Adaptation to Motivational States in Educational Systems

Stephan Weibelzahl & Declan Kelly
National College of Ireland
Mayor Street, Dublin 1, Ireland
[sweibelzahl,dkelly]@ncirl.ie

Abstract

Most current Adaptive Educational Systems model cognitive characteristics of students such as learning goals, knowledge and preferences. However, motivation obviously plays a key role in education. This paper reviews the state-of-the-art regarding adaptation to motivation. Open research issues that need to be addressed are identified.

1 Introduction

Technology enhanced learning environments often fail to motivate learners. However, motivation obviously plays a key role in learning and teaching. Teachers devote a lot of time to assess and increase their students' motivation. This paper outlines a proposal for an adaptive educational system that is able to adapt to motivational states. In particular, it explores how such a system might assess and model the learner's motivation and which adaptation strategies might be applied.

2 Motivation and Learning

Experienced teachers understand that it is crucial to keep students motivated in order to achieve optimal learning results. This is underpinned by an overwhelming amount of research (Corno, 2001; Snow, Corno & Jackson, 1996; Kanfer & McCombs, 2000). Students with high intrinsic motivation often outperform students with low intrinsic motivation (e.g., Martens, Gulikers & Bastiaens, 2004; Goleman, 1996), and students with high motivation engage more in learning activities and are more likely to complete a course (e.g., Militiadou & Savenye, 2003).

Successful teachers are able to detect the students' needs and preferences. They try to provide an environment that enables the students to achieve their goals. Empirical studies show that human teachers devote as much time to the achievement of students' motivational goals as to cognitive and informational goals (Lepper, Woolverton, Mumme & Gurtner, 1993; Lepper & Hodell, 1989).

2.1 Motivational Theories

Motivation is an internal state or condition that activates behavior and gives it direction (Kleinginna & Kleinginna, 1981). In particular, the motivation to learn is characterized by long-term, quality involvement in learning and commitment to the process of learning (Ames, 1990; Ames 1992). The concept of motivation (previously also called conation) has been the focus of many psychological studies. A wide spectrum of motivation theories has been developed to date. These include psychoanalytic theories (e.g., Freud, 1990), behavioral theories (e.g., Skinner 1969), humanistic theories (e.g., Maslow, 1954), and various cognitive theories (e.g., Heider, 1958; Weiner, 1974; Bandura, 1997; Vroom, 1964; Kuhl, 1986). In applied psychology such as organizational and educational psychology, value-expectancy theories have been shown to be fruitful.

One prominent example is Keller's theory of motivation in education (Keller, 1979). The theory distinguishes three main outputs: effort (engaging in actions), performance (actual accomplishment) and consequences (intrinsic and extrinsic outcomes, e.g., emotional responses, social rewards, material objects). These outputs are influenced by person inputs as well as by environmental inputs (see Figure 1).

This theory provides various ways to influence students' motivation and thus their performance. The distinction between motivational design, learning design, and contingency design is very useful for the implementation of motivation strategies in technology enhanced learning systems as described below.

2.2 Games and Motivation

Games have an enormous potential for motivating people. Computer games not only attract attention but often make people put a considerable amount of effort in playing a game. It has thus been proposed to abstract the most important motivational features of games and apply these to learning. These features include challenge, story, immersion, and mastery orientation (Table 1). For example, offering challenges at appropriate level, increasing the meaningfulness of material by embedding it in stories, high immersion, engagement, and goal orientation can increase learning motivation and thus learning gain (Bransford, Brown & Cocking, 1999; Kozlowski et al., 2001).

3 Adaptive Educational Systems

Adaptive Educational Systems are technology enhanced learning environments that can detect students' needs and preferences in order to tailor teaching strategies and learning content. Empirical studies show that in some domains such as algebra and programming, Adaptive Educational Systems can be at least as effective as human teachers (e.g., Corbett, 2001).

However, Adaptive Educational Systems usually adapt to individual differences in cognition such as the learner's knowledge, learning goals or cognitive styles (Brusilovsky, 2001) or affection (e.g., Hudlicka & McNeese, 2002). In the triangle of basic human mental functions:

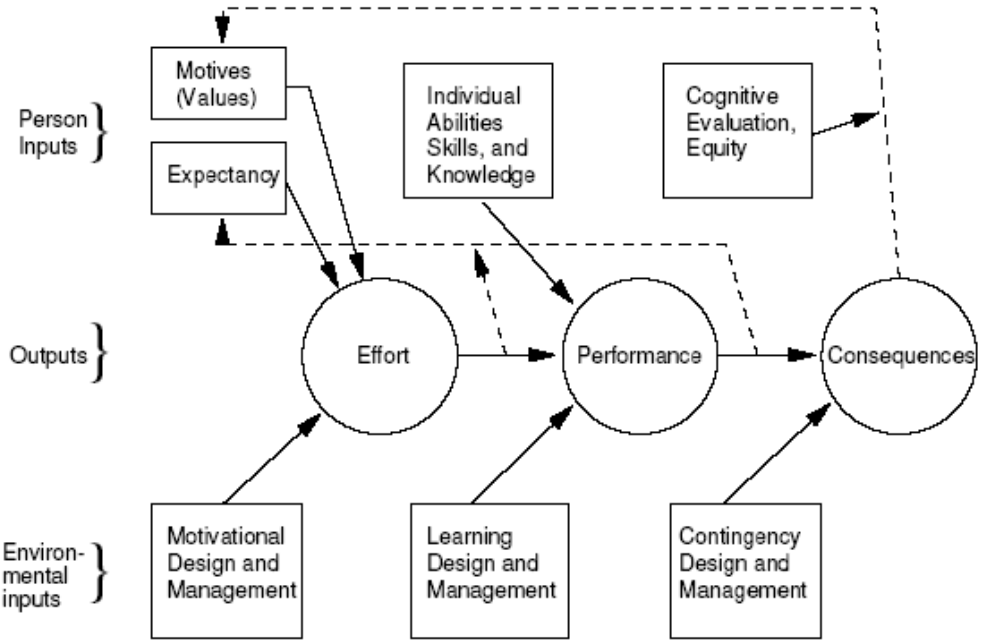

Figure 1. Motivation theory of Keller (1983), adopted from de Vicente (2003)

cognition, affect, conation (Parkinson & Coleman, 1995); the third side, i.e., conation/motivation, has been pretty much neglected so far. This is surprising, considering that motivation is crucial for learning but learners obviously differ in their motivational state depending on circumstances.

4 Adaptation to Motivational States

In fact, there is some promising work on assessing the motivational state of learners, and some preliminary results on appropriate adaptation strategies.

4.1 Assessing the Motivational States of Learners

Motivational states can be assessed in various ways. Porayska-Pomsta & Pain (2004) distinguish observational methods and knowledge elicitation methods. An extended list of these methods is shown in Table 2.

While some of these methods can be utilized for research purposes only (e.g., interviews, Wizard-of-Oz studies), some might be applied to Adaptive Educational Systems too.

The most straightforward way to get to know a learner's motivation is through self-report measures. It has been shown, that people are actually willing to express their motivational state (e.g., via sliders) and that these reports seem to be valid (de Vicente & Pain, 1999). However, this procedure requires additional effort of the learner and is not feasible for frequent update.

In the area of sentient analysis and affective computing, sensors have been developed to detect patterns in the physiological states in order to detect emotions (Picard, 1997). Similar devices could also be used to detect (or enhance) the assessment of motivational states. However, these sensors are often perceived as too intrusive.

A very promising approach is based on the observation of the interaction between learner and educational system (de Vicente & Pain, 1998; de Vicente & Pain, 2002; de Vicente & Pain, 2003). The authors identified and validated a set of rules to detect motivational states from behavioral cues such as speed or hesitation. Students' response times to tasks in combination with actual performance can also be used to model their disengagement (Beck, 2004).

Questionnaires and external standards can also be applied as external criteria of motivation (e.g., Westrom & Shaban, 1992; Waugh, 2002) to validate the system's assessment.

In summary, there exist several methods to assess the motivational state of learners in learning environments. However, all of them have been only validated preliminary, and their applicability and feasibility in different environments still needs to be tested. Moreover, it needs to be explored how the different approaches can be combined in order to achieve a higher accuracy in the assessment process.

4.2 Adaptation Strategies

Once the motivational state of the learner has been assessed correctly, there are several strategies to adapt to this state. While a few of the strategies reviewed here have been implemented in Adaptive Educational Systems, most strategies listed in this section are derived from instructional theories in general and in particular from the game characteristics reviewed above. According to Keller (1983) motivation strategies can be categorized into motivational design, learning design and contingency design.

Motivational design addresses the learner's motivation directly in order to increase the effort put into a learning task. This can be done by communicating with the learner in a so called affective dialogue (del Soldato, 1992). In particular, positive feedback and praise can have a positive impact on student motivation (e.g., Terrell & Rendulic, 1996). Motivational design might also aim at an improvement of students' self-efficacy, their attention to or perceived relevance of the topic (Keller, 1999). A motivational design strategy based on game characteristics would be to involve the learner in activities (Jones, 1989) with interactive tasks that require the learner's continuous attention.

Learning design aims at changing the content itself or selecting/recommending appropriate content according to the motivational state of the learner. This includes providing a variety of materials in order to avoid predictability and repeatability (Stipek, 1993), involving the learners in active problem solving and divergent thinking (Stipek,

Table 1: Motivating characteristics of games

Game Characteristic	*Description*
Challenge	Conflict, competition (Prensky, 2001); task can be completed (Jones, 1989), but attainment is uncertain (Malone, 1980)
Story	Task embedded in story; meaningful representation of material (Beffa-Negrini, Cohen & Miller, 2002)
Immersion/ Engagement	Deep but effortless involvement (Jones, 1989); rich interaction (Prensky, 2001); easy to isolate activity from other stimuli (Malone, 1980); sense of duration of time is altered (Jones, 1989)
Mastery Orientation	Learner attention is directed toward performance (Kozlowski et al., 1999); clear goals and objectives (Prensky, 2001; Jones, 1989)
Control	Clear rules (Prensky, 2001); clear criteria for performance (Malone, 1980); concrete immediate feedback (Malone, 1980; Jones, 1989)

1993), choosing activities that are meaningful and relevant to the student (Beffa-Negrini, Cohen & Miller, 2002), and deciding whether the student may proceed to the next topic or not (Georgouli, 2002, Weibelzahl, 2003). Effort behavior can also be scaffold by keeping learning activities short, using visual enhancement to support the activities, and intermingling information presentation screens with interactive screens (Song & Keller, 2001). The system might also adapt the difficulty of tasks (del Soldato, 1992) and offer help (Georgouli, 2002). Learning design strategies based on game characteristics suggest providing tasks at a challenging difficulty level (Bransford, Brown, & Cocking, 1999) and setting clear goals and objectives (Kozlowski et al., 1999).

Contingency design aims at making the learner confident that effort and performance are closely coupled with consequences. This might include informing the learner about procedures (number of tasks, evaluation criteria) as well as using words and phrases that help attribute success to learner's effort and ability (Song and Keller, 2001). Contingency design strategies based on game characteristics suggest enhancing the level of control by introducing clear rules and performance criteria (Malone, 1980) and offering immediate feedback (Jones, 1989).

In summary, adaptation strategies might aim at both the content level as well as the motivation itself (effort, performance, contingency of consequences). It should be noted that adaptation at the content level might interfere with other instructional strategies that are based on cognitive models. For example, motivational strategies might suggest selecting a simple task to avoid disappointment, while knowledge based strategies might suggest selecting a very difficult task, because the learner has already mastered the entry level. Thus, del Soldato & du Boulay (1996) proposed to use both a motivational planner and a domain-based planner that negotiate together the most appropriate strategy.

Table 2. Methods to assess motivation

observational methods	*knowledge elicitation methods*
– direct observation	– interviews
– video recording of behavior	– questionnaires
– transcripts analysis	– self-reports
– sentient analysis	– Wizard-of-Oz studies
– observation of interaction	– comparison to external standards

5 Open Research Issues

Having reviewed the state-of-the-art it is obvious that some vital components of such an envisaged adaptive system already exist. It is a matter of bringing together and enhancing existing findings in the assessment of motivational states (de Vicente & Pain, 2002) and the adaptation to these states (del Soldato & du Boulay, 1996). Gaming characteristics have the potential to serve as a new way to identify appropriate and efficient motivation strategies. It is very promising to explore how an Adaptive Educational System, using game characteristics, can explicitly model motivational states of learners and adapt to these states. Further studies are required to identify a generic reusable model for adaptation to motivational states and to implement a motivational adaptation engine using game characteristics. In particular, this would involve the following questions:

- How can an Adaptive Educational System detect and measure motivational states of learners? The existing model proposed by de Vicente & Pain (2002) is a very good basis for this. The reliability and validity of several kinds of self-reports needs to be tested. The quality and applicability of motivation assessment based on interaction cues needs to be formalized and validated in different educational settings. New forms of motivation detection based on affective computing techniques should be explored and validated.
- How can these motivational states be represented and stored in a student model? The assessments need to be stored in an appropriate way. Two representation aspects are of particular interest: First, how often and when needs the student model to be updated and how can the change over time be represented (increasing motivation might be treated different from decreasing motivation even if it is at the same level). Second, situational aspects of motivation, so called states ("I give up, because I cannot solve this task") need to be handled separately from general predispositions, so called traits ("I don't like math"). It needs to be explored how states and traits can be represented and how they interact.

- How can an Adaptive Educational System adapt to identified motivational states? This will involve implementing motivational strategies that encourage higher effort, and that tailor instructional design in order to improve performance. These strategies will be based on the application of motivational features of games such as challenge, story, immersion, and mastery orientation to technology enhanced learning. Appropriate and feasible strategies need to be developed for different target groups (e.g., students vs. adults), educational settings (e.g., exploration, assessment), and subject domains (e.g., programming vs. educational psychology).

6 Summary

Despite of the obvious importance of motivation for learning, most current Educational Adaptive Systems model cognitive characteristics of learners such as goals, knowledge or preferences. We have outlined the state-of-the-art and described which open issues need to be addressed before such a system can be implemented. Game characteristics have been identified as basis for potential adaptation strategies.

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