Developing a Framework for Automated Scenario-Based e-Learning Design

***Abstract*– Scenario-based e-learning can be used to enable students to develop expertise, in situations that are rare or infrequent, too hazardous for the inexperienced, too expensive to permit practice and failure, or simply not available. Developing automated courses requires significant technical ability, separate from the subject expertise of the educator. This paper introduces a framework developed to simplify this process, along with a scenario authoring and cloud-based training environment, Pandora.**

Keywords - scenario-based e-learning; accelerated expertise; scenario authoring; cloud-based training; authoring and development framework.

I. Introduction

The concept of scenario-based learning is inherent in modern educational practice, with educators referring to 4 types of scenario – skills-based, problem-based, issues-based and speculation-based [1]. However, it has a far longer history, being essentially derived from storytelling, which has been used as an educational technique throughout human history. When designing learning materials, it is standard for educators to consider how to present factual and technical information in a compelling way, that will engage and enthuse their audience, encouraging them to study often complex subjects more willingly. Many educators have a fund of stories, from their own experience or derived from the literature, that they can bring out to liven up a lecture or presentation at need. Likewise, anecdotes can be used to make technical explanations and answers more easily understood, or to contextualise them in a way that is useful to the audience. While some more abstract concepts may be difficult to reify, and require curious metaphorical devices such as living/dead cats in boxes, flashlights and passing trains, or even the use of bongos, in general the use of practical scenarios can ease and improve the learning process. However, whilst it is quite easy for an educator working face-to-face with a group to determine whether or not a scenario is effective, and when to offer more information or even change the focus, this becomes much more problematic in digital online learning situations. Scenario-based learning in digital online systems requires a more detailed and complex set of activities to get the story from the educator to the audience, and since the majority of educators are inexperienced or incapable of preparing online learning materials, the intervention of eLearning specialists is often also required. Unfortunately, in order to capture the original intention of the use of the story or anecdote, requires either that the educator develops skills in developing online learning materials, or that the eLearning specialist utilises Knowledge Acquisition (KA) skills [2] to elicit, analyse and interpret the educators story, in context, to reproduce it with fidelity online. In reality, both of these options have occurred, but it is not sustainable to expect either that all educators and experts of all sorts develop expertise in eLearning, or that all eLearning specialists become expert in all domains. In fact, the key argument must be that this is a digital domain, the systems that have been developed to deliver these materials are computer-based, and it should be feasible to develop models or frameworks for the design of scenario-based learning that are simply and readily translatable into such systems, without the significant redevelopment of the skillsets of the humans involved. This, of course, translates in to a research question – "Can a framework be developed for automated scenario-based e-learning design that readily translates learning materials into an online system?"

The rest of this paper sets out how the authors have gone about answering this question: Section II provides a review of scenario-based education and the existing research in this area; Section III sets out a brief overview of the Pandora^{+} system developed by the authors; Section IV describes scenario-based design using Pandora^{+}; and Section V provides some conclusions and a description of future work in this area.

II. Review of scenario-based education

As described in the Introduction, the use of scenario-based learning, particularly in the form of storytelling, has been a staple in education throughout human history, alongside game-playing, which has similar antecedents. Whilst there is a rich heritage of playground games and stories that children use to socialise and explain the world to each other [3], they also provide the background against which children become open to the use of games and stories as methods of teaching and learning. For the educator, the benefits are in the opportunity to provide realistic stories in safe situations, provide opportunities for skill-development and problem-solving, and the chance for students to learn from their mistakes, again in a safe situation. As Errington [4] describes, it also provides a bridge over perceived gaps between subject theory and professional practice. There are a plethora of different descriptions and titles assigned to scenario-based learning, from simulation to scripted role-play, and it is also frequently described by one of the sub-types described earlier, skills-based, problem-based, issues-based or speculation-based learning. However, the key concepts

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in designing scenario-based learning, as described by Clark [5], are:
"1. An authentic scenario or task assignment that serves as a context for learning.
2. Learner guidance while responding to and resolving the problem.
3. Feedback on problem solutions or problem-solving processes.
4. Explicit opportunities to reflect on problem solutions."

When designing learning materials for online learning, the terminology now transforms to Scenario-Based e-Learning (SBeL), which is defined thus:
"Scenario-based e-learning is a preplanned inductive learning environment designed to accelerate expertise in which the learner assumes the role of an actor responding to a work-realistic assignment or challenge, which in turn responds to reflect the learner's choices." [6]
This introduces an important aspect of SBeL in the acceleration of expertise. In essence, the argument is that many workers in a variety of industries, as well as students, need opportunities to be exposed to particular work situations, which may be uncommon, hazardous, difficult to understand, or multivariate (requiring skills from more than one expert). Utilising SBeL to provide those opportunities allows them to gain expertise more quickly, safely, and also allows them to make mistakes and learn from them, without danger and without having to wait for the opportunity to arise in reality. Many instructional videos and software programmes offer this kind of SBeL for industrial equipment, specialist software, tools and procedures, frequently developed by the manufacturer as part of the support mechanism for their product [7].

There are a number of arguments presented as to what constitutes SBeL and what does not, with Clark & Mayer [6] arguing strongly that it is neither simulation nor a game. However, there are competing arguments that there is a subset of serious games, called scenario-based games, which at least overlaps with SBeL [8], and that, likewise, there is considerable crossover with Simulation-based e-learning [9].

Whilst a number of specialist products have been developed to provide support for SBeL development, such as Emergo [10] and Pandora^{+} [11], the bulk of the existing SBeL implementations have been developed using existing tools, ranging from simple presentation tools with hyperlinks, through virtual learning environments, to animation and visualisation tools.

Having identified the importance of SBeL, the next consideration is how to design it, and here there is a need to make a distinction between scenario-based design [12], which considers user and usage scenarios as a design technique for human computer interaction (HCI) systems, and design of scenario-based e-learning, although there is some crossover in theory and techniques.

A. High level scenario design – the big picture

There has been considerable discussion in the literature about how to design scenarios [1][6][8] but the general consensus is that the following areas need to be considered:

- Who is the audience?
- What you would like the audience to learn (learning outcomes)?
- The nature of the scenario i.e. will one choice lead to another etc. and if so does the scenario branch providing a limited number of outcomes i.e. do learners learn from their mistakes? [5] Or, is the purpose of the scenario to open up discussion, make the students think, with perhaps a linear route through and consequences of actions which don't branch the scenario?
- Whether the assessment and feedback is built into the scenario or whether there is some post-discussion analysis as part of the assessment and feedback. Either way the type of feedback needs to be considered e.g. is it instructive (participant is told whether the answer is right or wrong) or intrinsic (consequential feedback) where the consequences of decisions taken are shown to the participant. Both of these could be immediate or delayed, and in order to decide there is a need to link back to the goals of the training session. Detailed feedback is important to learn why a choice was the correct one, not just that it was, as the learner might have chosen it for the wrong reasons. The design and timing of reflection and feedback is important to the learning experience [6]. Note that reflection may not always be a comfortable process as it forces the student to think about their own competence, however one of the most powerful forms of feedback in this situation is expert comparison [12].
- Physical location of the training / education e.g. in a lab or in situ, can affect the realism of the training. Ultimately there is unlikely to be one right answer, there may be a tradeoff in all these aspects.

In terms of scenario design, a sequence of steps has often been presented as guidance to scenario designers in much of the literature, typically covering identification of the audience and the learning outcomes, select a scenario situation, select the type of scenario e.g. skills based, problem-based, select the situation or problem to be solved, and identify how the reflection / discussion / feedback will be undertaken.

- Are the outcomes based on skills development or problem-solving?
- Is it difficult or unsafe to provide real-world experience of the skills?
- Do your students already have some relevant knowledge to aid decision-making?
- Do you have time and resources to design, develop, and test an SBeL approach?

- Will the content and skills remain relevant for long enough to justify the development of SBeL?

B. *Outline Scenario Design or detailed Scenario Design?*

Generating a detailed scenario can be a time-consuming, creative and complex process as there are many aspects to consider. The documentation of the final scenario will depend on the depth to which it needs to be created in advance. A considerable volume of scenario-based education relies on the educator, who can use scene-setting and their own expertise to enhance debate and guide learners into thinking more about the problem they are trying to solve. For these types of scenario, an initial scene setting and set of guidance notes for the facilitator might be sufficient [13].

The situation becomes more complex when there is more of a story involved and learners need to progress through a specific route to get to the endpoint, however the scenario is essentially a linear progression. That doesn't mean there aren't discussions along the way or some distractions but essentially progression of the learning route is fairly clear. For these types of scenario, the use of storyboarding, which is heavily used in games and the film industry, may be useful to outline the key stages of the scenario and the progression between them.

It is also pertinent to note here, as discussed earlier, that as we begin to design more detailed and complex scenarios, the expertise of the educator or the subject expert is challenged by the technological realization of their ideas, and we enter the realm of knowledge elicitation and acquisition [2]. It is for these more detailed and complex scenarios that there is the greatest need for frameworks and tools to simplify the process. However, there is an added element of complexity to consider, as almost all of the research in SBeL is focused on learning in the presence of, or with the support of, educators [1][3][4][5]. In this paper the authors are also describing a framework and tools that can be used to develop automated SBeL, running without the direct support of human educators, and that demands very detailed and well-designed scenarios.

III. Brief overview of the Pandora$^+$ system

A. *Development and use of the Pandora$^+$ System*

The Pandora system [14] was originally developed as a smart environment designed to train Gold Commanders in crisis management. It was developed as part of an EU FP7 project called PANDORA [15] which ran between Jan 2010 and March 2012. The focus of this early research was to develop a mode of operation where a group of trainees from different agencies e.g. fire, police, health, had to work together to find a solution to a crisis situation. We call this mode 1 and it is a synchronous mode of communication because the group of trainees experience the same scenario at the same time and are jointly working together to make decisions as a scenario unfolds. The training session is managed by a trainer who can observe or be involved as they see fit, for example, they could pause the scenario to have a discussion with the trainees or influence their experience as the scenario unfolds, for example by adding an additional event (inject) whilst the scenario is executing, or to speed up the running of the scenario, to place more pressure and stress on the trainees as would be the case in a real crisis situation.

Another mode of operation was developed during a second EU FP7 project called POP-ALERT [16] which ran between April 2014 and March 2016. The focus of this project was about how to alert the population in the event of a crisis and this included an analysis of how prepared they were for such a crisis, and their plans for preparation. Because the Pandora$^+$ system was to be used with members of the public, a second mode of operation was required which would allow an individual to work through a training scenario on their own, potentially in their own home as opposed to a training centre, with no trainer present. In this mode the training events and timings would not be adjusted during the training session other than the trainee being permitted to get the next event early if they were ready for it. Otherwise the events would be delivered to the trainee at the pre-determined times set by the design. We call this mode 2 and it is an asynchronous mode of operation, meaning that the trainees experience the scenario individually, whenever they want, wherever they are. This means there is no coordination or communication through the Pandora$^+$ system, with a trainer or other trainees during the training event. Whilst it is possible for individuals to undertake the training wherever and whenever they wish, the training could be run at a training centre with a trainer present to introduce the training event and the scenario and / or discuss the training experience, and to-date this has been the most popular way to utilise this mode.

Note that both modes can be run in two ways, either where the trainees are co-located in a classroom or where the trainees are in different locations using the Pandora$^+$ system over the web. Indeed, if desired, mode 1 could be run with groups of trainees co-located in different places e.g. a group of firefighters could be co-located in a room in place X and a group of police could be co-located in a room in place Y, both working through and experiencing the same scenario as it unfolds, making joint or independent decisions that affect how the scenario unfolds to all trainees.

Both mode 1 and 2 are being used, and further developed, in the H2020 TRILLION project [17] which runs from Sept 2015 to August 2018, and another H2020 project called GEO-SAFE (Geospatial based Environment for an Optimisation and Spatial Statistics System Addressing Fire Emergencies), which runs from May 2016 to April 2020, to train Law Enforcement Officers, Firefighters and the public.

B. *Design of the Pandora$^+$ System*

The main rationale for the design of the original Pandora System was to provide a more emotionally engaging, realistic experience for trainees, than a regular tabletop exercise, where trainees are typically provided with a paper based description of a scenario they have to discuss. An alternative to a tabletop exercise is the simulation of a real part of a scenario which is very emotionally engaging however these exercises are

extremely time consuming to design, prepare and execute, and ultimately can only yield a limited number of outcomes and typically run once. The Pandora+ system is designed to find the middle ground [18] – immersive, emotionally engaging, quick to upload a scenario into the Pandora+ system, with as many outcomes as the scenario author desires and be used repeatedly to train multiple groups of trainees. With a tabletop exercise a trainer may have limited capacity to adapt a scenario on the fly in response to the approach taken by a group of trainees to solving a problem, however in the Pandora+ system the trainer has a variety of tools at their disposal to adapt the trainee experience during execution e.g. to speed up or slow down the execution of the scenario, or to introduce a new event / inject on the fly, in order to raise or lower the stress levels, of the trainees.

A summary of the main requirements for the design of the trainer functionality, derived from all projects to-date, all of which have been implemented, can be summarised as follows:

- To be able to present the crisis as an unfolding series of events to and individual or group of trainees (modes 1 and 2), the duration of each event being pre-determined but with the possibility to adjust during a training scenario.
- Initially an event was either a piece of text or an image or a video etc. however recent requirements have been to offer the possibility of composite events i.e. an event which could contain some narrative, followed by an image, followed by a question for the trainees to answer.
- The ability for a scenario to branch depending on the decisions made by the trainees and thereby providing as many possible outcomes as desired by the scenario author.
- When problem solving under stress, as is usually the case in a crisis situation, it is well recognised that decision making behaviour can change [19]. It was therefore important to provide the trainer with the appropriate tools to manage the stress of each trainee through e.g. integration of biometric monitoring (e.g. heart rate / EEG), or to
- The trainer should also have the ability to adapt the scenario during execution in response to the perceived stress of the trainees or their discussions e.g. speed up / slow down the execution of the scenario or to insert a new event (inject) and send it to one or more of the trainees.
- The ability for trainees to communicate with each other through the Pandora+ when trying to solve a problem or make a joint decision about what action to take, and for the trainer to observe this and annotate events during the execution as memory aids for the debriefing session(s).
- To be able to offer scenario authors, trainers, and trainees a web-based interface in order to permit access anywhere in the world. This has been achieved through the use of cloud technology.
- To provide training on any topic not just crisis management, which is suited for delivery as an event-based scenario.
- Deliver event-based training scenarios suited to both novices and advanced trainees.
- The ability for both the Pandora+ system and the scenario to be presented in multiple languages.

In order to meet the above requirements and to provide as much flexibility as possible, the following key decisions were made:

- The typical focus for the applications in which the Pandora+ system has been used to-date have focused on problem based scenario design as defined by Errington [1], requiring trainees to apply both theoretical and practical knowledge to a particular situation using logical reasoning and critical thinking etc. However, it was felt important to design the Pandora+ system to be able to implement all four types defined and this has been implemented. For example, it is perfectly possible to implement a speculation-based scenario by asking trainees to predict the outcome of an event, or to implement an issue-based scenario by asking trainees to take a stand on issues and discuss a stance they would take in a specific context, or finally to ask the trainees to apply the skills they have learned to a specific situation.
- In order to accommodate both novice and advanced learners, Clark & Mayer [6] recommend that in a problem solving exercise, immediate feedback is provided to novice users (instructive), however for advanced learners, it should be delayed to allow them to learn from ineffective paths (intrinsic). The expected mode of use in the Pandora+ system is for learners to experience the consequences of their decisions as a scenario branches based on these, however it is perfectly possible to provide a more linear scenario where trainees are asked to make a decision, but receive immediate feedback on their choice which they can take on board for the remainder of their decisions. To-date this mode is mode commonly used for training members of the public. However, in either mode, the system provides the trainee with the ability to compare their answers to that of an expert, whether there is considered to be one right answer or whether it is only appropriate to provide an example of a good answer. This information can be set up in advance and associated with an event. Once the training has been completed, these additional explanations or example answers are displayed alongside the training record, provided to a trainee at the end of their learning and can be used for self-reflection or for discussion with a trainer if one is present. Note that for mode 1 i.e. where the trainer is managing a group of trainees, the trainer has the facility to view the training record of each trainee in order to have a personal discussion / debrief with them, or to view the records of all the trainers together, ordered by the time of an activity, for a group discussion and debrief if preferable.

IV. Scenario-Based Design using the Pandora+ system

A. *Framework*

As identified earlier, there is a wealth of literature on scenario design however, in the majority of situations, a computer system is not used. However, where it is, a human facilitator tends to lead the delivery of the learning supported by a computer system, as described by Huffman [9] inter alia. The work described here is very different in that the Pandora^{+} system will typically execute the training exercise with minimal or no intervention by a trainer. This means that a scenario needs to be scripted much more precisely than if it was used to support a trainer in a dialogue with their trainees.

A training exercise will be authored by a trainer or a scenario expert specifying the sequence of events that will occur as the scenario unfolds, the roles within the scenario, which roles receive what event, the duration of the events etc. Note that the scenario is not executed in real-time as it could take place over hours or days. For example, an event could occur 30 minutes after the last one in real time, however in scenario time, it may be experienced by the trainee perhaps one minute after the last event. The decision is up to the scenario author, however, as discussed above, there are options to vary the original plan, during scenario execution. Experience shows that generating a non-trivial scenario is an interactive process of design and debate, either with a group of people or in the head of one person, in order to home in on the key decisions and routes through the scenario.

The framework we have used for the process of design is similar to the process used by others such as Huffman [9], but is defined in more detail due to the nature of the requirements being solved here. It is also important to recognise that this is an iterative process, as with all learning materials there is always the need to update, revise and sometimes repurpose. The key steps in the design and implementation are articulated in diagrammatic form in Figure 1 below, and then described in more detail:

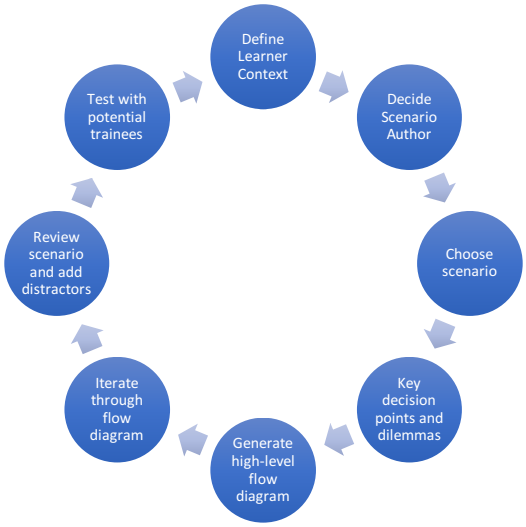

Figure 1: Iterative Scenario-based e-learning Design Process

1. *Define the learner context*: this step defines who the learners are, what the learning outcomes are (e.g. is this something a learner would encounter on a daily basis or a very rare event you would like them to have some experience of, helping them to accelerate their expertise? [20]), whether the learners are novice, advanced, or a mixed group, where the learning will take place, the approximate duration of the learning etc. These are not trivial questions to answer and when working with experts, who may well have experience of designing scenarios for other forms of delivery e.g. tabletop or real simulation, experts can still find this hard to articulate.
2. *Decide the scenario author(s)*: this may be the person who intends to deliver the training but if not, then there needs to be some consideration of training for the trainers to deliver the training exercise.
3. *Choose a scenario* – this should stretch the trainees and contain sufficient challenges to ensure that the learning outcomes can be met, whatever route through the scenario is taken. This is not a trivial design exercise, and will likely be an iterative process. In the context of the EU projects worked on to-date, the authors, whose expertise is in computer science, found it best to form a brainstorming group with the expert to help them develop and structure the design of their scenarios. This provides a challenge to ensure that not only does the scenario remain realistic but that it continues to meet the learning outcomes defined. A core decision in the choice of scenario is the level of realism required. As discussed in Huffman [9], a decision needs to be made about three types of fidelity: physical fidelity is where the "simulation looks realistic", has the right equipment etc.; conceptual fidelity focuses on whether the "theory, meaning, concepts and relationships" make sense; and finally emotional fidelity concerns "actions and relations of an emotional kind".
4. *Key decision points and dilemmas*: a decision needs to be taken about when a trainee, or group of trainees, needs to make a decision, and whether it is possible at each of these points in the scenario to create a dilemma. If this is not possible then all trainees may be able to guess the obvious answer. Thinking about generating decisions that address the educational objectives may be helpful [21].
5. *Generate a high level flow diagram:* this should outline the key events and decisions that branch the scenario. The draft could show an alternating pattern of: information – decision – information – decision etc. At each decision point, ensure the scenario has generated at least one viable alternative to the desired option, if one exists, or the key decision point, and all those that follow, will have to be reworked. Whilst this might sound obvious, experience of working with experts has shown that this is not trivial.
6. *Iterate through the flow diagram*: once you have generated the desired route through the scenario, return to the start and work out what happens on the next branch of the flow diagram, adding as many alternatives as appropriate. In

taking this approach, it will not be uncommon to update or rethink other routes as this occurs, despite best intentions in the original design. Note that there may of course not be a correct route, depending on the training, in which case, it is still generally easier to follow one branch of the scenario to the end and then work through the other branches, in order to generate the final flow diagram.

7. *Review the scenario to enhance, refine and add distractors*. Distractors in multiple choice terms are alternative answers i.e. different decisions [21], however in the context of scenario design, they can be used slightly differently, for example, Huffman [9] uses them not to create alternative branches in the scenario but to create more complexity and realism in a situation in order to make it more challenging. An example could be to raise the chaos level in an emergency room, or introduce people who make a mistake, or to lose a resource a trainee had expected to have available. The aim being to provide a more challenging decision-making environment, but not to affect the core storyline. A distractor could also be introduced early in a scenario, with the intention of seeing if the trainee remembers it later on in a scenario and makes use of it. Indeed, distractors could turn an event into a mini scenario in itself.
8. *Test the scenario with potential trainees* – It is very difficult for scenario authors to test their own scenarios. They can check that the intended paths through the scenario work correctly. However, in terms of whether it feels authentic, or whether some branches have obvious answers resulting in redundant paths through the story, these are hard to do as an author, as they are often too close to the scenario.

A. *Documenting the scenario*

Authors of scenarios have used a variety of techniques to document scenarios, however research has identified none with the rigor that would be sufficient for the automated delivery of a scenario to a trainee, other than perhaps that described in Stewart et al [22]. However, the type of scenario described in that paper is different to those delivered by the Pandora$^+$ system. During the four EU projects in which the Pandora$^+$ system has been used and developed [11;14-18;20], a variety of automated scenarios of increasing complexity, from linear scenarios with no branching, to complex scenarios that have a considerable volume of branching and decision making, have been developed and proven to work. With the potential of completely automated running of a scenario, with no outside human intervention, the documentation needs to be complete and rigorous with no room for ambiguity, in order to be implemented in the Pandora$^+$ system. The documentation is not just used for design, but also as a visual aid to understand the final design of the scenario. Whilst the Pandora$^+$ system has a graphical tool showing the tree structure of how events (nodes) are connected, which can aid visualization of a scenario and make the input of a scenario very easy (a demo of 5 minutes has proven sufficient for most experts to understand how to use it), it has been found hard to use in the creative design process because of the natural process of iteration. Stewart et al [22] encountered the identical problem and used a combination of word documents, storyboards and flow diagrams to iterate through the creative process of scenario design.

Our approach is similar to Stewart et al [22], who developed an e-learning scenario based authoring tool but also found the need to brainstorm on a whiteboard or paper first, and then to flowchart the outcomes. They then documented each element of the flowchart using a table schema in which they recorded details of each activity and invented their own coding scheme e.g. the use of particular fonts to distinguish between roles and narrative text, and used images as placeholders to show where video would appear. The detailed content, including reflective exercises, are included in the tables and provided a way of visualising the script before entering it into the tool. The detail was such that the content could then be cut and paste from the table schema into the authoring tool. A key conclusion from the authors was that low-tech solutions still have their place.

That experience was very similar to our own. The creative process of storyboarding non-linear interactive scenarios is not trivial and as discussed above requires considerable iteration. This is especially true when the authors are brainstorming the design with an expert, which might also include language barriers, not just the use of a foreign language but also the understanding the language used in the expert domain, and in the training domain. However, their use enforces the discipline and rigor required to design and implement an automated scenario-based learning experience. The documentation of any solution is inevitably dependent on the required format for entry into the authoring system. For the Pandora system and the nature of the information that needs to be entered, a similar approach was developed independently of the work of Stewart et al [22].

In the framework described above, steps 4-7 cover the details of the scenario design and are described in two documents. The main document, around which all other documents are based is the "scenario event flow diagram". At its heart, this is essentially a flow chart showing each event and the flow between them based on the decisions of the trainees. If each event does not require much information to document it, then this document alone could be sufficient. However, in reality each event (node) in the flowchart requires a significant amount of information to describe it fully for the purposes of entry into the authoring tool, and this level of information is too large to fit on a flowchart and still be readable. The solution to this is to use a table, so our events are recorded as rows in a Word table with close to the minimum information in common between the flow diagram and the table. Essentially each scenario event (node) in the flow chart is given a number and a name. Both these are used as identifiers to look up the event details in the "scenario event description document". In practice it would be possible to use only the event number to look up the

details. However, there is a risk in the iterative design process that a number could be mistyped or edited, leading to confusion if that is the only connection between the two documents, so a number and a title was considered safer, although it requires effort in the iterative design process to ensure that these two pieces of information are kept in sync.

In terms of what is stored in the event, for the type of scenarios developed in the projects to-date, these were all very much based on real situations that had occurred and timings were critical. So the content of an event (node) includes the following, however it is recommended that authors store what is useful to them:

1. The event number.
2. The event name.
3. The duration of the event (after which the next event is automatically presented to the trainee, and if a decision was required which the trainee did not take, one is chosen for them – a feature of our implementation of decision making under stress).
4. The real-time in the scenario. To give an example, a training scenario was developed in the TRILLION project [17] to help train law enforcement officers (LEOs) on the use of a social media platform to engage with the public during a child abduction case. Understanding how much real time had passed as the scenario executed could be critical to decisions, as all LEOs know that after the first hour, the golden hour, the chances of solving a crime rapidly diminish as witnesses disappear, memories fade, evidence is lost and those who committed the crime put more distance between them and the crime scene etc. So, in this instance, and it is not true for all scenario-based learning situations, it is important for the trainees to understand how much real-time has passed from the point of the child being abducted. Note that this is entirely different to the time it takes a trainee to experience each event.
5. Summary information. This is left open to the author to decide what is useful to fit on the flow diagram about the event. Experience suggests it is impossible to include all the information you need. However, only recording the first 4 items is insufficient to be able to view the diagram and understand the flow. At the very least, it should include decision choices and labelling of the nodes which follow each choice, as shown in figure 2.

An example section of a scenario flow diagram is provided in Figure 2. Note that if there is a correct path through the decision making then the nodes in the desired route are identified in green boxes.

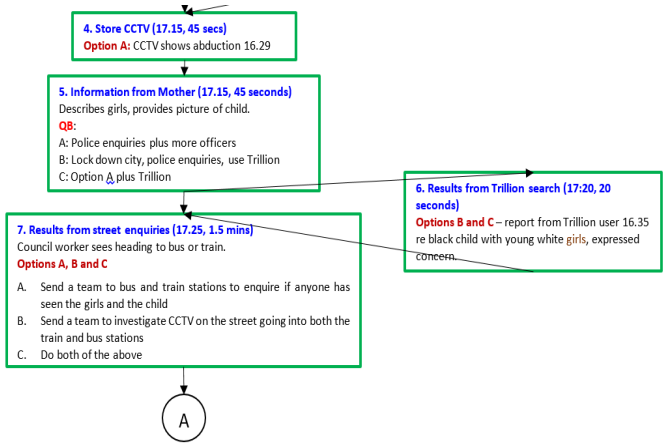

Figure 2. Example section of a scenario event flow diagram document

With regard to the scenario event description document, this contains a table of rows, where each row provides the details for one event and must include all the information required for an event to be entered into the Pandora$^+$ system. This includes the roles from which messages are sent from and to in a scenario, the content of the event, clearly labelling which items will be narrative, video, images, a question which doesn't branch the scenario, a question which does branch the scenario etc. Figure 3 provides a screenshot of the Pandora$^+$ system running the scenario, and Figure 4, at the end of the paper, provides an example of some table entries.

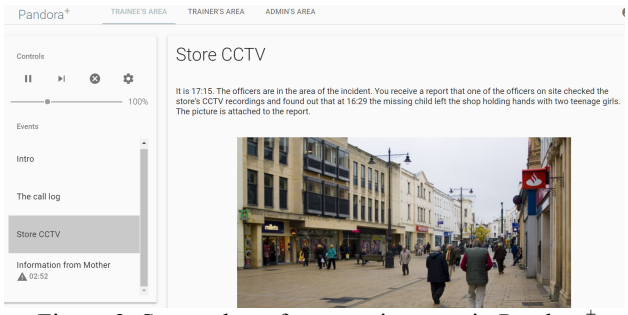

Figure 3. Screenshot of a scenario event in Pandora$^+$

V. Conclusions and Future Work

In conclusion, the authors have used the framework described in this paper, in conjunction with the Pandora$^+$ system, to develop a range of scenarios in EU and other research projects. These have all been used with their target audiences, ranging from first responders to the general public, successfully, as reported in [11;14-18;20]. A number of these scenarios have been designed to run automatically without educator or expert support, and the detailed and rigorous design, combined with a good feedback model, has also proven successful. In future work, the authors are already working on

a public information campaign, associated with the UK Government Run-Hide-Tell initiative for terrorism events, using the automated design process described in this paper. The Pandora+ system has been extended to provide more detailed and structured data analytics on usage and user responses, and these will be utilised in future papers and projects. Scenarios developed for the current projects are already in use, and several more are under development. However, as educators, perhaps the most important conclusion the authors can draw from this work is in the opportunity it offers to address the skills and expertise issues experienced by students and novices within the workplace, challenging the accepted perception that these can only be achieved from actual experience, and opening up a world of accelerated expertise acquisition.

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Event number	Title of event e.g. BBC news broadcast – this will appear as the title of the event on the left side of the screen	Role of Sender to Role of receipient – state role of person in the scenario who is sending the details of the event to the roles of the trainee(s), or "System"	Event types and contents Event types are: (N=Narrative, V = video, I=image, A=audio, D=pdf document, M=map, E=email QN=question which does not branch the scenario, state if multiple answers are valid and if free text is allowed QB=question which branches the scenario) Contents of event e.g. a picture or video to display. Must be in order you want them to appear. Note there can only be one branching question at the end of the event. If applicable, the name (and path location if needed) of the video, document etc. if not already provided in the contents box	Comments for the debrief for questions (if applicable) please state the event type it is associated with	Note changes required for different versions or languages
4	Store CCTV	From Dispatcher to LEO	N: It is 17:15. The officers are in the area of the incident. You receive a report that one of the officers on site checked the store's CCTV recordings and found out that at 16:29 the missing child left the shop holding hands with two teenage girls. The picture is attached to the report. I: 		
5	Information from Mother	From officer who questions the mother to LEO	N: You receive a report from an officer who questioned the mother of the child. Despite being immensely distressed, she provided a very good description of the teenagers and was able to provide a recent photo of the missing child (attached). I: 	QB: It doesn't make sense to put the City Centre on lock down now, since the teenagers left with the girl 46 minutes ago.	

			QB What do you do next? A. Lock down the city, send the team from the store to undertake street enquiries, and ask the dispatcher to send out a message to TRILLION users and check the logs. B. Send the team from the store to undertake street enquiries and submit a request for more officers C. Same as option B, but in addition ask the dispatcher to send out a message to TRILLION users and check the logs		
6	Results from TRILLION search	From Dispatcher to LEO	**N**: A report from a TRILLION user at 16.35, has been found in the logs stating that they saw a black child being led by two white girls and they were reporting it because something didn't "seem quite right". They report that the group were on Northumberland street heading towards the train and bus stations.		Street name needs to be localised for each location
7	Results from street enquiries	From the Lead Officer to the LEO	**N:** At 17.25, street enquiries find a council worker who reports seeing the girls and the child heading towards the train or bus station. Below is a map showing the relevant locations 1=store where child went missing, 2=location of report from TRILLION user sent in at 16.35, and 3=location of council worker. **M:**  **QB:** What do you do next? A. Send a team to bus and train stations to enquire if anyone has seen the girls and the child B. Send a team to investigate CCTV on the street going into both the train and bus stations C. Do both of the above		Change map (and text) to local area depending on exercise location

Figure 4. Example section of a scenario event description