.

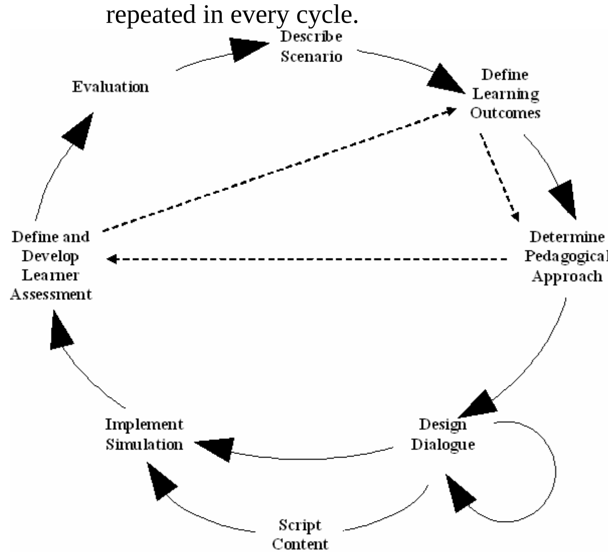


**Figure 3, Pedagogically Informed Process for Composing Adaptive Dialectic Simulations**

This pedagogically informed process creates the base for the pedagogic support framework for composing adaptive dialectic simulations. The following section describes how this support framework and the suite of tools built to support it are used to create real adaptive simulations for teaching communications skills to healthcare professionals in the School of Medicine at the University of Dublin, Trinity College.

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## 5. CASE STUDY: ADAPT COMPOSITION TOOL

ADAPT [ADAPT] is a joint project involving the Knowledge and Data Engineering Group (KDEG) and the Department of Psychiatry at the University of Dublin, Trinity College. While there are a number of eLearning topics being researched within this project, it is the development of a dialectic based simulation composition tool that is the particular focus of this case study. The composition tool, as illustrated in Figure 4, allows a domain expert to design personalised educational simulations. These simulations can then be made adaptable to the needs of the learner. The application of adaptivity at the composition level is completed in a manner so as not increase the complexity of composing the dialogue models. The designer would create the dialogue models first. Only after completing the dialogue model would the designer indicate how and where the adaptivity should take place. Composing the adaptive simulations in this manner insures not to put extra cognitive effort on the simulation design process.

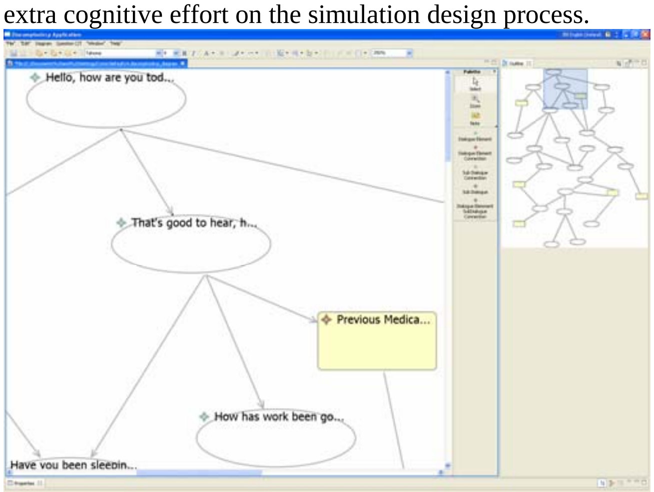


**Figure 4, ADAPT Composition Tool**

### 5.1. Visualization of Dialogue Model

The key challenge of composing a dialectic based simulation is the representation and visualisation of the dialogue. To achieve this, it is necessary to decompose a dialogue into its basic elements. Each of these dialogue elements (ellipses in main window, Figure 4) consisting of a *'statement'* and corresponding *'response'* that would take place within the dialogue. For example, a dialogue element could consist of a *'statement'* from one person *"Hello, how are you today?"* with a *'response'* form another person *"I feel fine"*.

The flow of the dialogue and possible dialogues that can take place can then be described through directed linking of different dialogue elements (directed links to and from ellipses, Figure 4). This allows the designer to build an acyclic graph to show the possible branches that will be available within an overall dialogue on different topics. These graphs are collapsible so one node can become a sub-graph/sub-dialogue (rounded rectangles, Figure 4) within itself. This is how different dialogues on different topics can be linked together. As this dialogue space can become very large and complex, navigation tools such as a map, zoom and search are provided.

An example of how a designer might construct part of a dialogue would be to first add a dialogue element to the dialogue canvas space. They would then set the *'statement'* and *'response'*, which could be *"Hello, how are you today?"* and *"I feel fine"*. The designer would then add another dialogue element, also setting its *'statement'* and *'response'*, which could be *"That's good to hear, how is your family?"* and *"They are well"*. The designer would then direct the first dialogue element to the second element with a link. If this branch were to be traversed the dialogue would run as follows:

Person1: *"Hello, how are you today?"*
Person2: *"I feel fine"*
Person1: *"That's good to hear, how is your family?"*
Person2: *"They are well"*

### 5.2. Application of adaptivity

Adaptive (Personalised) eLearning provides support for eLearning content, activities and collaboration, adapted to the specific needs and influenced by specific preferences of the learner and built on sound pedagogic strategies. In an eLearning experience, for example, personalisation could involve the selection of the most appropriate learning resources based on the learner's preferred learning style (more pragmatic learners could receive more examples or more interactive content) or the selection of the most appropriate subject concepts based on the learner's prior knowledge of the specific subject area or the selection of the most appropriate learning paths. Not only does personalisation provide a better learning experience, it also reduces the number of simulations that need to be authored. Two levels of adaptivity have been examined within the ADAPT project, element level adaptivity and branching level adaptivity.

**Element Level**

At this level adaptivity is applied to a dialogue element. While the information contained within an element is preserved, the manner in which it is presented is adaptable. As previously stated a dialogue element consists of a *'statement'* and corresponding *'response'*, which could, for example, be *"Hello, how are you today?"* and *"I feel fine"*. Instead of having just one type of *'response'* associated with the dialogue element there could be several. Each *'response'* conveying the message of *"I feel fine"*, but communicated in different ways. The *'response'* could, for example, be happy, sad, angry, depressed, etc. The dialogue element could then be adapted so its *'response'* is suited to the situation or context of the simulation.

**Branching level**

This adaptivity applied over an entire dialogue based on the inclusion of certain topics that are to be covered within a simulation. These topics relate to certain sections within a dialogue, usually encapsulated within a sub-dialogue. Topics not to be included in the simulation dialogue are 'pruned' from the dialogue space. For example, in a scenario where the learner is a doctor and the person being simulated is a patient and a topic to be included in the simulation is family history. The sequence (sub-dialogue) that details this topic would then be included in the simulation.

The following section describe the ADAPT composition tool with respect to the limitations identified in the survey section.

### 5.3. Analysis of ADAPT Composition Tool

In this section, the ADAPT composition tool is examined using complexity of development, reuse, scalability and integration of educational imperatives.

**Complexity of Development**

The development process for composing a dialectic based simulation is described in design process section. This is a complicated iterative procedure, blending several different aspects of computer design, from the ACCT course construction methodology to simulation phase development similar to that of SimWriter [SimWriter]. The difficulties involved in the **construction of the dialogue models** are themselves a separate set of complexities. The key being to decompose a dialogue into a collection of related dialogue elements. Where each dialogue element is represented by a node and any relationship between them represented by a directed edge, a methodology similar to that of the CSLU toolkit [CSLU]. However, in this case each element does not represent a single part of dialogue but instead a couplet of dialogue, with a *'statement'* and corresponding *'response'* as they would occur in a simulation of dialogue.

**Reuse**

The ADAPT composition tool was designed to support different levels of reusability. This includes models, model elements, dialogues and sub-dialogues. The reuse of a single model for multiple situations and learner roles through adaptivity is the most innovative form of reuse within the ADAPT composition tool.

**Scalability**

The aim of the ADAPT composition tool is to allow the user to create very complex intricate simulations. To do so it is necessary for the designer to create very large dialogue models, this became apparent in VISIOn. To aid in managing these large spaces several different navigation tools were included in the composition tool. Including a magnifying function to increase and decrease the size of the canvas; a map of the canvas which can be used to quickly move from one part of the canvas to the other; a search function; a function to allow sub-dialogues to be generated, allowing for encapsulation.

**Integration of Educational Imperatives**

Integrating educational best practice into a simulation is a complex task as previously described. This is achieved in the ADAPT composition tool by allowing the user to first define their learning outcomes with a limited vocabulary. The user can then assert an association between the learning outcomes the have defined and sub-dialogues that exist within the dialogue space. As the user develops the course, following the pedagogical framework outlined previously, they have a direct link between the simulation model and educational imperatives.

The dialectic simulations produced using the composition tool are used in training medical students best practice in communication skills although this approach can be applied to teach a vast range of communication skill regardless of context. The research is founded on a wealth of experience from KDEG and Psychiatry in personalisation and adaptive hypermedia systems, communications skills training and simulations, is based on prior research such as, VISION [Armstrong, 2002] and ACCT [Dagger, 2006], and from the limitations identified in the state of the art.

The ADAPT composition tool was implemented in Eclipse [Eclipse] with a suite of plug-ins.

## 6. CONCLUSIONS AND FUTURE WORK

Dialectic based educational simulations have clear benefits but their main disadvantages lie with the complexity of their composition [Page et al, 1999], lack of reusability and the need of pedagogic scaffolding within their design process. The goal of this paper was two-fold, firstly to highlight the limitations of current design methodologies and limited modeling design techniques. Secondly to outline the ADAPT application which combines a solid educational methodology with a suite of tools to aid the user in the design of their models. This research is ongoing and future work includes; evaluation of the composition tools usability; full implementation of personalization; and model validation. Although progress has been made in overcoming the complexities of composing educational simulations, a great deal of research is still needed.

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