Applying Pedagogical Approaches to Enhance Learning: Linking Self-Regulated and Skill-based Learning with support from Moodle Extensions

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Abstract: This paper provides an overview of the linkage of two pedagogical approaches; Skills-based Learning and Self-Regulated Learning (SRL) supported by software. In linking these approaches, adaptive skills-based learning tools based on a psycho-pedagogical competence model, were assigned to a cyclic SRL process-model. The INNOVRET project provides the underlying framework in which this new model will be tested. Software components for Moodle (the learning management system of choice) were specifically tailored to suit the needs of the project's targeted audience (i.e. heat pump installers). The entire system/model will be critically analysed in this paper.

Keywords; Online training, Competence-based knowledge space theory, Skills-based Learning, Self-regulated learning, Moodle, INNOVRET.

I. INTRODUCTION

Today's world frequently brings new informational breakthroughs and updates to previously held knowledge. As we can no longer trust that what we 'know' will remain static, this can generate an increasing need for life-long learning in many areas. Life-long learning is even more critical given the global green skills shortage [1] and the fact that investment in green technologies offers great potential for economic growth, competitivity, employability and sustainability [2]. Within this green context, heat pumps have been recognised as a critical component of achieving energy efficiency. Recent studies show that whilst heat pumps currently cut CO_2 emissions by 8% of global emissions [3, 4], which is one of the largest that a single technology can offer, this will increase in the near future, because of increased efficiency due to technological developments. Whilst European training programmes in heat pump technology are currently available, they have severe limitations. A report from the UK indicated that badly installed heat pumps resulted in 87% of these systems under-performing (below a COP of 3.0) [5]. In addressing the need for high quality heat pump systems training programmes and the EU focus on life-long learning (to promote European competitivity and growth), the INNOVRET (Innovative Online Vocational Training of Renewable Energy Technologies) project aims to provide an online training solution for heat pump installers which combines the benefits of both pedagogical approaches (Self-Regulated Learning and Skills-based Learning) within an integrated Moodle environment, thereby enhancing the benefits for the learner and enriching the learning experience.

II. PSYCHO-PEDAGOGICAL APPROACHES

A. Self-regulated Learning

Self-Regulated Learning (SRL) plays an increasing role in the modern world of education. It emphasises the learners' ability to control and regulate their own learning process. Most researchers define SRL as the way individuals control their own *feelings*, *thoughts* and *behaviours* which are oriented towards *goal achievement* [6, 7, 8]. The SRL process is accomplished in a *proactive way*, in which a learner's self-regulation of *cognitive*, *metacognitive* and *motivational processes* (within an educational context) is emphasised [7, 9]. Effectively, this means that the learners 'direct' their own way of learning based on their own decisions etc. Meta-cognition, which is required for self-reflection, plays a crucial role in this model. Zimmerman [7] described meta-cognition as the "awareness of and knowledge about one's own thinking". Meta-cognitive strategies are therefore defined as the attempt to be aware of one's own lack of knowledge. As an example, self-regulated learners know their strengths and weaknesses because they are aware of their goals. The process of SRL can be divided into three phases [7]: (1) Forethought, (2) Performance, and (3) Self-Reflection. The Forethought Phase is the phase which occurs before learning. The Performance Phase occurs during learning, whilst the Self-Reflection Phase occurs after learning [7].

Within the INNOVRET project, our understanding of self-regulated learning (SRL) is in accordance with Zimmerman's definition [6, 7]. SRL is understood as a learning cycle consisting of three phases with which the learner proactively engages. In INNOVRET, these phases are termed: "planning"; "learning"; and "reflecting" – with each phase being supported by a separate software tool.

B. *Skills-based Learning*

In Skills-based or Personalised Learning, the learning content is adapted to the learner's needs. Competencies and skills that already exist do not have to be taught and new learning content can be built on content that already exists. Ideally, skills-based learning systems should be adaptive - with regard to the assessment on the one hand and the recommendation of learning content on the other. The main advantage of adaptive and skills-based/personalised learning is a considerably greater efficiency in learning and increased amount of time saved in learning the content. In applying adaptivity, an underlying mathematical theory is required.

- Competence based Knowledge Space Theory

As an underlying psycho-pedagogical theory, the Competence based Knowledge Space Theory (CbKST) [10, 11] was selected to model the learner's skill (competence state). The CbKST is a framework for representing the conceptual organisation of a given body of competences. The CbKST, as a cognitive approach, extends the behaviourist Knowledge Space Theory [11, 12, 13] and requires the identification of threshold concepts and associated pre-requisites, and co-requisite relationships between competences. It also requires the creation of appropriate assessments to evaluate a learner's current competence state in said threshold concepts. Threshold concepts represent a transformed way of understanding something, without which the learner would find it difficult to progress [14]. In the case of the INNOVRET model, threshold concepts represent a set of competences (skills, abilities, knowledge and understanding of concepts) [10, 15, 16] which underlie the set of problems for the heat pump domain. The result of the application of the CbKST is a structured competence model enriched with corresponding learning objects (i.e. digital content that may be used for learning, education or training [17]) and associated assessments.

The main aim of the CbKST application in the INNOVRET model is the introduction of adaptivity by means of the adjustable presentation of the learning content (based on the learner's progress) and the adaptive assessment of the learner's current competence state. In this approach, the adaptive system recommends learning objects (LOs) which are appropriately related to a learner's competence state. The competence state is derived based on the results of the Assessment tool.

Adaptive assessment describes the situation where a question is selected relative to a learner's assumed competence state. The learner's answer to the question (which has a moderate difficulty) determines the selection of the next question, and so on. Therefore, it is necessary to make assumptions regarding the relationship between these questions (the so-called 'problems' or 'assessment items').

In INNOVRET, we model a competence structure based on assumptions about the prerequisites in relation to certain competencies. The questions (i.e. problems/assessment items) are assigned to the associated competence state. Thus, they can be presented in an adaptive way which is appropriate for each learner's current knowledge state.

III. SYTHESIS OF SELF-REGULATED AND SKILLS-BASED LEARNING

The INNOVRET model aims to combine Skills-based Learning with the principles of Self-Regulated Learning (SRL). SRL takes place when learners select a learning cycle's learning target (Planning Phase), freely navigate through the recommended LO[1]s (Learning Phase) or reflect upon their learning progress from a previous session (Reflection Phase). Therefore, the CbKST principles are linked to the three phases of Self-Regulated Learning through the use of certain tools (see Figure 1). The modelling of a learner's current competence state is mainly used to assist the learner during the Learning Phase of the SRL cycle. Through the application of the CbKST, it is possible to identify a learner's current competence state, while also recommending appropriate learning content (in the form of learning objects), according to the competence state. The main aim of the application of the CbKST is to support learners within their self-regulated learning process in an efficient and time-saving manner without being over challenged or under challenged by the content. Although the combination of guidance (applied through the CbKST) and self-regulated learning might look inconsistent at first glance, it has been shown to be successful when applied in other research projects, such as iClass [17] and Role [18].

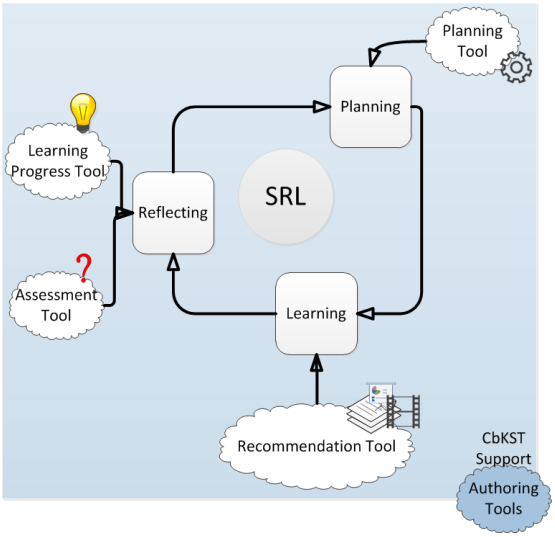

Figure 1: SRL in INNOVRET in relation to the applied software components

[1] Learning objects

A structured competence model, complemented by corresponding learning objects (LOs) and assessment items (AIs), form the CbKST Domain Model on which INNOVRET's (SRL) tools are based. Through the CbKST based adaptive assessment, it is possible to identify a learner's current competence state while presenting a reasonable number of assessment items, potentially saving valuable learning time. Based on an assessment of the learner's current competence state, the Recommendation Tool presents a set of learning objects (LOs) selected according to an individual's abilities (i.e. neither over- nor unchallenging the learner). The learner may then select the content in a self-regulated manner. The learning progress is again captured in associated assessments, which then leads to a learning progress visualization, designed to stimulate reflection.

IV. MOODLE SRL-TOOLS

Moodle (Modular Object-Oriented Dynamic Learning Environment) is an open source Learning Management System (LMS) which is capable of supporting the necessary high levels of interaction, web visibility, online social networking, and knowledge exchange [20]. Moodle includes many features that improve pedagogical quality and many of the essential tools that an e-learning system should contain [21]. It provides a variety of features to support teachers and course developers, allowing them to create and manage online courses, and typically include different types of Learning Objects.

Despite the afore-mentioned advantages, Moodle is usually course based and does not cater for the individual needs of students [23]. One of the main reasons for the choice of Moodle however, is its supported extensibility in terms of plug-ins and modules that can be integrated to deliver personalised learning support. It is therefore an excellent platform with respect to adaptation. Although some adaptive approaches have already been integrated in Moodle, none so far take into account the SRL phases or applications of the CbKST. Services and tools based on the CbKST algorithms have been tailored specifically to INNOVRET's needs and embedded into Moodle.

A. Support in the Planning Phase

The Planning Phase in SRL includes strategic planning and goal setting ("Forethought Phase" [7]). Albert, Nussbaumer and Steiner [23] state that goal setting can be implemented by defining the set of skills which are expected to be achieved (competence goal) or by defining a set of problems which the learner should be capable of solving [23]. To become aware of the competence gap between the competence goal and the current competence state, an appropriate assessment is required. The CbKST provides algorithms for such an adaptive assessment in order to identify a learner's current knowledge and competence state. This information affords the opportunity to create personalised learning-paths which lead to the intended competence goal [22]. In INNOVRET, the Planning Phase is supported by an initial competence assessment (i.e. questionnaire) and the selection of a predefined learning profile.

B. Support in the Learning Phase

As described earlier, learning objects are adaptively recommended in the INNOVRET model. This first occurs with an initial assessment. Based on the knowledge of learner's current competence state, the INNOVRET model will recommend those learning objects which are neither too easy nor too difficult, regarding the learner's competences and pre-knowledge. Hence, the adaptive system provides flexible navigation support through such direct guidance [24]. Although recommendations could be termed guidance, this does not limit the learner's freedom as they can choose freely between different recommendations. This approach is compatible with Self-Regulated Learning (SRL) insofar as it is an appropriate combination of guidance (through recommended learning objects (LOs)) and self-regulation (through the free selection of LOs). In the INNOVRET mode, the recommendation of LOs happens during the Learning Phase of the SRL Cycle.

C. Support in the Reflection Phase

As the competence for the recognition of visual information is highly developed in humans [23], visualization plays an important role within the learning process. Visualization enhances a learner's ability to process information effectively, especially when exploring large amounts of data [23]. The visual representation of knowledge is useful for the teacher as well as for the learner in terms of further planning and the evaluation of the ongoing learning process. The visualization approach followed in the INNOVRET model will therefore report on the learning objects which have been accessed, the results of the assessment questions and the learner's progress within the targeted learning profile.

V. CONCLUSION

It is expected that the end users of the INNOVRET system will be made up of a heterogeneous group (i.e. heat pump installers). Given the fact that their knowledge (or lack thereof) will vary greatly, there would be no sense in teaching the same content to everyone. Although there will be differences in the goals/aims of individual learners, there are still some aspects which need to be considered for all of them. These are skills which serve as a knowledge foundation and are prerequisites for the acquisition of other skills.

The application of a CbKST-based adaptive approach means that:

- Adaptive assessment makes it possible to easily identify a person's current skill (i.e. competence) state thereby saving time which can then be used for learning.

- Learning objects (LOs) can be adaptively presented that are at an appropriate level for the learner (i.e. without challenging them too much or too little).
- Adaptive LO recommendations are time and energy saving, as well as efficient and motivating. This can lead to the so-called 'flow experience' [25], wherein frustration (caused by over-challenging LOs) and boredom (caused by less challenging LOs) are avoided.

Although the approach adopted in the INNOVRET project is a personalised approach to learning, it also supports the learners within the Self-regulated Learning (SRL) process. Effectively, the learner is able to pick from the recommended LOs freely, while also benefitting from support with their self-assessments. The software tools that have been described in this paper are currently under development. Evaluation studies will be carried out to ascertain the successful application of the developed tools in linking Self-Regulated Learning and Skill-based Learning .

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