An Emotional Student Model for Educational Gaming

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I. Introduction and Motivation

Game-based Learning

- Game-based learning offers advantages for learning through experience in conjunction with offering multi-sensorial and engaging communication (Sykes, 2006).
- Intelligent Tutoring Systems (ITSs) are incorporated into game-based learning environments to provide adaptable instruction (Conati & Maclaren, 2009). An ITS's student model facilitates understanding of students' interaction data (Woolf, 2009).

Emotion in Education and Computing

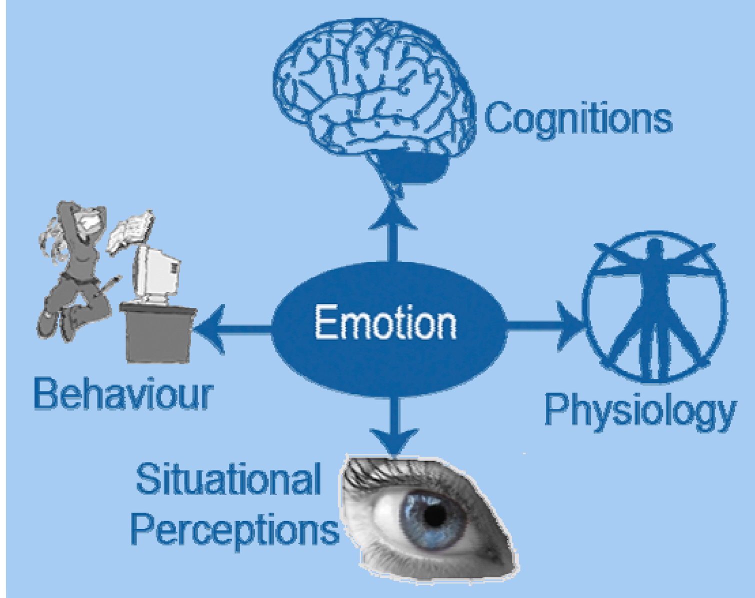
- Students' emotions influence motivation, learning and performance (Pekrun et al., 2007).
- Creating computer tutors that recognise and respond effectively to students' emotions promise a more effective and pleasant learning experience.
- Enabling computer tutoring systems to recognise and show emotions involves knowing:

  -What emotions are relevant to the learning situation.

  -How and when emotion arises.

  -What factors determine an emotion.

Emotion in Cognitive Psychology



- Emotions involve physiology, behaviour, cognitions and situational perceptions.
- Control-value theory of Pekrun et al. (2007) assumes that value and control appraisals of ongoing activities and their past and future outcomes are the most relevant when determining *achievement emotions, which are* experienced in educational settings.
- Control appraisals are related with students' expectations about being capable of initiating and performing an activity.
- Value appraisals are related to attainment of success and prevention of failure.
- There is not currently a computational emotional student model using control-value theory as a basis.

II. Aims and Objectives

- Create a computational emotional student model that can reason about students' emotions using control-value theory (Pekrun et al., 2007) as a basis.
- Provide suitable pedagogical and emotional feedback.
- Design, implement and test PlayPhysics, an emotional game-based learning environment for teaching Physics at undergraduate level.

III. Affective Student Modelling

- There is **uncertainty** regarding relevant emotions that occur in a learning and teaching context. Social standards and interpersonal differences confound recognition of emotions.
- To model inherent uncertainty, we employ **Probabilistic Relational Models (PRMs)** to facilitate derivation of **Dynamic Bayesian Networks (DBNs)**, which facilitate using prior domain knowledge and model dependencies in the emotional domain.

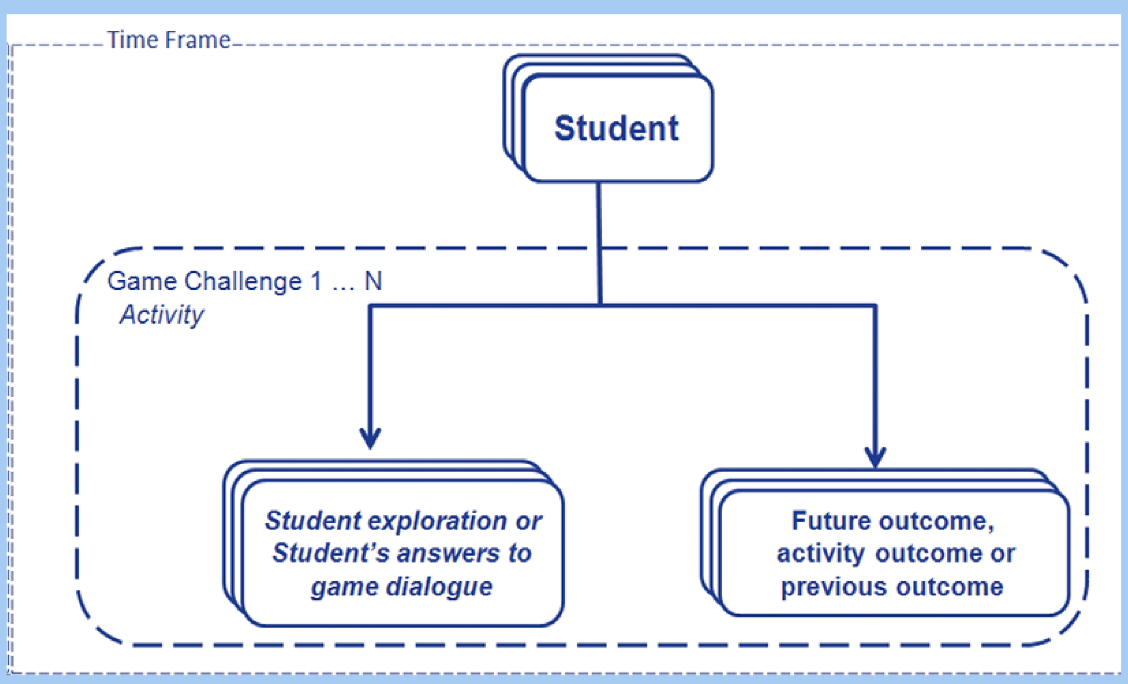


Figure 1. General PRM Schema for control-value theory.

- We derived three DBNs corresponding to three types of emotions defined by Pekrun et al. (2007): ***outcome-prospective, outcome-retrospective and activity emotions***.

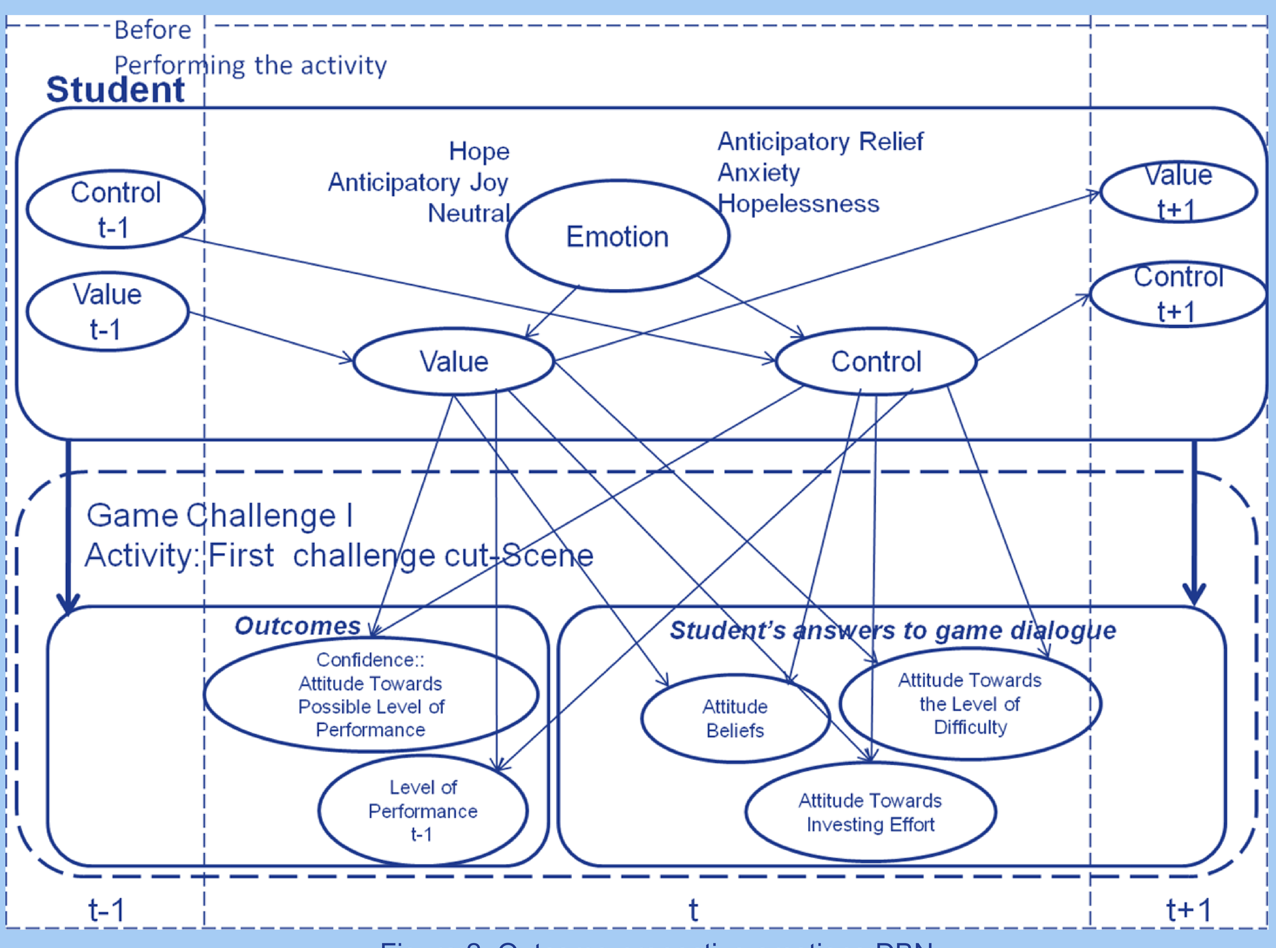


Figure 2. Outcome-propective emotions DBN.

IV. PlayPhysics Design

- An online survey was employed to identify the most difficult topics, such as principles of linear and circular kinematics, in an introductory Physics course at Tecnológico de Monterrey (ITESM-CCM), Queen's University Belfast and Trinity College Dublin.
- PlayPhysics uses the Olympia architecture (Muñoz et al., 2009) (Figure 3) that was adapted to recognise and show emotions.

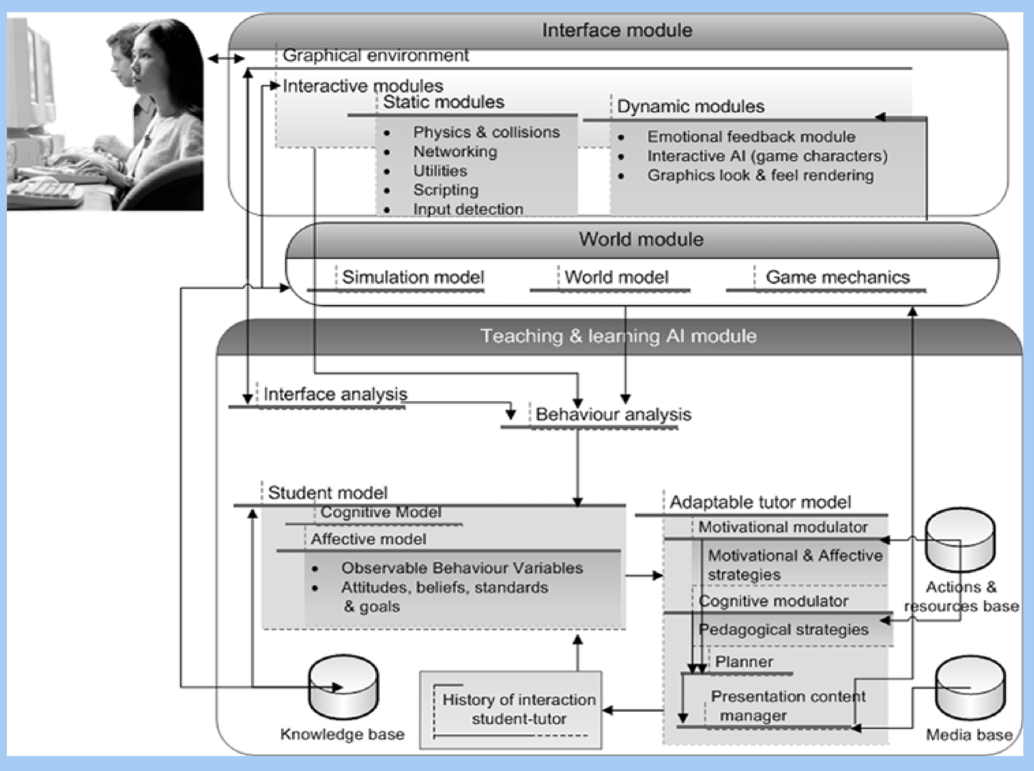


Figure 3. Olympia architecture.

V. PlayPhysics Implementation

- PlayPhysics deploys role playing games (RPG), e.g. space adventures, where students achieve goals using their Physics knowledge and understanding. The first level challenge concerns docking the student's spaceship (Alpha Centauri) with the space station Athena.
- PlayPhysics uses Java, Jakarta Tomcat, MySQL, the Unity game engine, 3D Studio Max, Adobe Photoshop, Adobe Fireworks, Audacity and Spacescape.

Figure 4. PlayPhysics' game dialogue.

Figure 5. PlayPhysics' first level external view.

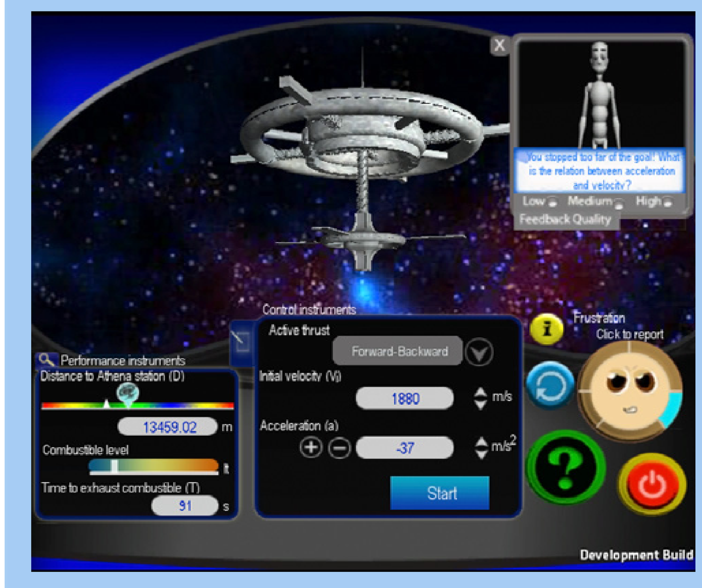


Figure 6. PlayPhysics' first level internal view.

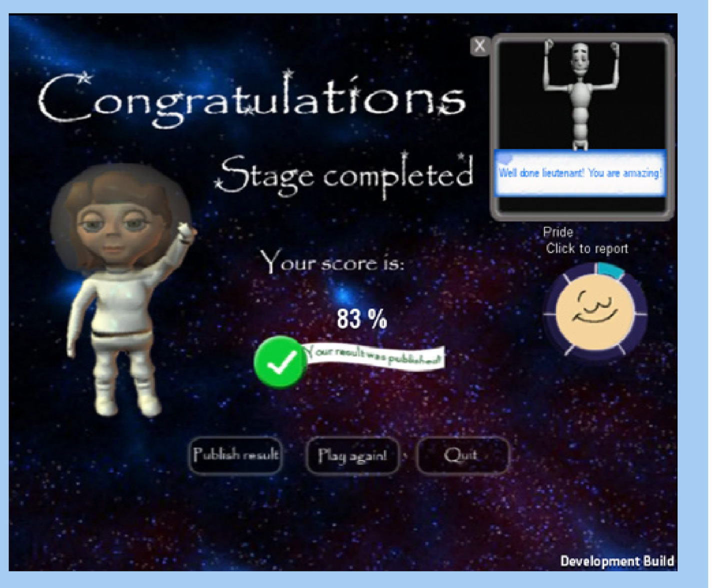


Figure 7. PlayPhysics' first level success view.

VI. Experimental Results

- 61 students of Engineering at ITESM-CCM solved a pre-test, interacting with PlayPhysics' game dialogue and reporting their emotional state.
- Each emotion reported was converted into its corresponding value and control appraisal according to control-value theory.
- The data was analysed through Multinomial Logistic Regression using SPSS. Two variables were identified as the best predictors of category membership, as shown in Table 1.

Dependent variable	Predictors	Significance (p-values)	Odds ratios	95% C.I. (confidence intervals)	% cases correctly classified
Value	Confidence: attitude towards the possible level of performance	0.002	6	1.957-18.398	70.5
Control	Attitude beliefs towards Physics	0.021	7.885	1.364-45.577	88.5

Table 1. Multinomial Logistic Regression estimates of the predictors of control and value for the outcome-prospective emotions.

- The model, outcome-prospective emotions DBN, was updated in structure and probabilities. The final student model attained 70% accuracy.

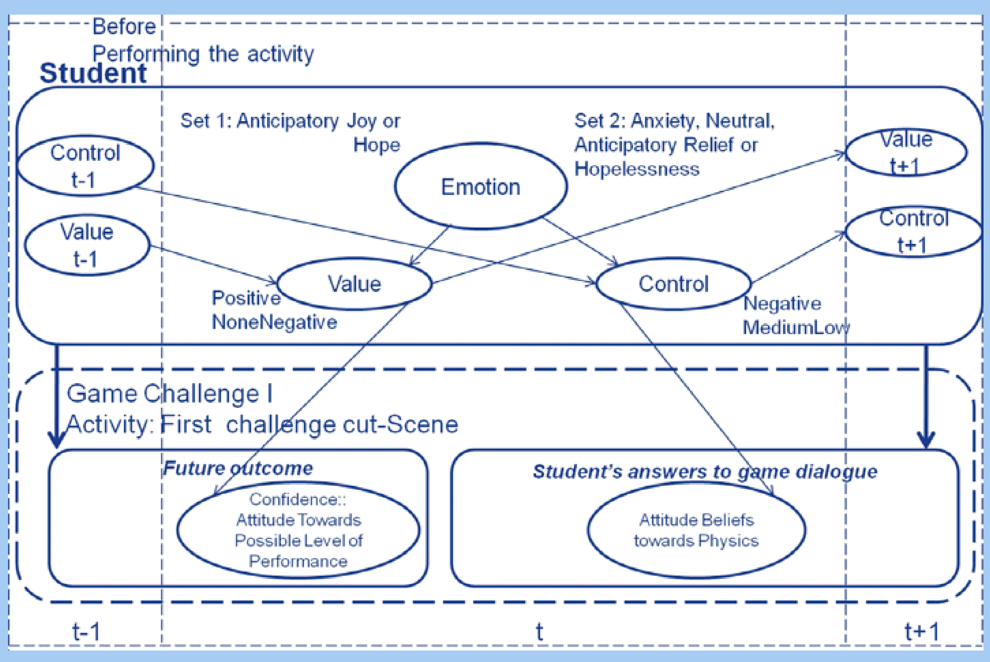


Figure 8. Updated outcome-prospective emotions DBN according to Multinomial Logistic Regression results.

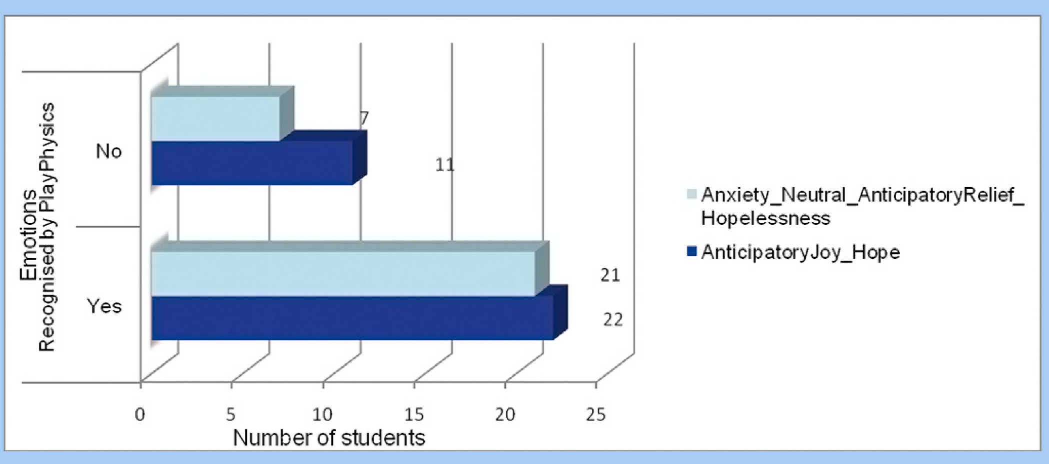


Figure 9. Prediction of membership by PlayPhysics' emotional student model.

VII. Conclusion and Future Work

- Preliminary evaluation of our emotional student model shows promise. Outcome-prospective emotions are identified with 70% accuracy, which corresponds with the accuracy of a human expert classifying emotion.
- Negative and neutral emotions are more accurately distinguished by the model.
- The proposed approach has proven effective for creating an emotional model that can reason about students' emotions using observable behaviour and answers to posed game-dialogue questions.
- Future work will include conducting tests and evaluations with the other two DBNs, activity and outcome-prospective emotions.
- PlayPhysics' first level challenge and future levels will be completed. PlayPhysics' effectiveness for teaching and learning will be assessed.
- We will explore the incorporation of physiological variables, such as Galvanic Skin Response (GSR), to enhance the accuracy of emotion classification.

VIII. Selected Publications

- Muñoz, K., P. Mc Kevitt, T. Lunney, J. Noguez & L. Neri (2011). An emotional student model for game-play adaptation. In M. Ma, N. Antonopoulos, M.F. Oliveira (Eds.), Special Issue on Serious Games Development and Applications, *Entertainment Computing.*
- Muñoz, K., P. Mc Kevitt, T. Lunney, J. Noguez & L. Neri (2011). Affective educational games and the Evolving Teaching Experience. In M. Cruz-Cunha, V.H. Carvalho, P. Tavares (Eds.), *Business technological and social dimensions of computer games: multidisciplinary developments.* Hershey, PA, USA: IGI Global.
- Muñoz, K., P. Mc Kevitt, T. Lunney, J. Noguez & L. Neri (2010). PlayPhysics: an emotional games learning environment for teaching Physics. In Y. Bi & M.A. Williams (Eds.), 400-411, *Proc. of the 4th International Conference on Knowledge, Science, Engineering & Management (KSEM-10), Europa Hotel, Belfast, Northern Ireland, UK, September 1–3.* Heidelberg, Germany: Springer Verlag.