ELECTRIC DREAMS
30th ascilite Conference, 1-4 December 2013
Macquarie University, Sydney

Action-based Learning Assessment Method (ALAM) in Virtual Training Environments

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Specialised and high priced simulators for surgical training, chemical labs, and flight training can provide real-world simulation in a safe and risk-free environment, but they are not accessible for the broader community due to costs for technology and availability of experts. Thus, training scenarios shifted to virtual worlds providing access for everyone interested in acquiring skills and knowledge at educational or professional institutions. Even in this context, we still expect a detailed formative feedback as would have been provided by a human trainer during the face to face process. Whilst the literature is focusing on goal-oriented assessment, it neglects the performed actions. In this paper, we present the Action-based Learning Assessment Method (ALAM) that analyses the action-sequences of the learners according to reference solutions by experts and automated formative feedback.

Keywords: Action-based Learning Assessment, Virtual Training Environments, Formative Feedback

Introduction

The effectiveness of learning and teaching depends on various attributes; most relevant are the context and surrounding in which the learning occurs. Literature studies and classroom lectures are effective ways to generate theoretical knowledge, but are insufficient for acquiring experience about the application of knowledge in real-world scenarios (Kolb & Kolb, 2012). For example, we would most likely trust a historian to research accurate information about historical events from ancient books, but would feel quite uncomfortable to participate in the very first flight of a pilot trained just with books about how to fly. We approve a skillset by conducting either real-world or advanced simulator training; the latter one transferring and simulating all relevant factors within an artificial (virtual) environment. Therefore, creating an authentic learning environment could be seen as one of the most salient challenges in educational research, resulting in a continuous development of new models, frameworks and technologies for an immersive learning experience.

Real world experiences are challenging to replicate in a purely virtual learning environment and generally require the well balanced combination of technology, domain expert knowledge, and developers knowing how to build authentic virtual environments. The need for the virtual environment can be justified with various arguments depicting the infeasibility of scenarios for real world training; i.e., high costs (e.g., aircraft pilot training), high risks of injuries for learners and educators (e.g., hazardous chemicals), or impossibility (e.g., deep space rocket missions or natural disaster recovery). Flight simulations are commonly known to train standard as well as emergency procedures using a cockpit simulation. Detailed replicas achieve authenticity, projection of real-world images on the cockpit window and a pneumatic system for movements create a high degree of immersion for the learner.

The advent of powerful computational devices, 2D/3D displays, human-computer interface technologies, and associated algorithms to process the vast amount of information in real-time has given impetus to further, specialised as well generalised environments (Reiners et al., under review). There are virtual training environments to train students in particular disciplines; e.g., surgery, mechanical engineering, and other domains (Filigenzi et al., 2000; Kizil, 2003; Gunn, 2006; Hockemeyer et al., 2009). The virtual training environment is used to recreate the "real world" in as much detail and authentically as possible. Virtual training environments create a sense of reality for learners, often represented by an avatar, to support the immersion in such a way that simulation "feels" real for the duration of the training; i.e., to engage the learner and promote intrinsic motivation. There are many advances being achieved in terms of automating these environments; e.g. by substituting the human actor for the simulation with so called non-player characters (NPC), bots, and intelligent environments (Wood & Reiners, 2013). It provides learners with independence as they do not rely on others for the learning session (with respect to timing, capacity and qualification), can choose to learn at any time from any location, and can repeat specific situations as long as required without 'wearing out' other stakeholders in this process.

For an effective learning outcome, it is also tremendously essential to assess the learners' activities. Despite all improvements over the last years, the learner is currently still relying on summative feedback; mainly evaluating the successful completion of a learning scenario and achieving the learning objectives; however, this highly limited perspective ignores how the learner reacted on stimuli and applied learned knowledge to make decisions during the learning process. To provide an extensive formative feedback, we cannot restrict our focus on the outcome, but include the learners' sequence of actions to deduct implications for the assessment and formative feedback (Reiners et al., forthcoming). Scholars keep pushing the boundaries to develop intelligent assessment systems that can provide a qualitative formative feedback similar to one being done by an expert human evaluator (Fardinpour & Dreher, 2012). Assessing only the outcome would also implicate that the choice and correct application of actions are irrelevant; e.g. a professional athlete who is winning medals and sets new world records. From a goal oriented perspective, this learner achieved all training and learning objectives and is capable of recalling the skills in a competition. Assume further that the athlete, despite the success, did not execute accurate training units and, therefore, caused extreme stress on the joints. Goal oriented assessment would not recognise this unless the achievements are inferior to the expectations and often after being able to counteract the damage. Another example is exams, where a goal-oriented approach evaluates the answers despite their origin. Yet, we control every action from handing out the exam questions to the final submission, even though the control is mainly about detecting misconduct like consulting an expert via phone during the exam. Overall, it is critical to look at the action sequence that leads to the outcome, either to prevent failures or cheating, but also to allow learners to explore the environment and discover unique solutions based on their experience and prior knowledge.

In this paper, we introduce a framework to assess all learners' actions in a virtual training environment with respect to the learning objectives and to create a computer-generated (formative) feedback as well as improve the self-guided repetition of key lectures, refinement of skills by comparing different training sessions, and the experimental evaluation of errors and their effects on the overall outcome. We are interested in the applied knowledge rather than the memorisation of facts being repeatedly repeated as the ultimate solution to a problem. Note that the applied knowledge equals the 'level of application' in Bloom's taxonomy (Bloom et al., 1956). We continue with a review of relevant literature and introduce the terminology for the *Action-based Learning Assessment Method* (ALAM). Here, we restrict ourselves on a formal description of the method to outline ALAM and its application within *virtual training environments*. We should note that we focus on these environments, but intend to generalise our approach for other virtual environments. We conclude the paper with an outlook on future research.

Background

In this section, we introduce the used terminology to achieve a common understanding. For this reason, we discuss virtual environments in education and action-based learning, and the relevance as well as challenge of providing formative assessment. Here, we restrict ourselves to virtual learning environments and demonstrate the incorporation of formative assessment to improve the learning process. Note that this section does not intend to provide a complete literature review, but argues the need and motivation for our framework and how it can contribute to the field of education.

Virtual Environments in Education

Virtual Learning Environments (VLE) are "computer-based environments that are relatively open systems, allowing interactions and encounters with other participants" and generally provides access to a wide range of resources (Wilson, 1996, p. 8). The “success” of VLE relates to the Internet as it transfers the existing technology as well as the philosophy of the Web to the educational system. Learners and teachers are able to access a learning space that contains all the required materials and information (e.g., classes, class material, assessments, or grades) but also provides communication means that are independent of time and place (discussion boards, chat). VLE become social spaces, building networks, and groups especially in a distance education context.

A special type of VLE is represented by Virtual Training Environments (VTE), such as Intelligent Pedagogical Agents (Rickel et al., 1998), Game-based Tutoring Systems (Craighead, 2008), and Educational Simulation Environments (Dede & Lewis, 1995; Dede et al., 1999). Often, VTEs are realised as a layer on top of a VLE; the VLE provides the necessary functionality to administrate and manage the course while the scenario and interface is represented in the VTE. Different industries are using VTE for their employees. In surgery training, systems are proposed such as collaborative virtual sculpting with haptic feedback (Gunn, 2006), Spinal Anaesthesia (Hockemeyer et al., 2009), the dynamic hip screw surgery training in Vitro (Ahmed et al., 2012), force feedback haptic device for oral implantology (Chen et al., 2012) and many others. In the mining industry, virtual training system applications in virtual reality for mine safety training are extensive (Filigenzi et al., 2000), and some of the VR applications developed by the SMI-VR research group (Kizil, 2003) include drill rig training simulation, open pit simulation, underground hazard identification and barring down training simulation, instron rock testing simulation, accident reconstruction, three-dimensional mining equipment, ventilation survey and real-time monitoring simulations, and virtual mining methods.

The main intention of virtual worlds was not necessarily education, but it has demonstrated the capability to take the distance out of distance education, increase engagement with online learning students, and blend the new environment with the traditional learning approaches from the classroom environment (Wood & Reiners, 2013). Twining (2009, p. 498) further points out “virtual worlds allow you to do things which would be difficult or impossible to do in the physical world – both literally and pragmatically.” Traditionally, virtual worlds provide an environment with basic functionality to build individualised scenarios. Open virtual worlds; e.g., Second Life or OpenSim, offer manifold opportunities to create or import objects; often without any restrictions on defined spaces (Bainbridge, 2007). Virtual experiences to support real-world situations have been used in education in several areas such as teacher education (Gregory et al., 2011), engineering (Bresciani et al., 2010), health sciences (Thompson & Hagstrom, 2011), logistics and manufacturing (Wriedt et al., 2008) and would be valuable in other areas, such as the simulation of hazardous situations for training purposes (Reiners & Wood, 2013).

It is fascinating to observe the shift from VLE and VTE towards virtual worlds; transforming a hard technology with massively restricted freedom on how to manage the administration of the educational task towards a soft technology with an open and unrestricted virtual (learning) space (Dron et al, 2011). Some approaches like Sloodle (Kemp & Livingstone, 2006) link the open space with Learning Management Systems (in this case Moodle) to recreate the course structure with all its elements and tools for assessment. Observing the development of VLE over the last year reveals the struggle to find the right balance of open and structure, of guidance and freedom. However, we require structures and environments like Second Life to transfer the real world into the virtual space such that learners can train in a safe environment (Jarmon et al., 2009). VTE seem to form consent and a context by providing the necessary structure and administrative tools; yet offer the learners enough freedom to explore scenarios to achieve certain learning outcomes.

In VTE and virtual worlds, learners often operate through avatars to represent themselves in the environment; either in the third person perspective showing the whole avatar or the first person perspective where the learner often sees only the arms and hands. The avatar is controlled by the learner using either traditional input devices (e.g., keyboard and mouse), advanced technology (e.g., Kinect or Razor Hydra), or even authentic tools to map the real-world haptic experience to the virtual environment. The input is translated to specific commands being executed by the avatar. The environment is often shared with other avatars; either controlled by other learners or teachers, or so-called intelligent bots or agents being controlled by the computer (Reiners et al., in press). In addition to verbal communication using (voice) chat, virtual worlds allow the learner to use gestures as further means of communication (Traum & Rickel, 2002).

Action-based Learning

Learning-by-Doing or *Action-based Learning* is a valuable methodology for educators and researchers in education, and refers to "all learning that is orchestrated by some activity on the part of learners" (Naidu & Bedgood, 2012). We adapt for the term *action* the definition used for agents in artificial intelligence, "*with action [being] an occurrence caused in a 'certain' way by the 'Avatar'*" (Allen, 1984, 138). Thus, legitimate learning actions may vary from a real participation of students (in building, creating, or drawing something) to learners watching a video clip that is later examined, reflected on, or plants a seed for a later decision making process (Naidu & Bedgood, 2012).

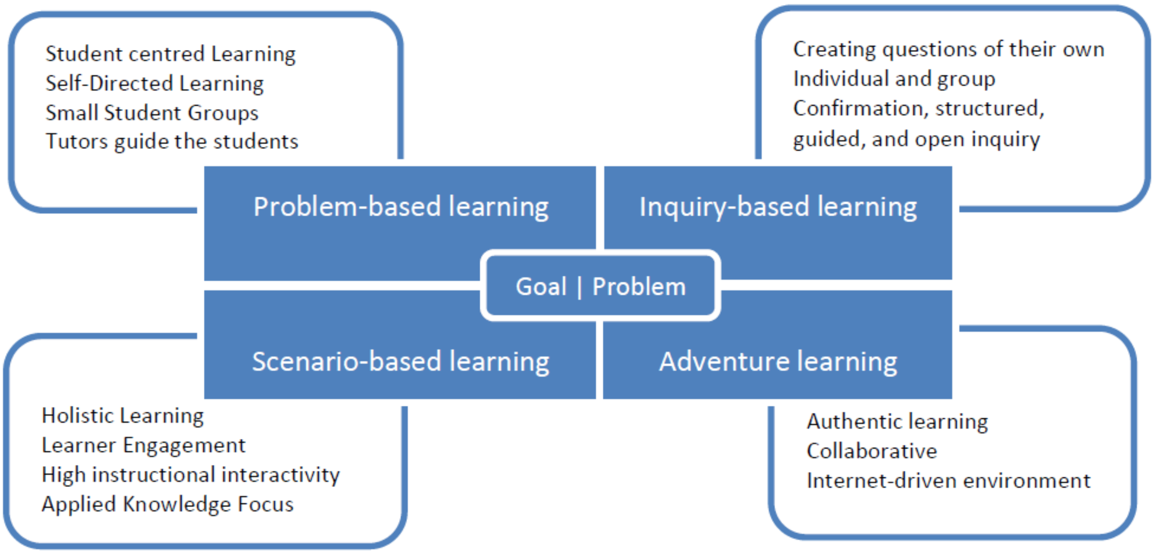

Figure 1: Different types of Action-based Learning

The literature distinguishes different models of action-based learning (see Figure 1). That is, problem-based learning (Barrows and Tamblyn, 1980), inquiry or goal-based learning (Schank, 1997), scenario-based learning (Naidu, 2010), and adventure learning (Doering, 2006). Whilst each of the different types has a distinguished focus or perspective, for all it is common to start from a defined problem or goal, which has to be achieved (Naidu, 2007). Action-based learning characterises a learner-centric model where the learner studies the learning material and then applies the *lesson learned*. This *learning by doing* approach discriminates action-based learning from action learning where learning is achieved "by using personal experience and reflection, group discussion, and analysis, trial-and-error discovery, and learning from one another" (Lasky & Tempone, 2004, p. 87). Action learning appears within a group of employees, by discussing, analysing and solving certain problems. Action-based learning is about actions, which the learner performs in the learning environment to achieve a learning outcome.

Learning Assessment in VTE

Learning assessment is about grading a student's learning outcome, which can be either tangible like a report or artwork, or intangible like skills or knowledge (Sadler, 1989). Scriven (1967) coined the main categorisation of assessing students' learning outcomes in *summative* and *formative* assessment to qualify the assessment to improve the learner (formative), or just rank the outcome in categories like pass or fail (summative). Individual explanatory feedback is one of the key elements in formative assessment and is usually about providing detailed information about the assessment and how it could be improved in the future. It is about making the learner understand, not about reporting numbers and grades (Sadler, 1989). A further differentiation is presented by Rogers (1951), where feedback is classified in evaluation (total score), interpretive (detailed score), supportive (score and guidance information), probing (score with a detailed analysis), and understanding (score and support to understand the reason for deductions). Stages 1-2 (evaluation, interpretive) are summative, and Stages 3-5 (supportive, probing, understanding) are formative. Overall, the learner relies on (formative) feedback to improve and progress in the learning process. Traditional assessment methods (e.g., multiple-choice and closed answer questions) are too restricted to cope with the flexibility, complexity, and creativity that a learner gains with action-based learning (Naidu, 2010).

The use of simulated actions as substitutes for real-world actions in the aerospace industry, especially for pilot training, is exceptionally strong evidence of the significance of learning using virtual worlds and environments. Assessment of learners' mastery in these training environments is mainly based on observation of an expert or videotaping the training and analysing it by the experts after the training session. For automation of this evaluation process, activities in the virtual space can be recorded as a continuous sequence of performed actions; keeping a history of what was done at what point of time; including the environmental information and interaction with other avatars. Actions executed in the virtual space are generally performed using commands through the avatar. For advanced formative assessment, we have to record and analyse the learning path rather than just the learning outcome. Shute et al. (2009) argue that the assessments should be "seamlessly woven into the fabric of the learning environment" so that it is virtually invisible to the learner and, therefore, causing no distraction. The so-called *stealth assessment* uses automated scoring and machine-based reasoning techniques to infer, for example, the "value of evidence-based competencies across a network of skills" (Shute et al., 2009, p. 299). Stealth assessment was formally used by Shute for the first time in 2005 during an AERA (American Educational Research Association) symposium on diagnostic assessment, but it was designed and employed two decades earlier as part of a guided-discovery world called Smithtown (Shute & Glaser, 1990; Shute, 2011). It is mainly used to assess action-choices in games for learning, but it has the potential to be improved and used in training systems as well. Al-Samadi et al. (2012) propose a framework using Stealth Assessment to assess action choices and sequences in serious games; creating formative feedback on the 'interpretive' level of Rogers' feedback classification (Rogers, 1951), in which players get a score.

The benefit of immersing learners into an authentic learning experience is well established in the literature (Hannafin & Land, 1997; Herrington et al., 2003; Yahaya, 2006). There are significant advantages for virtual training systems in which the learner is represented by an avatar. However, there is not yet a comprehensive solution on how to assess students' learning. This establishes a need for further research to design and implement an automated action-based formative assessment in virtual training environments and virtual worlds. To extend the goal-oriented assessment, where we just take a snapshot of the whole learning process and compare it to an expected outcome, to an evaluation of the process of how a learner is reaching that outcome, doing things is challenging. Especially in cases where we have some requirements on actions, but allow also for exploration of the learning space. In addition to comparing expectation and outcome, we also have to identify, classify, and evaluate the learners' actions.

Action-based Learning Assessment Method (ALAM)

Action-based Learning Assessment in VTE is focussing on assessment of goal-oriented actions and action-sequences; reflecting the learned knowledge. These goal-oriented actions include verbal and nonverbal actions, speech acts and gestures. Action choices are also as essential as actions in assessment; they are reflecting the users' learned knowledge and they are classified in 'Application' level of Bloom's taxonomy (Bloom et al., 1956). The design of Action-based Learning Assessment Method is motivated by the theoretical contributions of the educational psychologist Rogers (1951). Action-based Learning Assessment contributes to the theory, practice and public utility; enabling automated assessment of actions and learning at the highest levels of Bloom's taxonomy (Bloom et al., 1956) and demonstration of knowledge - not just the memorization and application of knowledge. The concept of Stealth Assessment (Shute, 2011) has emerged from the computerized game-playing environments where users' activities are constantly being recorded and assessed. The developed Taxonomy of Actions for Action-based Learning Assessment in Virtual Training Environments enables the recognition of relevant actions due to certain goals that have to be achieved or problems to be solved.

What is ALAM?

Action-based Learning Assessment Method (ALAM) is a formative assessment method in virtual training environments, assessing learners' goal-oriented actions and action-sequences and providing them with formative feedback. Assessment of action choices is used in educational games and virtual training systems for summative and formative assessment of memorized knowledge and in some cases application of the learnt knowledge. ALAM creates the opportunity to analyse and assess how learners do things, and not just what they do. The main difference of ALAM to other assessment methods, involving learners' activities, is that ALAM does not restrict the learner with predefined action choices like educational games do. Learners perform the full operation, and they see the consequence of their actions within the limitations of the designed system. Based on performed actions and the sequences of those actions formative feedback will be generated that describes the correctness of learner's performance, possible mistakes and best given solution.

What does ALAM assess?

The Taxonomy of Actions for Action-based Learning Assessment in Virtual Training Environments is developed to classify learners' goal-oriented actions. This taxonomy classifies trainees' actions into *The Goal Act, Constitutive Acts, and Functional Acts.*

1. *The Goal Act:* The Goal Act is the highest level of action in VTE, can be complex and/or composite, which is a specific goal to be achieved by the trainee. The Goal Act is formed of one or more Constitutive Acts; e.g., fixing the rotating shaft or doing a heart surgery.
2. *Constitutive Acts:* to achieve the Goal Act in VTE, trainees need to perform a sequence of high-level compound actions called Constitutive Acts; these high-level actions are composed of other low-level actions named Functional Acts. The objective of Constitutive Acts is to achieve the Goal Act.
3. *Functional Acts:* They are the lowest level of actions in VTE, which enables avatars to act within VTE. Objective of Functional Acts is to form Constitutive Acts. Functional Acts are classified in six action classes: Gestural, Responsive, Decisional, Operative, Constructional, and Locomotive

Functional Acts are classified as follows:

- *Gestural:* These actions are movements in the avatar's body and/or face expressing different meanings, and communicating particular messages, a variety of feelings and thoughts, from contempt and hostility to approval and affection.
- *Responsive:* These actions are responses triggered by changes in the environment or objects; like pushing the button when the green light comes on or taking your hand back after touching the hot metal.
- *Decisional:* Avatars have to reflect their decisions by choosing between different options; like choosing between left or right, up or down, yes or no, quantity, numbers, etc.
- *Operative:* Simple basic acts enabling avatars to function in VTE by executing different non-constructive actions; e.g., push, collect, grab, etc.
- *Constructional:* Simple fundamental manipulative acts allowing avatars to impact on their environment as well as its objects; e.g., cutting, screwing, etc.
- *Locomotive:* Actions empowering avatars to move around or teleport to different parts of the virtual environment to execute their tasks; such as walk, run, fly, teleport, and etc.

In ALAM, action-sequences are encoded in form of a list of single actions using the following syntax: <id><Action.Class><Action.Type>[<Action.Attribute>][<Action.Relation>], with <id> being the position in the sequence, <Action.Class> being a Functional Act, <Action.Type> being the instantiation of different actions (specific representative of the class), [<Action.Attribute>] being a list of possible attributes such as quality, quantity, and locations, and [<Action.Relation>] being a list of possible relations to other actions. Note, that ALAM also recognizes Irrelevant Actions to allow fault-free assessment and comprehensive feedback.

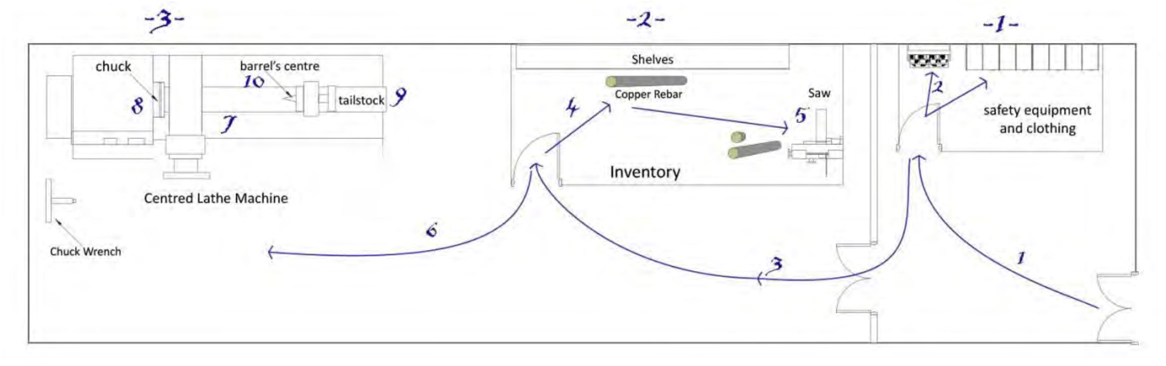

Figure 2: ALAM example scenario- Supporting copper rebar in the lathe machine chuck

The example scenario in Figure 2 shows how users perform different actions in a certain sequence in a virtual machinery shop. The Goal Act is "Supporting copper rebar in the lathe chuck" and the trainee needs to perform three Constitutive Acts successfully. To support the rebar in the lathe machine the trainee has to 1: enter the shop and collect safety equipment and clothing, 2: Choosing and sizing the cooper rebar, 3: Put the rebar in the chuck and fix the tailstock. The trainee enters (Locomotive) the virtual shop, goes to safety room (Locomotive) and collects safety equipment and clothing space (Operative); then moves to inventory room (Locomotive), chooses a copper rebar with a diameter of 0.4 inch (Decisional) and cut two pieces of rebar (Constructional) in sizes 1.5 and 0.5 inch (Decisional). While cutting the rebar, the trainee places his hand too close to the saw blade so by feeling the blade near his finger takes his hand away (Responsive) extremely fast to avoid hurting himself. The trainee moves to the machine shop (Locomotive), and opens the chuck (Operative), puts the rebar (Operative) in it and supports the rebar by turning the chuck wrench (Operative) to the right (Decisional). The trainee then pushes the tailstock (Operative) and puts the barrel's centre to the end of rebar (Operative) and tightens it (Operative). Trainee checks the rebar between the chuck and the centre by shaking it (Operative), makes sure it is tight enough (Decisional) and nods to the operator (Gestural) to turn on the lathe.

How does ALAM work?

Trainees interact with the VTE using different technological peripherals, performing a sequence of actions, to achieve a predefined goal, namely the Goal Act. The recorded data is processed to recognize actions, which are further checked for their relevance and belonging to a specific action-sequence. Then, the trainee's actions and action sequences are compared to the one recorded by experts' in terms of correctness and relevance of actions and action-sequences; based on this comparison and evaluation, formative feedback and an assessment score is generated and provided to the trainee.

ALAM uses Rogers' 5-stage feedback classification, which is still valid and commonly used in assessing students learning outcomes (Al-Samadi et al., 2012; Dunwell et al., 2011). Human markers are capable to provide feedback on all stages. Yet it is far more common to simplify (mainly concerning the workload) the process by designing multiple-choice or short answer assessment. Especially as formative feedback at Stage 4 or 5 requires expert understanding if the answer of the student is valid with respect to the scope and body of knowledge, and if not, exploring the train of thoughts that lead to the given answer. Automating Stage 1 and 2 is relatively easy and often done. The other stages have a higher complexity as it requires understanding of the problem, the context, and often natural language, tasks that cannot yet be done automatically by intelligent assessment algorithms (Shen et al., 2001). The complexity is reduced by specifying constraints to reduce the problem and solution space.

In this assessment method, ALAM, we are interested in actions and action-sequences that lead from the initial state of the environment to a final state where the problem is solved. For each change of state, we record the actions and action-sequences being executed by the learner; providing us with a complete protocol (sequence of actions representing the solution for a problem) of how the learning objectives were achieved. The learners' action-sequences are compared to the expected action-sequences recorded by experts or instructional designers. It is not essential to have a complete match, as the solution to a problem might not be unique. Both these sequences are compared by verification based on the milestones that are needed to find a solution.

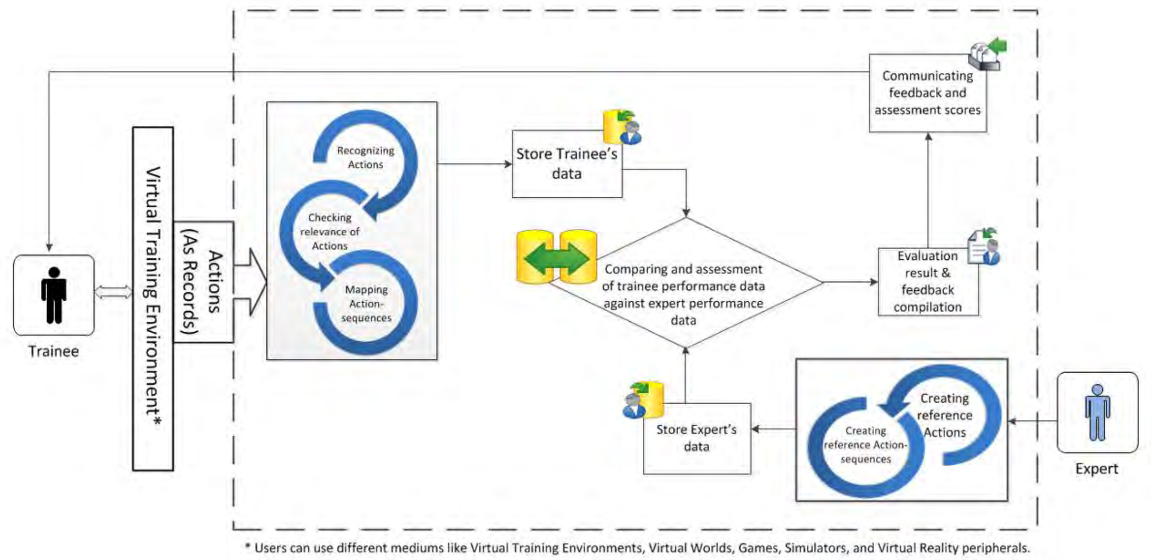

Figure 2: System design for the Action-based Learning Assessment Method (ALAM)

The learner has the opportunity to proceed from one milestone to the next without being constrained in between; yet milestones and their sequential order might be crucial. The restricted scope allows us to implement an immediate formative feedback, being triggered when the learner hits a milestone; see also Reiners et al. (2013).

The system design for ALAM includes a subsystem called Action Recognition Agent that is responsible of recognizing actions, checking the relevancy, and mapping the action-sequences. The output of this subsystem is a list of coded actions with a certain sequence, ready to be used by the Assessment Engine. As a demonstration, you can see this output for Constitutive Act 1 (enter the shop and collect safety equipment and clothing) performed by the user and its reference solution performed by an expert, in Table 1 below:

Table 1: Action Recognition Agent's output for Constitutive Act 1 (enters the shop and collect safety equipment and clothing)

User's Actions and Action-sequences	Expert's Actions and Action-sequences
<1><Locomotive><teleport>[<Enter>]	<1><Locomotive><Walk><Enter>
<2><Operative><read>[<manual>]	<2><Locomotive><Walk><in>
<3><Locomotive><Walk>[<in><SafetyRoom>]	<3><Decisional><choose><equipment>
<4><Decisional><choose>[<equipment>]	<4><Operative><collect>
<5><Operative><collect>	<5><Decisional><choose><cloths>
<6><Decisional><choose>[<cloths>]	<6><Operative><wear>
<7><Operative><collect>	<7><Locomotive><Walk><out>
<8><Locomotive><run>[<out><SafetyRoom>]	

By creating a list like Table 1, the assessment system creates feedback for learners showing the errors, extra actions, and correctly performed actions; all with extended explanations. The system reflects the mapped sequence and compares it with the reference solution. The relevancy of actions will be assessed in three different levels. First level is the lowest rated (Action Class), the second level is Action Class and Type, and the third and the highest level of relevancy is an exact match of actions with the experts' reference solution.

Why do educators need ALAM?

The significance of learning assessment is well established and accepted among educators. Immersive virtual learning environments such as virtual worlds, games for learning, virtual training environments, and simulators play an important role in today's education and assessment is an inevitable part of it. Not all training courses are cost effective and safe or even available. There are so many training courses with high costs and safety issues involving human lives like nuclear power plants, mining, army training, chemical labs, and mining. There are different available 3D virtual training systems to teach these courses but few of them have the ability of assessment and even fewer support feedback. An expert usually creates provided feedbacks during or after the assessment that is so time consuming for experts and very expensive for training institutes and companies and not forget to mention that in so many fields of knowledge, the number of experts is very limited.

To overcome this limitation, ALAM proposes a new approach towards assessing learners, based on their performed actions in virtual training environments to achieve a predefined goal or solve a problem. Using this assessment method provides the opportunity for learners to learn from their mistakes and repeat the assessment until they master it without the waste of financial and human resources. It also enables educators to assess more effectively and efficiently a higher number of assessable learners in less time. Furthermore, educators have the freedom of creating new problems, add different solutions, extend the taxonomy and redefine the actions due to their needs; which offers a greater flexibility.

Conclusion and Outlook

Automated Assessment with formative feedback based on the actions and performances of learners in Virtual Training Environments is still not established. With ALAM, we suggest a method for the educators to automatically assess their trainees, online and in real-time, and overcome the dependency on experts and reduce the waiting time for students to receive their formative feedback. ALAM recognises trainees' actions using the taxonomy of actions for Action-based Learning Assessment, developed specifically to be used for this method. Receiving the list of performed actions enables the assessment system to compare these actions and their sequence against the reference solution to the given problem. ALAM is currently an ongoing research project, yet the first outcomes demonstrate the need for these systems and the potential to provide a powerful tool to educators who use action-based learning and virtual environments. This paper described the concept of ALAM from an educator point of view; thus focuses on the non-technical aspects and the introduction of ALAM itself.

Acknowledgment

Support for the production of this publication has been provided by the Australian Government Office for Learning and Teaching (Grant: Development of an authentic training environment to support skill acquisition in logistics and supply chain management, ID: ID12-2498). The views expressed in this publication do not necessarily reflect the views of the Australian Government Office for Learning and Teaching.

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Please cite as: Fardinpour, A,, Reiners, T., & Dreher, H. (2013). Action-based Learning Assessment Method (ALAM) in Virtual Training Environments. In H. Carter, M. Gosper and J. Hedberg (Eds.), *Electric Dreams. Proceedings ascilite 2013 Sydney*. (pp.267-277) https://doi.org/10.14742/apubs.2013.1369