Raising Confidence Levels using Motivational Contingency Design Techniques

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Abstract: Motivation plays a key role in learning and teaching, in particular in technology enhanced learning environments. According to motivational theories, proper contingency design is an important prerequisite to motivate learners. In this paper, we demonstrate how confidence levels in an adaptive educational system can be raised using a contingency design technique. Learners that saw parts of a complete picture depending on their performance were more confident to solve the next task than learners who did not. Results suggest that it is possible to raise confidence levels of learners through appropriate contingency design and thus to automatically adapt to their motivational states.

1 Introduction

Motivation obviously plays a key role in learning and teaching. However, technology enhanced learning environments often fail to motivate learners. Teachers devote a lot of time to assess and increase their students' motivation. 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 [6]. Students with high intrinsic motivation often outperform students with low intrinsic motivation [21], and students with high motivation engage more in learning activities and are more likely to complete a course [23]. Accordingly, 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 [19].

The evident importance of motivation for learning, and the fact that learners differ in their motivational state, open promising perspectives for an adaptive educational system that adapts to these motivational states. In this paper we outline a framework for modeling the motivational states of learners. Some first empirical results indicate how parts of this framework, in particular how contingency design might be implemented in an adaptive educational system.

2 Motivational Theories

Motivation is an internal state or condition that activates behavior and gives it direction [17]. In particular, the motivation to learn is characterized by long-term, quality involvement in learning and commitment to the process of learning [1]. 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 [7], behavioral theories [25], humanistic theories [22], and various cognitive theories [22] [32]. In applied psychology such as organizational and educational psychology, value-expectancy theories have been shown to be fruitful.

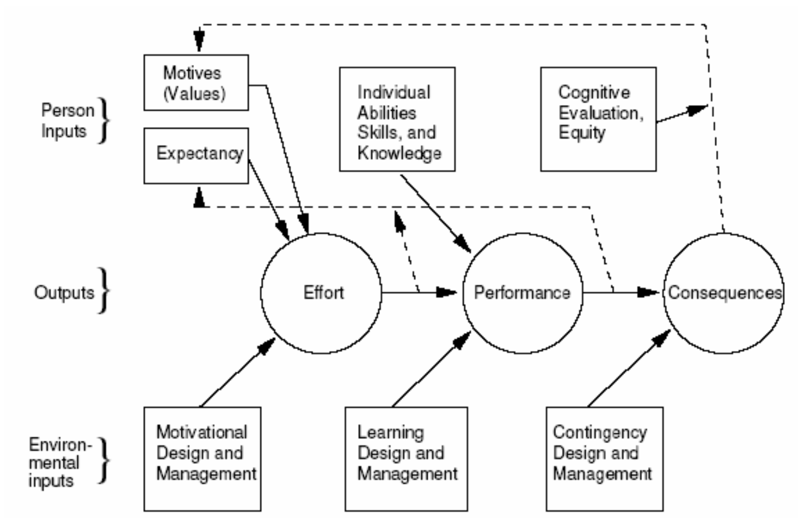

Fig. 1. Motivation theory of Keller (1983), adopted from de Vicente (2003)

One prominent example is Keller's theory of motivation in education [11]. 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 Fig, 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. In accordance with results presented by [30][31], we suggest that Keller's theory can serve as a framework for guiding the modeling of motivation in adaptive educational systems.

2 Adaptation to Motivational States

The adaptation to motivational states can be divided into two phases: assessment of the learner's motivational state and adaptation to these states with motivational strategies.

2.1 Assessment of Motivational States

Several different ways have been proposed so far to detect the motivational state of learners, including self-reports through sliders [30], behavioural cues in the interaction between learner and educational system [31], students' response times to tasks in combination with actual performance [3], as well as learner's attention, current task and expected time to perform [24]. Questionnaires and external standards can also be applied as external criteria of motivation [33] to validate the system's assessment.

2.2 Adaptation Strategies

Once the motivational state of the learner has been assessed correctly, there are several strategies to adapt to this state. According to Keller [12] 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 [27]. In particular, positive feedback and praise can have a positive impact on student motivation [29]. Motivational design might also aim at an improvement of students' self-efficacy, their attention to or perceived relevance of the topic[13].

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 [26], involving the learners in active problem solving and divergent thinking [26], choosing activities that are meaningful and relevant to the student [4], and deciding whether the student may proceed to the next topic or not [9]. 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 [28]. The system might also adapt the difficulty of tasks [27] and offer help [9].

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 [28]. It has also been suggested to enhance the level of the learner's perceived control by introducing clear rules and performance criteria [20] and by offering immediate feedback [10].

The study reported in this paper focuses on the effects of contingency design in an adaptive system called EDUCE. The technique used in this study is based on gradual manifestation of pictures in dependence on performance.

3 Motivation Modeling in EDUCE

EDUCE is an adaptive intelligent educational system [14][16]that uses Gardner's theory of Multiple Intelligences (MI) as the basis for dynamically modeling learning characteristics and for designing instructional material [8]. The theory of Multiple Intelligences reflects an effort to rethink the theory of measurable intelligence embodied in intelligence testing. It is also a rich concept that offers a framework and a language for developing adaptive educational systems that supports creative, multimodal teaching [18].

The Multiple Intelligence theory states that there are eight difference intelligences that represent a different way of thinking, solving problems and learning. In EDUCE, four intelligences are used to develop instructional resources and model the learner. These are defined as the verbal/linguistic, logical/mathematical, visual/spatial and musical/rhythmic intelligences. The musical/rhythmic intelligence was chosen because it is not considered as an intelligence that can be used to deliver and inform the design of content yet the emotive power of music is widely acknowledged [5].

The motivational features of EDUCE can be described along Keller's theory as learning design and contingency design.

3.1 Learning Design in Educe

The learner's performance obviously depends on the individual abilities (Fig. 1). EDUCE recognizes the learner's MI profile using a predictive engine. The current version uses the following four intelligences in modeling the student:

- Logical/Mathematical intelligence (LM) - This consists of the ability to detect patterns, reason deductively and think logically.
- Verbal/Linguistic intelligence (VL) - This involves having a mastery of the language and includes the ability to manipulate language to express oneself.
- Visual/Spatial intelligence (VS) - This is the ability to manipulate and create mental images in order to solve problems.
- Musical/Rhythmic intelligence (MR) - This encompasses the capability to recognize and compose musical pitches, tones and rhythms.

EDUCE builds a dynamic model of the student's MI profile by observing, analyzing and recording the student's choice of MI differentiated material. Other information also stored in the student model includes the navigation history, the time spent on each learning unit, answers to interactive questions and feedback given by the student on navigation choices.

EDUCE holds a number of tutorials designed with help of subject matter experts. Each tutorial contains a set of content explaining a particular subject area. For the experiment described in this paper, Science is the subject matter. A tutorial consists of learning units that explain a particular concept. In each unit there are four different sets of learning resources, each based predominantly on one of the intelligences. The different resources explain a topic from a different angle or display the same information in a different way. Students are adaptively guided through this material based on their dynamic MI profile [15].

3.2 Contingency Design in EDUCE

Contingency design aims at making the learner confident that effort and performance are closely coupled with consequences. Each learning unit in EDUCE consists of several distinct stages. The first stage aims to attract the learner's attention (Fig. 2), the second stage provides a set of different MI resources, the third stage re-enforces the key message in the lesson and the final stage presents interactive questions on the topic. After accessing the second stage, students may repeatedly go back and use the same or different MI resource.

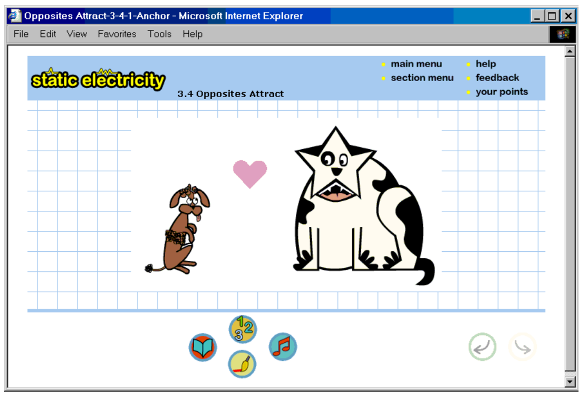

Fig. 2. The Awaken stage of "Opposites Attract" with four options for different resources

The question phase offers an ideal opportunity to implement contingency design. EDUCE displays a picture which partially reveals itself based on the number of correct questions answered. In this particular tutorial a cartoon was divided into nine pieces. The meaning would not be revealed unless the learners answered all questions correctly and all nine parts are actually shown.

According to Keller, such a contingency design would increase the learners' confidence in answering questions and their performance. We designed an empirical study that aimed to demonstrate these effects.

4. Experimental Design

In order to explore the effect of Contingency Design on confidence levels and learning performance we set-up and experimental study with students. In particular the impact of the independent variable, picture strategy, on two dependent variables, learning performance and confidence levels was explored.

The picture strategy for raising confidence levels encompasses two main strategies:

1. *Show Picture*: After each question the student answers, the overall progress of the student is displayed through the use of a partially displayed picture. For example if 9 questions have been answered correctly then 4 pieces of the

picture are displayed. In total there is 9 pieces in a full picture. Fig. 3 displays a sample picture a student may see.

2. *Without Picture*: Here after the student answers a question no feedback is provided. The student continues to move through the tutorial without any feedback on progress.

To determine confidence levels, before each question, the student was asked the question: *Do you feel able to answer the next question?* The response to the question was gathered using a 4 point likert scale with 1 = no and 4 = yes. These answers are collated to determine confidence levels throughout the tutorial.

Learning performance is defined by the post-test score and the learning gain. To calculate the relative learning gain each student before and after a tutorial sits a pre-test and post test. The test for the pre-test and post-test is the same and consists of questions that appear during the tutorial. The questions are multi-choice question with four options.

The experiment was conducted during one session on the computer, with each student spending on average 18 minutes exploring one tutorial. The session was preceded by a pre-test and followed by a post-test. The pre-test and post-test had the same 10 multi-choice questions, which were mostly factual. Students were randomly assigned to one of the two groups defined by the picture strategy: *show picture* and *without picture*. Within each group, students explored one of two different tutorials: *static electricity* or *electricity in the home*. They were also assigned to one of two groups, one group was forced to explore all the MI informed resources, the other group was free to progress through the tutorial after looking at least at one resource.

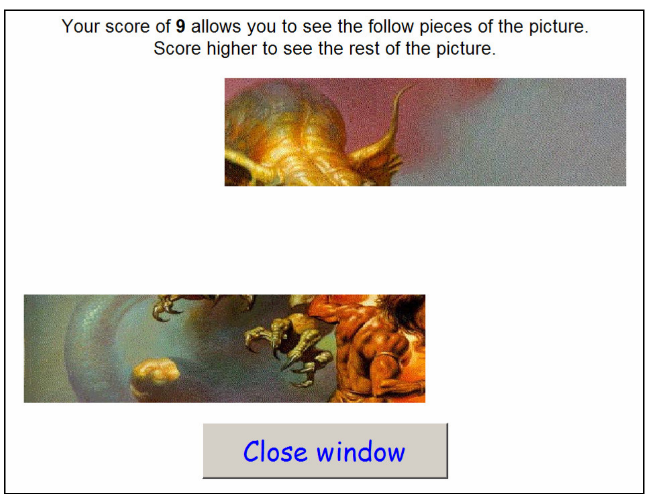

Fig. 3. Picture with fours pieces displayed

5 Results

35 boys and girls participated in the study. The ages ranged from 12 to 17, with an average age of 14. The students were randomly assigned to one of the two versions. 13 students were assigned to the show picture version and 19 students were assigned to the do not show picture version. Each student spent on average 18 minutes exploring one tutorial. The students were participating in a “Discovering University” program being run in the author’s place of work. The objective of the program was to give students the experience of third level education and to encourage them to continue education in university. The students attending this program would primarily be from areas designated as disadvantaged in terms of the number of students who participate in third level education. The study itself was conducted in the computer laboratories in the college and took place within the ‘Computer’ sessions on the Discovering University program. No reward incentives were provided to the students who participated.

The results were analysed from two perspectives, the effect of the picture strategy on confidence levels and performance levels. It was expected that the show picture strategy would raise performance and confidence levels.

A one-way ANOVA was conducted to explore the impact of the picture strategy on the post-test score. Disappointingly the results were not statistically significant, however post-test score for the picture strategy (M=55.4, SD=21.45) was slightly higher that the post-test for the no picture strategy (M=54.2, SD=20.63). A similar analysis was also conducted on the relative gain score and the results were also not statistically significant. One reason may be that the assessment instrument was not sensitive enough to measure differences in performance levels.

To determine if picture strategy had impact on confidence levels, the change in confidence level between the beginning and the end of the tutorial was analysed. To determine the change in confidence, the responses to the confidence question were aggregated. For each section, the total confidence level or the sum of all responses to the confidence questions was calculated. Subsequently, the change in confidence level was calculated by finding the difference between the confidence level at the end of tutorial and the beginning of the tutorial.

A one-way ANOVA was conducted to explore the impact of the picture strategy on the change in confidence level. The results were statistically significant: $F(1, 31) = 6.613$, $p=.05$. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the show picture group (M=19.23, SD=24.33) was significantly different from the no show picture group (M=3.73, SD=16.6). Fig. 4 illustrates how the confidence level changes over time.

The results suggest that the confidence levels of students could be raised by showing the performance level through the form of a partially displayed picture. The suggested that students could raise their confidence levels by being able to immediately link performance level to effort.

Together the results indicate that the picture strategy had an impact on the confidence level of students. However in this experiment an increase in confidence level did not translate into an increase in performance in the post-test.

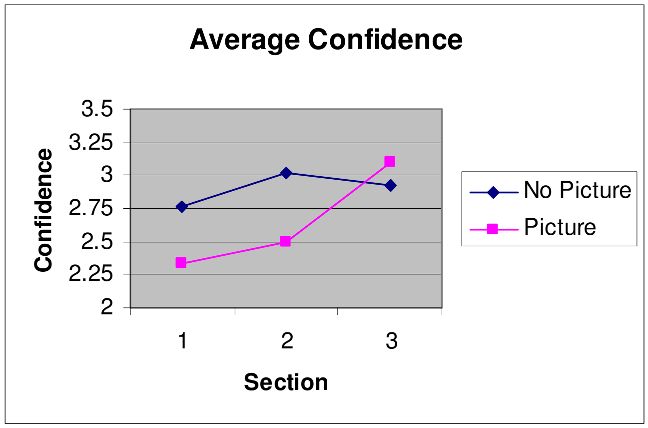

Fig. 4. Average Confidence Levels for Picture and No Picture group

6 Conclusions

This paper has described a framework for supporting motivation in an adaptive system. It has demonstrated how the EDUCE adaptive systems can be categorized according to this framework. It has also described an experiment that measures on aspect of this framework, contingency design, or the confidence that effort is linked to performance.

Results indicate that confidence levels can be raised through the use of contingency design. In EDUCE this was implemented using a picture that reveals more as the student gets more questions right. The implications for the design of adaptive systems are that it is possible to raise confidence levels through contingency design. It may be that for students with low confidence levels, an intelligent tutoring system may use adaptive strategies to support contingency design. The challenge of future work is to determine how to automatically detect confidence levels and to determine the relationship between confidence level and performance. Future work will also address other aspects of the motivational framework such as motivational design in order to increase motivation in learning environments.

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