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Formative Interfaces for Scaffolding Self-Regulated Learning in PLEs

Mustafa Ali Türker[1] and Stefan Zingel[2]
[1]IES Information and Education Technologies
[2]Laboratory for Mixed Realities

Summary
A Personal Learning Environment (PLE) is a software application (desktop or web-based) which allows students to organise learning resources and publish individual outcomes. Although PLEs are built for bottom-up personal use, they involve communication and increasingly social tools, promoting networked learning scenarios. Knowledge management, syndicating resources, trustworthiness and assessment on the assemblage of resources are actual research issues related to the improvement of PLEs.

Without a pedagogical value-add, PLEs cannot be viewed as educational tools, but perhaps advanced, user-friendly file management tools. Therefore, how can such a user-centric tool influence the study process so that meaningful and constructive activities are committed more often than rudimentary informal learning? In other words, how can self-regulation be scaffolded by a PLE? Based on research that points out the role of scaffolding in activating higher order learning competencies it is theorised in this paper that these competencies can be performed even by young users.

iClass is an integrated project which is partially funded by the 6th Framework Programme for Research and Technology Development of the European Commission. Although it started off to develop a user-centric intelligent tutoring platform, the educational vision of the project was updated during the third year and bringing support for self-regulated personalisation on mainstream virtual learning environments became the objective.

In this paper, formative features of the visual interface of the iClass Web-based RIA will be explained as signifiers of typical regulatory structures. Semiotic principles underlying each signification will be described and the role of visualisation in operant conditioning and empowerment will be discussed.

Keywords: PLE, Learning Theories, Self-Regulated Learning, Visual Interfaces, Connected Learning, Informal Learning, Attitudes, Design, scaffolding, iClass, RIA, platform

1 Introduction

As the information age evolves into a connected age, the so called knowledge worker also evolves and develops a more advanced relationship with knowledge. A new understanding of knowledge is emerging which is very pragmatic in its nature (Bélisle, 2008).

Inspired by the maturing theories of consciousness, Harter (1999) claimed that from a cognitive-development perspective, the construction of self-representations is inevitable. From the neuroscientific perspective, Hawkins (2004) went one step further and claimed that the brain is a mechanism evolved to predict action outcomes based on schemas and models learned through sensory observations. As the brain actively creates theories about the world and the self within that world, it goes about to test these theories with all the actions taken consciously and subconsciously.

Hence prediction, action and making sense occur simultaneously and that is simply what the brain does with its cortical circuitry (Osada et al. 2008).

Henceforth, the act of self-regulation during learning and the performance with the acquired knowledge there after, inevitably result in a change of self-representation.Three psychological needs arise in a person who is undergoing such a change: competence (perceived self-efficacy), relatedness (sense of being a part of the activity) and acceptance (social approval). Moreover, there are regulatory structures that can be used to govern the learning process.

The research challenge addressed in this paper is to determine design principles for a tool that helps to exercise these regulatory structures with ease, that fulfils psychological needs, and that helps the user develop a strong personal agency. Such a user-centric tool can influence the study process so that meaningful and constructive activities are committed more often than rudimentary informal learning.

The proposed solution uses semiotic engineering principles to develop a visual language at the user interface that acts as a two way mediator:

1. Reflects user intention onto the study process
2. Reflects regulatory structures of the study process onto the attention of the user

2 Connectivism, Self-Regulated Learning and Personal Agency

Consider how everyday life is affected from the advent of Web, and the active relationship we all developed with the knowledge on the Web. We not only try to address everyday challenges with the help of Web-based information, services and applications, but also we retrieve pointers to a substantial amount of our future actions from Web-based resources. Naturally, the subjects and acts of learning get to change on the face of this relationship, as well. The pedagogical research investigating this change followed two different, but necessarily convergent routes:

1. Connectivism: Siemens (2006), in his book which was written through a democratic, end-user controlled process, identifies contemporary learning as residing outside of us (within a virtual organization), hence what we do can be described as an act of connecting specialized information sets in an ongoing fashion to recognize new information and alter the observed landscape of knowledge. This acquisition of actionable knowledge is not entirely under control of the individual, as a matter of fact follows principles explored by chaos, network, complexity and self-organization theories. As an umbrella term connectivism covers web-based social learning, networked learning, microlearning, and emergent learning.
2. Self-Regulated Learning: Learners can be described as self-regulated to the degree that they are metacognitively, motivationally and behaviourally active participants in their own learning processes (Boekaerts, 2000). SRL ideas have been born out of educational psychology research in the 1980s and they have gained popularity as “learning to learn” crept into the agenda of educational institutions while computerised tools such as intelligent tutoring systems failed to do so.

Both approaches were first attributed to adults and adolescents. For instance a certain cognitive development threshold was identified whereby a learner stops imitating other’s regulation and feels the efficacy for self-regulation (Kayashima, 2005). This “scientific belief” is in line with Piaget's final stage of cognitive development: formal operations, occurring from age eleven years to adulthood. People who reach this stage (and not everyone does, according to Piaget) are able to think abstractly. They have achieved skills such as inductive and deductive reasoning abilities (Woolfolk, 2004).

Later though, Mehler and Bever's (1967) experiments challenged these developmental limits by proving that, if presented in a situated manner, children did demonstrate skills such as number conservation at ages deemed impossible by Piaget. Lately Wynn et al. (2002) published work which received extensive media coverage, where they have shown that 5-month-olds can determine the number of collective entities – moving groups of items – when non-numerical perceptual factors such

as contour length, area, density, and others are strictly controlled. This suggested that infants can represent number per se, and also that their grasp of number is not limited to the domain of objects. Today, self-regulation (Paris, 1990) and connectivism (Siemens, 2006) are both regarded as competencies which are practiced at "varying degrees" by learners, almost regardless of their ages. This degree depends on the support provided. Research has shown that children's perceptions self-efficacy on academic achievements decline precipitously with advancing school grades (Eccles, 1999). Especially junior high school transition brings a dramatic decline. The role of the educational environment in this decline is identified to have the largest impact by altering their understanding of the relation between ability and effort within the changing educational practices and cues for assessing competence.

As they promote the ownership of the learning process to be held by the learner, the convergence point of connectivism and SRL is the "identity". The degree by which they are practiced relates to the "theories" the learner develops about self. Bandura, (1997) has introduced the notion of "personal agency" and stated that thought affects action through the exercise of this agency. Perceived self-efficacy changing during developing personal identity is a critical component of personal agency. Henceforth, the research about the effect of support on developmental limitation, and personal agency in particular is extremely important. If the thought referred by Bandura relates to "choice" or "decision making" and the action relates to "construction" or "assemblage", then personal agency relates to the identity.

Wenger (1998) defines "identity" as a layering of learning events of participation and reification by which our experience and its social interpretation inform each other. If these learning events take place while using a Personal Learning Environment (PLE), the above discussion leaves us with a critical research question: How can SRL and connectivism be supported while using a PLE so as to empower personal agency?

This major research question has been addressed within the iClass integrated project which is partially funded by the 6th Framework Programme for Research and Technology Development of the European Commission. Although the project started off to develop a user-centric intelligent tutoring platform, the educational vision of the project was updated during the 3rd year and bringing support for self-regulation on mainstream managed learning environments with collaborative features became the priority.

The iClass system is essentially a PLE. PLEs are user-centric tools which are becoming increasingly visual with the advent of Web 2.0 application paradigms. iClass employs a Web-based Rich Internet Application (RIA) to add value in terms of supporting self-regulation and empowering personal agency.

Having a highly visual interface the one strand of research was devoted to visual languages and semiotics in reinforcing the interface with visual cues and signs that bring the regulatory structures of the study process onto the attention of the user.

3 Visual Languages and Semiotics

The debut of "visual languages" as a recognized research field can be dated to the 1st Intl. Workshop on Visual Languages held in Hiroshima in 1984. A new research domain was charted with the idea that graphical and pictorial representation of certain data and information could better enable comprehension and manipulation by human subjects. Today, IEEE Symposium on Visual Languages and Human-Centric Computing is the major event for knowledge exchange in this field.

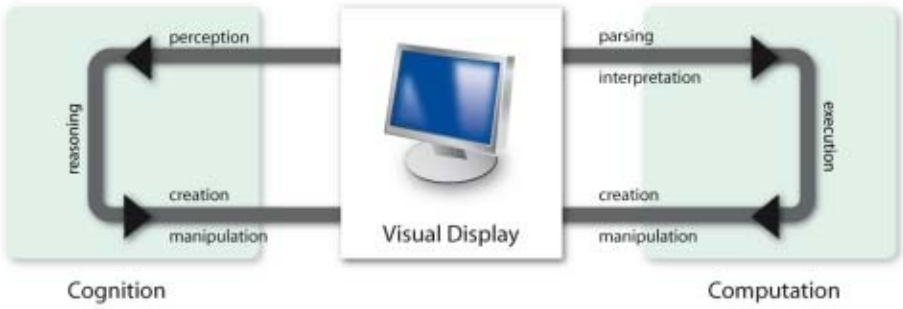

Figure 1: A Model of Visual Languages

Although visual formalisms that depict linear logic or grammars with clear inference rules are quite advanced, the following challenges in cognitive utility of visual languages still prevents usage en masse for human-computer OR human-WWW interaction (Marriott, 1998):

i) Direct manipulation of visually displayed objects to complete actions without resorting to other modes of representation (e.g. textual commands).
ii) Visualisation of Information to make higher order relations more accessible to human intuition.
iii) Visualisation of static or dynamic characteristics of computer programs to facilitate comprehension and debugging for the user
iv) Compact diagrammatic representations of information or procedures which are cumbersome to describe adequately using propositional statements.

Among these challenges, especially the combining of direct manipulation and diagrammatic reasoning has become an important tool in educational research and studied as simulation-based learning or game-based learning techniques. These techniques are commonly ascribed to "learning by doing" or "understanding by performance" approaches, because visuals link easily to intuition and hence urging the user to move, to act.

As the processing power of computers grows, the personal computers are no more regarded as devices to be programmed but rather as a bunch of applications to manipulate media. In this new setting, visual languages play a fundamental role, providing interactive or even proactive elements to manipulate not the computer but the applications. The novelty here (Fogli et al., 2008) is that the visual language must not only fit its users' culture and capabilities, the context of use, and the task being performed, but it also must be amenable to efficient computer implementation. Its design is no more only a question of graphical representation of formalisms and inferences but it also requires the definition of direct manipulation and dynamic interaction processes.

Language is the main mediator in learning activities between the involved people and also the resources in the environment (Vygotsky, 1934). Similarly in instructional design visual languages are mediators between what the instructor has in mind and what the learning presenter must render. Actually, besides the presenter, there are other applications which need to interpret the instructional design such as the repository of designs, the exploration utility, authoring tools etc. Therefore, generally a mark-up language is used for the representation and then a flow diagram, UML, Petri Nets or some other process visualisation tool is used to display this mark-up representation (Botturi, 2006).

Organising learning resources available at a PLE into meaningful learning activities towards achieving set goals can as well be considered as an act of instructional design. This corresponds to the forethought phase of SRL. Zimmerman (2008) established a very useful overview SRL as composed of three phases:

1. Forethought: Includes such cognitive processes as goal settings, self-efficacy beliefs, and strategic planning
2. Performance or volitional control: Includes subprocesses of attention focusing, self-instruction, and self-monitoring
3. Self-reflection: Examples of self-reflective subprocesses are self-evaluation, attributions, and adaptivity.

Besides the planning features, iClass application also provides sections for performance and self-reflection. It is trivial to claim that a PLE that reserves screen space for these three phases explicitly at once brings them to the awareness of the user. However, this "macro" level support is not sufficient to claim that users are adequately supported to bring regulation patterns to their study processes.

As a part of the visual language used to interface with the learner at each one of these phases, semiotic signs are utilised for operant conditioning.

Semiosis is the unlimited sign-production process triggered by the presence of representations that stand for any quantity and quality of meanings (de Souza, 2005). The process is unlimited in the sense that its duration, path, content etc. cannot be predicted. Following the aphorism "the medium is the message", popularized by Marshall McLuhan, Semiotic engineering as applied to HCI (Human-Computer Interaction) regards not only the user and the system but also the designer to frame HCI as a semiotic problem. The interface ontology does not belong to the system but indeed the designer. The system is a particular state of the designer's semiosis with respect to what the user's expectations are (and should be).

Observe that the layering of learning events in Wenger's definition of identity can as well be compared with Peircean semiotics and the endless interpretant: the thought/interpretation will continue changing according to previous thoughts/interpreations and the recently obeserved signs. These sign systems are designed according to the studies of how meaning is constructed and understood. Examples of such operant conditioning can be observed in other PLEs such as Plex which has been developed at the University of Bolton. At the Plex user interface aggregated learning material is called as "opportunities" while the aggregation tool is called "the opportunity explorer", and the presenter is called "the opportunity viewer". Here the selection of the word "opportunity" is a semiotic sign towards increasing the attributed value to the outcomes. Another example is to name a PLE feature for collecting and filtering RSS feeds as "harvesting".

In general all attributions can be manipulated by signs towards operant conditioning. The critical features of self-regulation from operant perspective are listed as follows (Mace, 2001):

1. Choosing among alternative actions
2. The relative reinforcing value of the consequences for the response alternatives
3. Temporal locus of control for the alternatives (immediate vs delayed consequences)

The user behaviour occurring as an outcome of these three elements distinguishes self-control, commitment and impulsivity pertaining to self-regulated actions. Henceforth, operant researchers have analyzed the SRL process into the following subprocesses:

1. Self-Monitoring
2. Self-Instruction
3. Self-Evaluation
4. Self-Correction
5. Self-Reinforcement

In the visual design of the iClass interface semiotic engineering practices were used for operant conditioning along these five subprocesses. Therefore, the iClass application is claimed to have a formative interface that utilize visual signs for conditioning the user towards applying SRL and hence, support the reification of the interactive experience with the PLE as an individual act of personal learning.

4 A Formative Interface for Scaffolding SRL

The Web-based RIA of iClass consists of a set of features that stem from a pedagogical model built on SRL (Aviram, 2006). In implementing these features, semiotic visual signs are used to constitute a formative interface towards operant conditioning in SRL subprocesses.

4.1 Formative Features on Self-Monitoring

Self-monitoring can be described as a multi-stage process where the user recognizes actions whose outcomes are to be controlled to yield effective learning. Naturally at the main stage these actions comprise goals and learning activities towards achieving those goals.

There are many authoring tools which utilize visual notations to assist the user in expressing instructional ideas in a particular instructional design language (a.k.a. educational modelling language). Some examples are eXe, Reload, MOT+, LAMS, Copperauthor and aLFanet. However, for the non-experts, the authoring and design process using the above tools is still an overly complex and time-consuming task which has limited the acceptance of the benefits that are offered (Sodhi, 2007). Teachers still do not invest time in putting down their designs in digital form (Masterman, 2007).

In the iClass interface the users are prompted to set subgoals on the way to the final goal and add activities that contain digital material in order to study towards achieving these subgoals. These study plans are visualised to highlight time and knowledge management requirements.

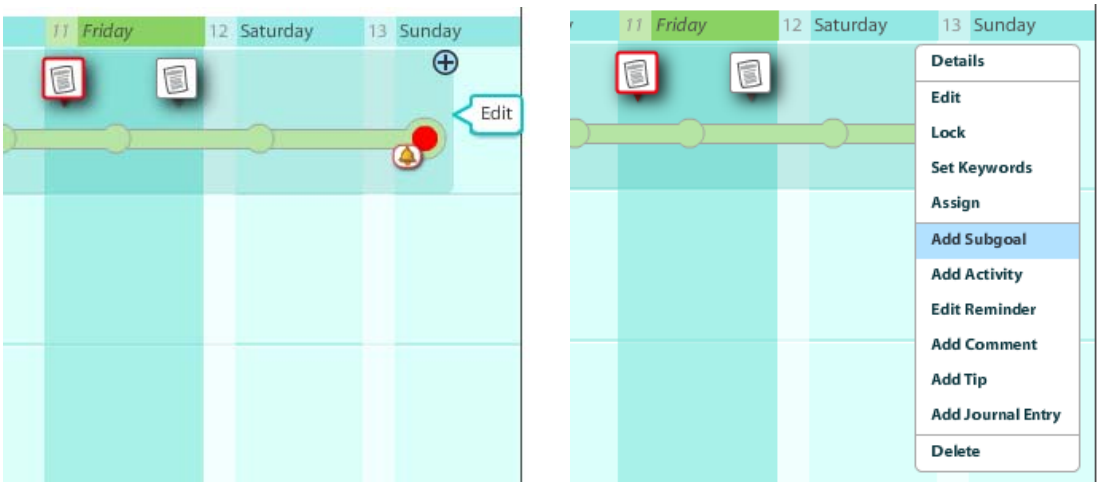

Figure 2 (a) *Sub-goals on the path to the final goal and* ***(b)*** *their manipulation*

Grading the path to the final goal with subgoals, boosts self-efficacy as attaining goals become a frequent event. Besides this "milestones" approach to self-monitoring of achievement, some other visuals signs are

1. Color-coded goals by the user to allow for priority grouping,
2. Listing of subgoals for consideration during the addition of a new subgoal.

It is recognized that self-monitoring is granted by the teacher to the student in most educational settings to transfer responsibility of behaviour assessment. In order to accommodate for varying degrees of this transfer the teacher can "lock" the activities and/or subgoals before assigning to the students. If the user is a student, locks can still be employed in sharing self-made plans with peers.

Turning our attention to the control over the content that can be brought in to the learning path, it is imperative mention the formative design on handling material and activities as related but essentially different entities.

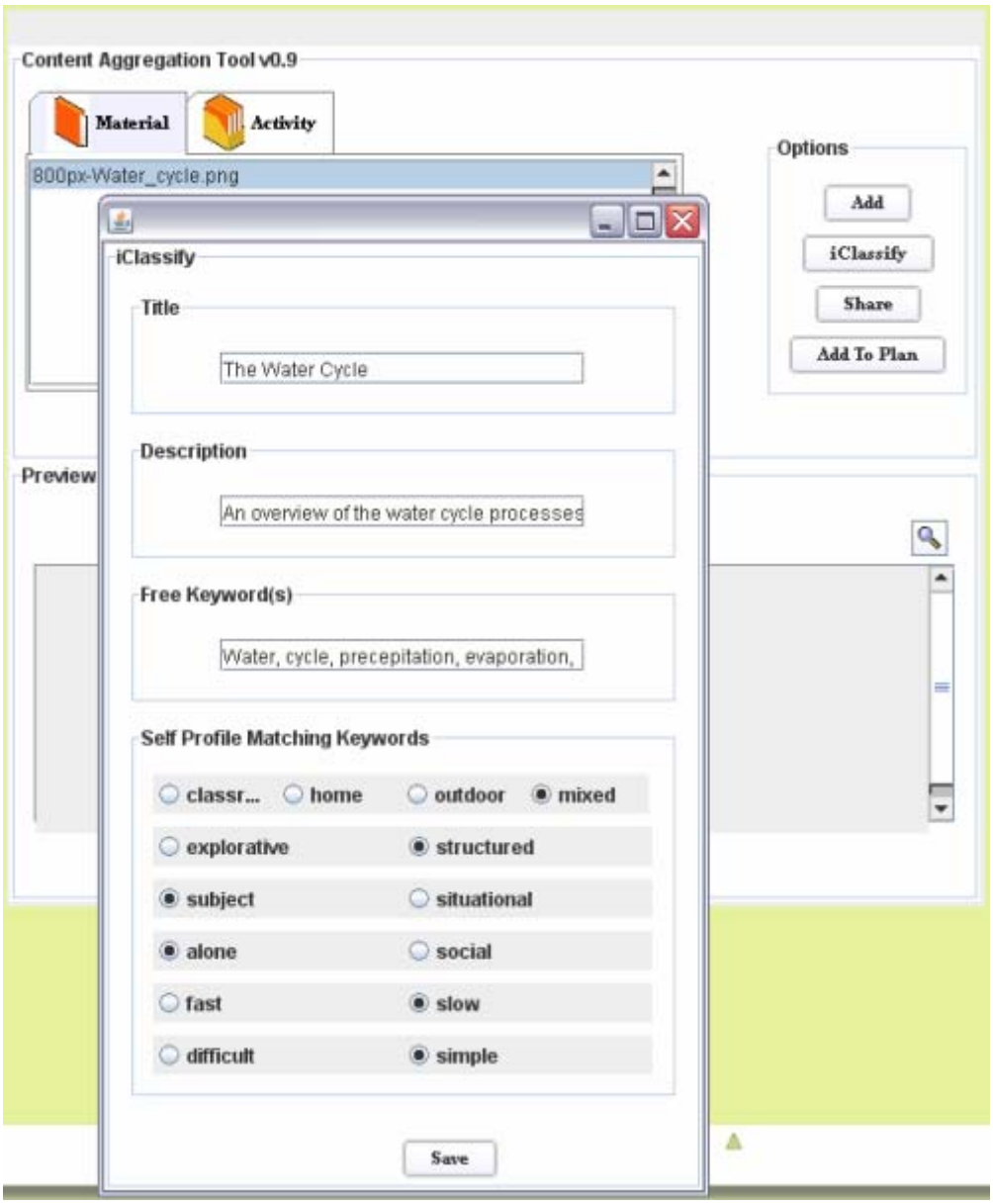

Figure 3 *Discrimination of material and activities during aggregation*

A pre-condition for any event to be monitored is discrimination. That depends on the saliency/consistency of the stimuli as well as the experience of discrimination. By means of a content aggregation tool a separation of content hierarchy is presented to the users in the form of material and activity so that the experience of utilising either one can be discriminated.

A learning object is considered to be any type of digital resource that can be used to support learning (Downes, 2003). To earn the name "object" the material needs to be apprehended as separate from random content. The boundaries of this separation abound, yet generally domain competencies are a good vantage point. Consequently, Web pages consumed or recorded during a study episode does not qualify as "objects", but identified as "assets". There has to be a speciality that binds these assets so that they would gain meaning accordingly. Besides domain competencies the activity (hence the context, situation and approaches it entails) within which these assets are consumed can prompt a separation.

Teachers and increasingly students are accustomed to utilize their self-created materials for fulfilling the curriculum. Being confronted with a technology enhanced learning system, they feel the need to bring their own resources into those systems Using this aggregation tool, the it is possible to upload learning "Material" such as presentations, pictures and movies. At a separate tab called "Activity", the

material is annotated (iClassified) with meaningful data and then aggregated into a SCORM 2004 compliant learning object.

4.2 Formative Features on Self-Instruction

In operant self-instruction can generally manifest in two ways:

1. The user may arrange the environment so as to come in contact with one or more noticeable features that set the occasion for desired behaviour
2. The user may set rules to govern personal behaviour

In the iClass interface the visual tool that promote the first manifestation is custom tips that can be attached to activities and goals.

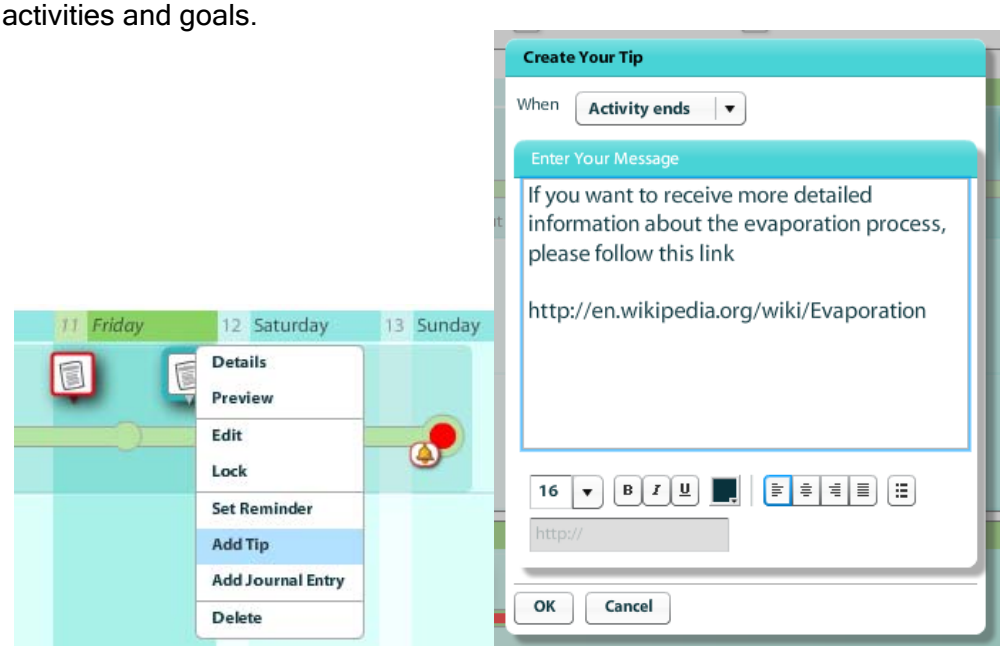

Figure 4 (a) Adding custom tips (b) Custom tip on activity

This visual sign on the ability to use "event triggered" actions can as well be used by teacher to who not only would like to create personalisable lesson plans for their students, but also provide assistance and guidance during their learning process. By creating a customized message to be shown e.g. after the student experiences a specific video, a teacher can refer him/her to a web page providing additional information. With this tool, the learning flow will be adapted to individual competencies and needs of the student.

Moreover, on a separate tool where outcomes and evaluation criteria on the subgoals are defined, reminders can be placed on the subgoals, signifying the link between self-evaluation and self-instruction.

4.3 Formative Features on Self-Evaluation

The operant self-evaluation necessarily should be based on a set standard, criteria or a particular dimension of self-regulation. Simply, by providing a set of options for such dimensions the users are made aware of this "basis" of evaluation.

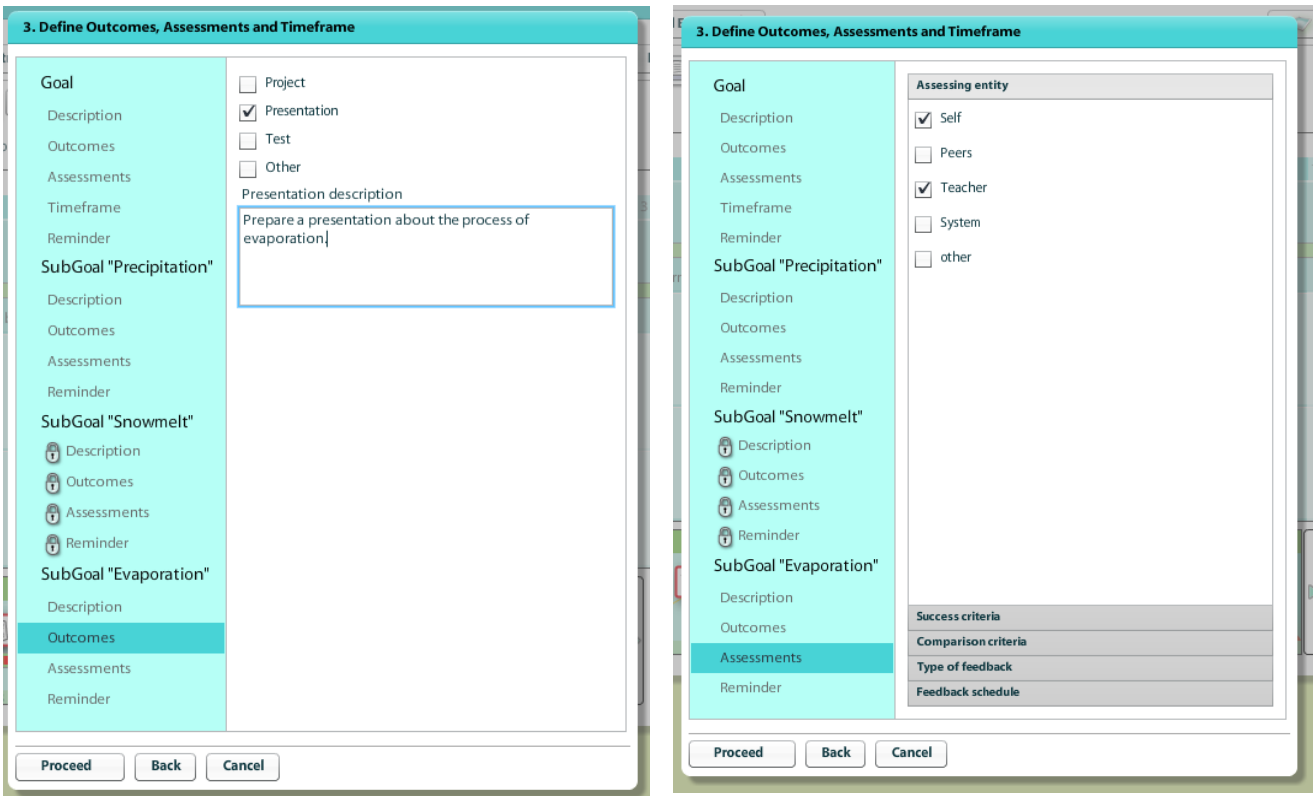

*Figure 5: Setting **a)** outcomes and **b)** assessments*

For each goal and sub goal, outcomes and assessments can be defined separately. This provides users with a finer granularity regarding the expected results to be delivered.

Competency-based Knowledge Space Theory (CbKST) is also incorporated to iClass to allow for formal assessment (Türker, 2005). This functionality is confined in the self-reflection part of the screen space. Nevertheless, the underlying competency maps (Steiner, 2007) for CbKST to work is allowed for editing via a map-editor tool so that the standard/criteria against which the evaluation would be made can be incorporated by the users.

4.4 Formative Features on Self-Correction

In conjunction with self-evaluation the operant will necessarily engage in self-correction, yet without impairing self-efficacy. This subprocess is confined mainly in the performance section of the screen space.

Figure 6: Showing progress information during the learn actions

On entering the learning section of iClass, the user will be presented with an overview of the day's agenda. This overview reflects a cross section of the activities of all plans scheduled for the day. After selecting an activity, the personal learning progress of the corresponding study plan is loaded. Activities which should have been completed earlier are marked with a red frame. The student either has to "catch up" or take corrective action and change the plan to re-schedule those late activities. Manipulation of the plans is not allowed here for the sake of signifying a clear separation of the three phases of SRL

4.5 Formative Features on Self-Reinforcement

The operant view of self-reinforcement should be based on a stimulus (a trigger event) which is contingent on target behaviour and regard a temporal locus. The self-made or teacher provided tips described above are immediately available as such reinforcers that use achieved subgoals or completed activities as trigger events.

Nevertheless, a journal tool is provided to record reflections on tasks and to track these reflections later on.

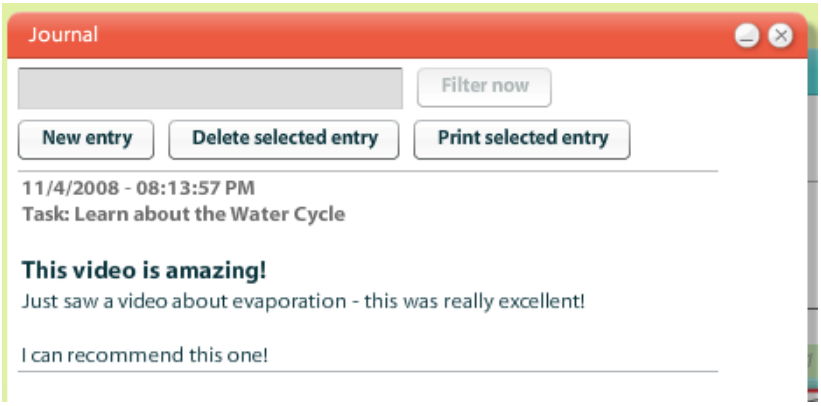

Figure 7 The Journal

At any stage of scaffolding personal lesson plans and during the learning process, iClass enables a student to reflect on his/her actions and thoughts using a personal journal.

Finally a self-profile tool is provided where the same fixed vocabulary is used to describe learning process preferences as the vocabulary used in formulating a search profile for learning activities and plans made before. Observing the match between the profiling choices on self and on content constituents of the study process reinforces the awareness of how the personal agency best performs.

5 Validation of Research Outcomes

The iClass system is extensively and methodically piloted during various workshops with end-users in France, Turkey, Lithuania, Austria, and Israel. It will be further piloted in Italy, Czech Republic, Poland, Spain and UK. During some of these pilots the validation methodology of European SchoolNet (Lewin, 2004) is used for ratifying research results in their degree of achieving the project objectives.

In evaluating Web-based learning systems and software there are various approaches depending on the type (formative, summative, educational, technical etc), form (surveys, pre/post tests, quizzes, pilot journals, web-based questionnaires, phone interviews), level (society, institution, system, programme, set of pages) and factors (usability, retention, coherence, business value) of the evaluation (Savenye, 2004).

A very good example is the web-based peer review evaluation tool developed by the TELEPEERS project to evaluate self-regulated learning in technology enhanced learning environments (TELEs). It consists of three parts:

1. Technical description of TELE
2. Detailed evaluation of support for self-regulated learning – 43 evaluation statements on three phases of SRL are presented to distinguish between cognitive, motivational, emotional and social aspects.
3. Global evaluation of support for self-regulated learning.

A similarly detailed evaluation methodology is used in the rest of the iClass pilots.

Although the complete validation results will be reported by the project's end (June 2008), the existing results and feedback from the end-users are in favour of the research outcomes. Not only the learners reported increased aptitude for self-regulation but also teachers denoted ease of use while handing over design responsibilities to learners of varying self-regulation competencies.

6 Conclusion

In this paper the convergence of two contemporary pedagogical approaches, connectivism and self-regulation, on the "identity" of the operant user is argued for. Based on research that points out the

role of scaffolding in activating higher order learning competencies it is theorised that these competencies can be performed even by young users. As long as such support improves the personal agency on practicing ownership, the degree by which these approaches are mastered will increase.

A formative interface which uses semiotic signs for operant conditioning is described as a source of such scaffolding is detailed. Example features of such a formative interface from the iClass Web-based RIA are provided, which are grouped under operant subprocesses of SRL as established by Mace et al. (2001).

Self-regulation entails a cognitive load (Kirscher, 2006) which makes it harder for typical learners to practice repeatedly. A system which attempts to relieve this load can only do so by supporting the users in becoming increasingly effective self-regulators.

A common shortcoming of "language-centric" learning design or lesson plan authoring tools is that in an attempt to well-define designs so that they can play-out in various players, the language of definition becomes too complex, inhibiting both intuitive visual authoring and also variations in players, hence contradicting their main goal.

It is recognized that the harder it is for the author to design learning, the less likely it is that such authorship would be adopted in mass scale. Hence a holist approach is proposed to encompass all three phases of SRL and semiotic signs are used to influence operant behaviour at all phases in a non-intrusive manner.

The results, though not available in great detail, have been found to be very much favourable, indicating fruitful prospects for PLEs in adopting such an approach.

The range of users can be expanded by additional support to the higher and lower competencies in exercising self-regulation. The novice users can benefit from self-reflection triggering tips and performance enhancing alerts. Moreover, a handbook that covers practical use cases and classroom pedagogy is a key element. Note that these elements are also provided by the iClass system. On the other end of the user spectrum, the advanced users can be provided with

3. Plan branching and linking functions during forethought
4. Self-monitoring functions that cover not only the performance phase but also the planning and self-reflection phases
5. Assessment via self-evaluation to improve self-reflection

Finally, it is imperative to mention the role of the Gannt charts which were selected as the plan visualisation paradigm. Although Gannt charts are ideal for time management, further research on visualisation paradigms that would better represent the general flow of the learning episode and the strategies used is likely to have the highest impact on mindfulness and engagement.

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Authors

Mustafa Ali Türker
Project Manager
IES Information and Education Technologies, Turkey
Ali.Turker@sebit.com.tr

Stefan Zingel
Head of R&D
Laboratory for Mixed Realities, Germany
zingel@lmr.khm.de

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