Affective Metacognitive Scaffolding for the Enhancement of Experiential Training for Adult Learners

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Abstract. The EU funded ImREAL project addresses the question as to how to align the learning experience obtained from a simulated environment with the real world context and day-to-day job practices of the workplace. This requires the development of a radically new way of enhancing these simulated environments to provide augmented simulated experiential learning. A suite of intelligent services are being developed that augment an experiential learning environment by connecting the simulated learning experiences with real world practice in a user-adapted way.

ImREAL is developing tools to support a growth in *knowledge of real world activity* which enables reasoning about what is relevant and how to exploit that relevance. ImREAL will also derive an *augmented model of the learner* which connects performance in the simulated world with performance in the real world Finally, ImREAL will offer *adaptive affective metacognitive scaffolding* via metacognitive tools to provide positively valenced feedback adapted to experience in the simulated and real world, and to promote self-regulated learning adjusted to the requirements of adult learners.

Keywords: Affective metacognitive scaffolding, affect, metacognition, scaffolding, adult learning, experiential learning

1 Introduction: Simulated Environments for Learning

Immersive simulated environments for experiential learning are growing in popularity and will play a key role in tomorrow's technologies for adult training. The major challenge is to effectively align the learning experience in the virtual environment with the 'real-world' context and 'day-to-day' job practice.

The ImREAL project aims to provide a new class of cost effective adaptive systems adjusted to adult learners' needs, pioneering a new psychologically and instructionally sound technological approach to seamlessly link the simulated learning experience and 'real-world' job-related experiences; developing a novel conceptual framework — augmented simulated experiential learning — where innovative adaptive services extend virtual environments by making a connection with the 'real-world'; and delivering a new open framework of intelligent services which can be plugged into virtual environments to enhance self-regulated learning.

In order to leverage real world experiences, the following are the key properties of the ImREAL **augmented simulated experiential learning environment**:

Real world activity modelling — developing a holistic representation of real world activities grounded in job practice and incorporating cognitive, social and affective aspects;

Knowledge-enhanced access to real world experiences — multi-faceted capture of real world experiences through seamless integration of analysis and semantic annotation of existing records, collectively created user content, and storytelling;

Advanced context awareness — aligning the real world activity model with a model of the simulated situation to gain a better understanding of the learners and to map the activities in the simulated world to activities in the real world;

Improved learner models — combining performance analysis in the simulated world with dynamically obtained characteristics of real world activities, e.g. in an interactive open learner model providing an extended understanding of the learners' behaviour;

Adaptive affective metacognitive scaffolding — generating user-tailored affective feedback which can influence the learner's motivation, reflection, emotion and promoting metacognition focused on self-reflection, self-evaluation and self-awareness;

Openness (scrutability) — providing appropriate means to engage learners and tutors/trainers in tuning the environment by allowing them to provide feedback on the quality of adaptation and the mechanisms for promoting metacognition.

In this paper we outline our approach to enhancing how simulations are experienced/used by a learner to promote self-regulated learning (i.e. stimulating motivation, self-reflection and self-awareness and learning competence). More specifically, we outline our approach to the development of intelligent services for affective metacognitive scaffolding. These scaffolding services will interact with the simulation environments to help learners develop a better awareness of their skills, tendencies, practices and training needs/performance. The scaffolding services can be thought of as a 'coach' or 'mentor' (learning companion or buddy) which can (based on context models, learner models or simulation execution feedback) suggest, indicate or promote actions within the simulations or within the overall learning environment to enhance self-regulated learning. The scaffolding services will be delivered via a 'non-invasive' approach so as to ensure that interactions with the learner are perceived as an integral part of the simulation and such scaffolding services do not break the fidelity, momentum or engagement of the learner. By non-invasive we mean interventions that are cognitively approporiate and in line with the instructional model. A non-invasive intervention therefore should seem to seamlessly fit within the immersive simulation, most importantly maintaining the fidelity of the simulation. For example, in an instructional model where training is taking place with oversight by a tutor, the scaffolding intervention may be represented as input from the tutor. This may apply a cognitive load on the learner and interrupt the flow of the simulated interactions they are undergoing, however, it does not invade upon the instructional model, nor overwhelm the fidelity nor flow within the learning scenario as a whole.

There are, therefore, three facets of the framework:

1. A learner monitoring system that is assessing and evaluating behaviour according to pre-defined indicators and learner behaviour.
2. A learner support system focusing on metacognition and affective aspects.
3. A learner support system that relates learner's experiences to peer experiences of similar situations.

2 Affective Metacognitive Scaffolding

Scaffolding has been a major topic of research since the pioneering work of Vygotsky [29] and the key work of Bruner and Wood and colleagues (cf. [31]). Ensuring the scaffolding support is removed as a learner's skills progress (i.e. fading) received more attention as a result of the work of Palincsar and Brown [17] and Collins, Brown and Newman [6].

Work on the use of scaffolding with the help of computer-based learning environments has been extensive (cf. [12]). Originally, the emphasis was on cognitive scaffolding which has many forms (cf. [5]). In the last twenty years or so, there has been a move towards research in metacognitive scaffolding (e.g. [2, 8, 10, 28]) as well as in the use of metacognitive scaffolding in adaptive learning environments (e.g. [14, 3, 24]).

Other forms of scaffolding have also been explored both in educational and technology enhanced learning contexts — such as affective scaffolding and conative scaffolding. Van de Pol et al. [28] sought to develop a framework for the analysis of different forms of scaffolding. In the technology enhanced learning community, Porayska-Pomsta and Pain [20] explored affective and cognitive scaffolding through a form of face theory (the affective scaffolding also included an element of motivational scaffolding). Aist et al. [1] examined the notion of emotional scaffolding and found different kinds of emotional scaffolding had an effect on children's persistence using a reading tutoring system.

There are different forms of metacognitive scaffolding. Molenaar et al. [16] investigated the distinction between structuring and problematizing forms of metacognitive scaffolding and found that problematizing scaffolding seemed to have a significant effect on learning the required content. They used Orientation, Planning, Monitoring, Evaluation and Reflection as subcategories of metacognitive scaffolding.

Sharma and Hannafin [27] reviewed the area of scaffolding in terms of the implications for technology enhanced learning systems. They point out the need to balance metacognitive and procedural scaffolds since only receiving one kind can lead to difficulties — with only procedural scaffolding students take a piecemeal approach, and with only metacognitive scaffolding students tend to fail to complete their work. They also argue for systems that are sensitive to the needs of individuals. Boyer et al. [4] examined the balance between motivational and cognitive scaffolding through tutorial dialogue and found evidence that cognitive scaffolding supported learning gains while motivational scaffolding supported increases in self-efficacy.

While it is recognised that all scaffolding is likely to have a mix of affective, cognitive and conative effects it is also to be expected that there are metacognitive, meta-affective and meta-conative aspects as well. There have been relatively few attempts to examine the ways in which metacognitive scaffolding can be supplemented with affective scaffolding. The key question is whether the affective scaffolding is intended to support performance or the process of learning from the experience.

In this latter sense, affective metacognitive scaffolding is to be understood as various forms of metacognitive scaffolding combined with affective support for metacognition. Rather than, for example, praise a learner for performing at the domain level, the praise is targeted at a metacognitive activity. This approach potentially supports learning from the interaction at the metacognitive level — for example, Roll et al. [24] point out that few systems provide evidence for lasting improvements in student's self regulation skills, and Roll et al. [23] argue that the provision of a metacognitive scaffold does not always lead to metacognitive learning.

For the ImREAL project, we therefore take affective metacognitive scaffolding to mean the provision of an affective dimension to metacognitive scaffolding. This conceptualisation has to be fleshed out further in future work; and adopting this notion does not preclude the project from incorporating elements of affective and motivational scaffolding where appropriate. The affective metacognitive scaffolding services required support metacognitive activities (e.g. Orientation, Planning, Monitoring, Evaluation and Reflection) within those environments by providing appropriately tailored dialogue.

An important aspect of metacognitively adaptive teaching, essential within a process of guided self-regulated learning, is the removal of the scaffolding, allowing the learner to take control/responsibility. It could be said that there are much more serious consequences in too much scaffolding — distraction, annoyance, overwhelming any core subject material and so on, than there are in providing few prompts. The fading of scaffolding, this removal of support, is therefore a key facet of the services provided by the framework. A number of approaches will be investigated including those based on metrics such as the time the user has been engaged with the system, their competency and familiarity with the environment and material; and more complex models of learner behaviour, cognitive dissonance and metacognitive profile.

Recent work by Saadawi et al. [25] reinforced the importance of the intervention not only being appropriate in terms of the frequency of intervention, but also the timeliness — their work clearly demonstrating that feedback should be immediate to be effective. As such, the services provided by the framework will not only be non-invasive but also real-time — operating with minimal separation between the requirement for scaffolding and its provision. It should be pointed out here that the long-term goal for the framework is to provide packaged content for simulation environments — whilst the framework itself may deliver scaffolding content within microseconds, the delivery of the same may be framed within the wider context of the simulator — for example not inserted directly on delivery but rather at a time appropriate to the context of the training simulation.

Work such as Puntambekar and du Boulay's [21] and Lane's [13] typically concerns embedding metacognitive scaffolding WITHIN a particular learning framework. Often technologies which have some kind of support for reflection or other metacognitive activities (Such as Gama's [9]) do this in a manner discontinuous with the training material — in a similar way that early education games often contained crude switches, so-called Shavian reversals [18], between gaming and learning content. In order to avoid this, there will not be a need for the learner to move between different modes either cognitively or within the training environment in order to deal with the scaffolded material.

The service proposed herein will sit alongside learning scenarios, providing contextually aware (in the broadest sense) support. It is important to note that, although the scaffolding service is technically decoupled from the learning system, supporting and training learners' metacognition is not independent from actual domain learning, but should be integrated in that learning process and thus constitute a symbiotic part of the system (e.g. [30, 32]).

3 Implementing Affective Metacognitive Scaffolding Support

Unlike others, this framework is decoupled from the learning system. Whilst support systems in general generate a certain level of dissonance and distraction, that's in line with the real world training experience, where there are both aspects of distraction from the external 'guide' (e.g. the senior registrar overseeing the interview in Use Case A below) and internal cognitive processes (reflection, recollection, application, etc.). The real challenge is to ensure that the interventions during the training encounters are of appropriate and timely content, of suitable size and duration.

Therefore, we will take semantically tagged triggers from the learning environment and delivers scaffolded support, informed by the real world model of the learning scenarios — both in terms of activity and content. The domain model of the training content may not be particularly relevant to the metacognitive scaffolding (it may inform the examples chosen), but the characteristics derived from inferential processing of learner contributions to be a key facet to improving the models of metacognitive behaviour.

Building on the previous work in the area of enhanced personalised learning through non-invasive adaptation of immersive learning environment [19], the project will develop adaptive scaffolding services which can affect motivation, reflection and awareness of the learner without breaking the simulation's fidelity and immersive experience [7]. The approach to affecting the learning experience can, for example, be realised by affecting particular actors' behaviour within the simulation, influencing the simulation to increase/decrease challenge, unobtrusively suggest reflections or self awareness (metacognition). The project also envisages a dialogic approach following mentor-like coaching interactions.

The Metacognitive Awareness Inventory (MAl) [26] will be used. The MAI is comprised of five factors that describe the regulation of cognition including planning and information management strategies. Planning itself is not an observable construct, however it may be exemplified by a number of observable items. On the MAl, these include items such as 'I pace myself in order to have enough time' and 'I set specific goals before I begin a task'. In order to map the learning task to the inventory items, an extra layer for modelling learner traits has been created. Such a model is ETTHOS (Emulating Traits and Tasks in Higher Order Schema) [15], where each learner is modelled according to Traits and Tasks. Traits are high-level metacognitive aspects such as Metacognitive Knowledge, subdivided into Factors (a lower level than traits, such as Planning). The structure of these traits draw from methods used to create psychometric inventories (such as factor analysis). A factor can be described as a linear sum of variables. The combination of a number of related observable items describes each factor. (I pace myself while learning, I ask myself questions). The tasks modelled are a set of cognitive activities a learner undertakes where each activity may be broken down into Sub Activities: for example, the Activity Overviewing the Learning Object (part of the Before Starting task), may be broken down into sub activities such as: Noting important parts, Gathering information relevant to the goal, Determining what to do in detail.

We will also consider affective factors in the SRL processes in order to create positive experiences that empower learning.

Finally, we propose filtering the *open social* noisy real world inputs and scaling them for cognitive dissonance, appropriateness, quality, etc. Whilst King's [11] approach to constructivist teaching, the Guide on the Side decentralises authority, it still provides a role for it. Utilising the model of cognitive load illustrated by Gama then, perhaps, we can see a sliding (parabolic?) scale of disruptive content where the farther away from the Performance phase you are, the higher the level of non-salient, non-Quality Assured content would be allowed.

For example, work such as Richardson & Newby's [22] focuses on cognitive engagement with learning systems as a measure of on-task activity. We will derive similar models to address distance from the performance phase of the

Self-regulated learning model as a driver for engagement with non-normative information.

4 Context

The work is being applied within two complementary use cases. The affective metacognitive scaffolding framework itself sits within the ImREAL suite of services and simulated training execution environments. We will now indicate how the framework might actually perform.

In brief, a learner will register for a training course using a supported simulator. They will receive prompts from the framework before they attend the training session, perhaps as an email, perhaps as Google calendar appointments to plan/prepare. At the start of the training session the framework supports their preparation within the simulator execution environment, then through to the main learning scenario, providing opportunities to reflect and record learning in an appropriate, non-invasive manner, as above. After the session, the framework will provide scaffolded deeper reflection, and ways to allow the learner to tune their interaction with the services provided.

During the training session, the services provided by the framework will enrich that environment with examples from the learner's previous training (if available), that of their peers (e.g. at this point Alice thought X) and from andragogically designed prompts (e.g. did your actions have the outcome you expected?).

Either side of this central performance phase there are opportunities to deliver further scaffolding targeted to forethought and reflection, based on the pool of examples and delivered through a variety of media depending on the training scenario — perhaps through LMS messages, SMS, email, additional text on training calendar reminder prompts, etc.

Use Case A: Medical Interview Training This use case concentrates on the *enhancement of an existing simulator and on facilitating its integration in a training environment.* The use case will be developed within the **medical interview training domain** (training doctors to interview patients) with the EmpowerTheUser's simulator ASPIRE. It simulates diagnostic interviews with patients, which would ordinarily be carried out under the supervision of a senior registrar, who would sit in on interviews, providing minimal support and prompting as required with actors representing patients in the first instance, then moving on to real patients. The focus is on adding new functionalities (feedback, metacognitive scaffolding) and improving the adaptation (augmented user model). Creation of new content for the simulation itself is not directly targeted. However, it is envisaged that ImREAL services will facilitate content expansion and augmentation by enabling tutors and simulator developers to become aware of relevant examples with real world situations.

Use Case B: Job Interview Training / International Mentors This use case focuses on *intelligent support to develop a simulation environment for training based on real world modelling and content input.* This use case will be implemented within the imaginary simulator and illustrated in several connected scenarios. Starting from a simple **job interview scenario**, the simulator will include situations for training the recognition of verbal and non-verbal signals. Further iterations will involve training for cultural awareness in typical scenarios involving **communication between international students and their buddies (mentors)**. The simulation environment will be expanded based on the provision of new content with examples of real world situations. Content about real world experiences will be collected either from open social spaces or from social spaces for storytelling developed within the project. The content will be semantically tagged using an activity ontology, which will facilitate its aggregation.

5 Methodology

To provide initial experimentation of metacognitive scaffolding, an adapted Wizard of Oz methodology will be employed to identify the effects of certain metacognition or adaptation suggestions in the simulation. In this methodology a human coach will perform the expected affective metacognitive scaffolding to extend the base level interactivity in the simulators, we will then derive heuristic rules for what support should be given and when from this initial human-based simulation of the framework's function.

These initial models will be implemented using ETTHOS in order to provide a framework for metacognitive competencies and processes. Learners' initial metacognitive awareness will be tracked and enhanced by non-invasive interventions in order to promote the development of self-regulated learning practices.

In order to investigate affective models, an explicit affective monitor, the Smiley-Based Affective Index, will be deployed alongside simulators. Provided as a small popup, it allows learners to indicate their emotional state by clicking on a 'Smiley' as pictured below in Figure 1. These smileys are aligned to Ekman's basic emotional states and a cross-correlated study with IMA's moodmap (an example of which is shown in Figure 2) will allow further development of the affective model and interventions within the framework.

Currently, one partner's simulator (ETU's ASPIRE) has a space after each phase of the interview to allow free text reflection of the learning just undertaken. In order to evaluate initial appropriateness and suitability for the ETTHOS framework we will replace the open reflection within ASPIRE with text from the MAI, aligned with the phases of the simulation. Alongside this will be a short feedback mechanism to measure the appropriateness of the provided text and for the learner to provide their own scaffolding prompt and answer. A collected corpus of this material will be compared to the responses from the open-ended free-text material collected during the project's initial base-line study. A

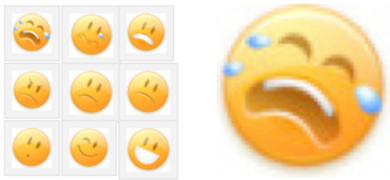

Fig. 1. Smiley-Based Affective Index — presented as a popup — the learner can click on one of the smiley faces to indicate their current affective state at any point during the learning scenario.

screenshot of a prompt, along with the feedback gathering within ASPIRE can be seen in Figure 3.

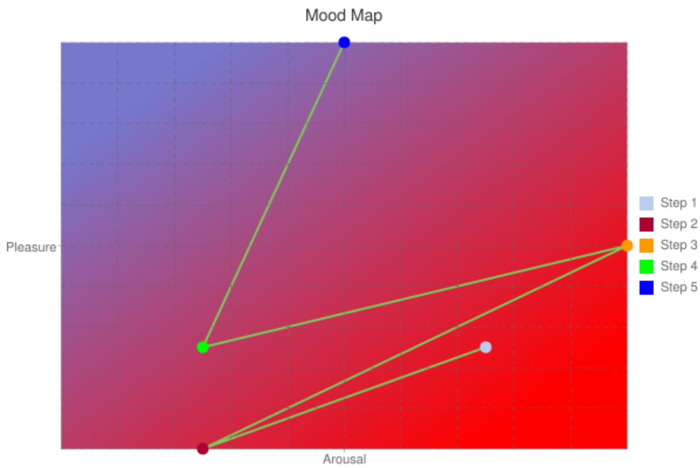

Fig. 2. An example of the IMA moodmap final diagram. A learner's mood state is plotted for each of the five steps taken along 2D axes of Pleasure vs Arousal.

All of these approaches are part of the work scheduled to begin to formulate an approach to the provision of affective metacognitive scaffolding and will lead to the development of the roadmap to the design of future interventions combined with the instructional models and revealing answers to the questions below, which have been developed to drive the research.

6 Discussion and Conclusions

We have outlined our approach to developing affective metacognitive scaffolding services, and, as usual, there are a number of key questions that need to be

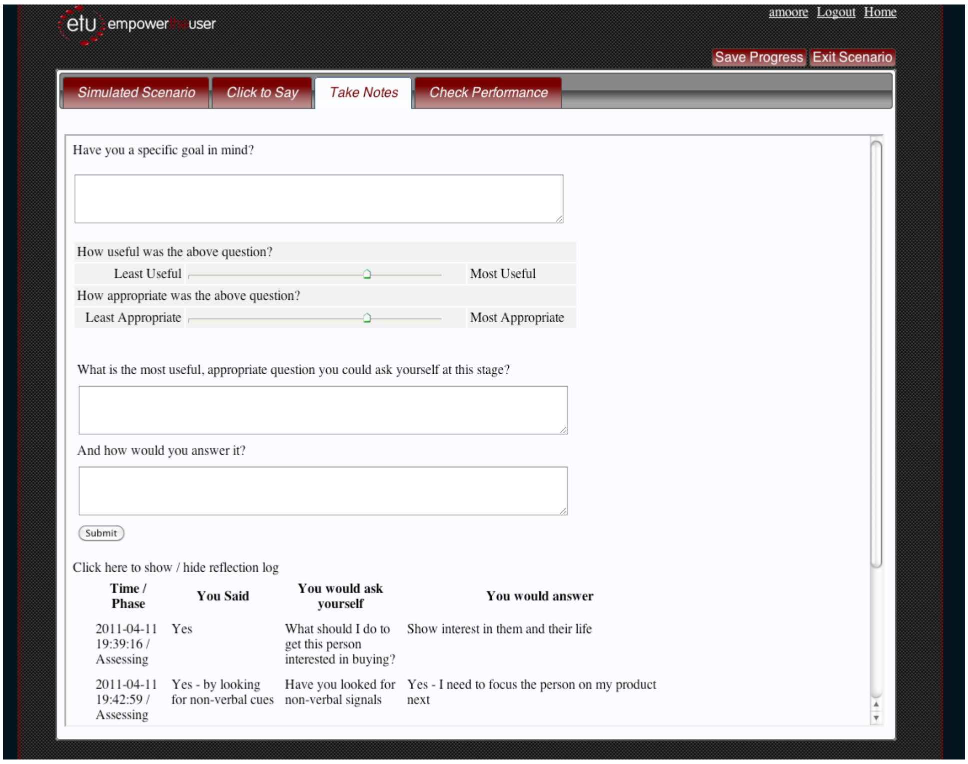

Fig. 3. Screenshot of ASPIRE training simulator showing a reflection prompt (the top text and text box) along with feedback gathering and an extract from previous reflections.

resolved both during the design and implementation and afterwards through appropriate experimental work and field trials.

The overarching issue is how to provide salient, timely services to support the metacognitive processes involved in self-regulated learning within the framework of experiential training in a cognitively sensitive (non-invasive) manner related to, but not embedded within, e-Learning simulation execution environments. This can be broken down into a number of questions.

How to specify the needs of affective and metacognitive features of a user model — the mapping of knowledge captured from these (possibly external) models, and their correlation with metacognitive strategies and affective triggers? That is, how do we ensure that the internal representations of the metacognitive characteristics we are hoping to monitor and develop are aligned with the real characteristics of the learner, reflecting their goals, surroundings and progress?

How to ensure saliency and timeliness? That is, how do we ensure that the interventions we provide through the services developed are delivered when they are required and the contents are appropriately framed?

How to ensure non-invasive interventions that are not too cognitively demanding nor out-of-reference/frame? How do we ensure that the interventions, when delivered, make sense to the learner and don't overly distract from the learning task at hand?

How to provide scrutability and personal tuning of the services we provide? How much is appropriate/effective? It is almost impossible to deliver too little scaffolding but how much is too much and how much control should the learner have over these levels?

How to measure/evaluate the efficiency and effectiveness of the services we create? It is often stated that metacognitively aware learners are better learners but how do we measure the improvement of learners' abilities and then relate that back to the interventions we have provided?

The ImREAL project team is going to address these questions. Hopefully, we can begin to flesh out our response to the underlying issue — does the approach lead to more effective training?

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