

# Affective Support in Narrative-Centered Learning Environments

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## Abstract

The link between affect and student learning has been the subject of increasing attention in recent years. Affective states such as *flow* and *curiosity* tend to have positive correlations with learning while negative states such as *boredom* and *frustration* have the opposite effect. Consequently, it is a goal of many intelligent tutoring systems to guide students toward emotional states that are conducive to learning through affective interventions. While much work has gone into understanding the relation between student learning and affective experiences, it is not clear how these relationships manifest themselves in narrative-centered learning environments. These environments embed learning within the context of an engaging narrative that can benefit from “affective scaffolding.” However, in order to provide an optimal level of support for students, the following research questions must be answered: 1) *What is the nature of affective experiences in interactive learning environments?* 2) *How is affect impacted by personal traits, beliefs and learning strategies, and what role does affect have in shaping traits, beliefs, and learning strategies?* 3) *What strategies can be used to successfully create an optimal affective learning experience?*

**Keywords:** Affective Interfaces, Intelligent Agents, Applications in Education

## 1 INTRODUCTION

Affect has begun to play an increasingly important role in intelligent tutoring systems. The intelligent tutoring system community has seen the emergence of work on affective student modeling [1], detecting frustration and stress [2, 3], modeling agents’ emotional states [4, 5], devising affective-informed models of social interaction [6, 7], detecting student motivation [8], and diagnosing and adapting to student self-efficacy [9]. All of this work seeks to increase the fidelity with which affective and motivational processes are understood and utilized in intelligent tutoring systems in an effort to increase the effectiveness of tutorial interactions and, ultimately, learning.

This level of emphasis on affect is not surprising given the impact it has been shown to have on learning outcomes. Student affective states influence problem-solving strategies, the level of engagement exhibited by the student, and the degree to which he or she is motivated to continue with the learning process [10, 11, 12]. All of these factors have the potential to influence both how students learn immediately and their learning behaviors in the future. Consequently, developing techniques for keeping students in an affective state that is conducive to learning has been a focus of recent work [13, 14, 15].

Unfortunately, there is not yet a clear understanding of how emotions occur during learning and, in particular, how individual learning environments impact the emotional experience. It is also unclear which emotional states are optimal for individual students. This is likely to vary based on student needs and experience. Affective experiences may also have interesting immediate and long term effects on how students perceive learning and their levels of confidence and motivation moving forward. Finally, current research on how best to respond to student affect has yielded varying and often conflicting conclusions [9, 16, 17]. For these reasons, it is challenging to design affective support systems for learning environments.

The goal of this research is to examine these issues within narrative-centered learning environments. These environments embed the educational process within a story with the objective of leveraging narrative’s motivating features such as compelling plots, engaging characters, and fantastical settings [18]. These environments also offer the potential for affective experiences that are supplementary to those experienced in more typical interactive learning environments [19]. The ability to understand and control the emotional experiences of students in narrative-centered learning environments could lead to significant gains for student learning and motivation. The proposed

research aims to achieve this goal by answering the following three research questions: (1) What is the nature of affective experiences in interactive learning environments? (2) How is affect impacted by personal traits, beliefs and learning strategies and what role does affect have in shaping these qualities? (3) What strategies can be used to successfully create an optimal affective experience?

## 2 RESEARCH QUESTIONS

The overarching goal of the proposed research is to *characterize* and *facilitate* affective experiences in narrative-centered learning environments in order to achieve *optimal* immediate learning gains and future long-term outcomes. This goal can be achieved through exploration of three lines of investigation. The first relates to the *characterization* of affective experiences. In particular it is important to understand the types of emotions that are experienced in narrative-centered learning environments as well as the antecedents and consequences associated with each. The second research question relates to defining *optimal* experiences. Many user traits and beliefs about learning may impact affective responses and may in turn be altered by powerful learning experiences. Understanding the interrelation between these personal traits and student affect will contribute to a clearer understanding of optimal outcomes. Finally, the third research question builds directly on the second by attempting to *facilitate* affective experiences. These efforts are intended to yield a variety of strategies that can be shown to induce optimal affective experiences. Collectively, these three areas of investigation suggest a comprehensive approach to supporting student affect in interactive learning environments.

### 2.1 NATURE OF AFFECTIVE EXPERIENCE

While much effort has been invested by the affective community to characterize the emotional experiences associated with learning, there is still no comprehensive model of the role that affect plays in learning. Understanding the role that affect plays in interactive learning environments, which is the focus of this research, is especially challenging. The types of emotions students experience in one-on-one tutoring may vary significantly from those experienced in computational environments, and the characteristics of particular learning environments may further influence the range of emotions experienced. For instance, the presence of pedagogical agents may promote the occurrence of social emotions, such as *pride*, while learning environments with a narrative focus offer the opportunity to investigate a potentially different set of affective states.

While the precise cognitive and affective mechanisms underlying learning experiences is not yet well understood, there has been significant progress in attempting to identify the emotions that students are likely to experience and how these may affect the learning process. For instance Kort *et al.* present a model of learning emotions which can be represented as a cycle that occurs throughout the learning process [10]. Other studies have investigated how emotional experiences transpire in computational environments. Both D'Mello *et al.* and Baker *et al.* have shown that students are most likely to remain in the same state through time and that certain emotional transitions are more likely than others [20, 21]. The results of these studies, and their replication in subsequent work, suggest that there is an underlying model modulating the likelihood of students experiencing particular affective states. Understanding the details of this model is the major goal of this first research question.

### 2.2 PERSONAL TRAITS AND AFFECT

The next research question relates to how individual traits can impact and be impacted by the affective experiences of learning. There are many traits, such as goal orientation, self-efficacy and motivation, that significantly impact how students approach learning situations. Consequently, these differential traits likely result in varying emotional experiences. Similarly, our experiences shape our beliefs and approaches to learning. Therefore, strong or repeated affective experiences can greatly impact student traits in future learning. Understanding how these two notions of individual traits and affective experiences relate to one another is key to supporting student affect.

The impact of student traits on affective experiences can clearly be seen when examining the construct of goal orientation. *Goal orientation* refers to the focus of student behavior in learning situations [22]. Students are typically classified as having a mastery or performance orientation. *Mastery* orientation refers to the tendency of a student to focus on the academic material and particularly on the acquisition of knowledge and skill for their own intrinsic values. Alternatively, *performance* oriented students focus on how well they are achieving particular tasks and how their performance compares to others [22]. Interestingly, goal orientation has been shown to impact student affective experiences in response to learning tasks of varying difficulties [23].

Self-efficacy is also strongly related to emotional experiences. Defined as an individual's belief in his or her ability to successfully complete a given task [24], *self-efficacy* has very strong correlations with hope and optimism. These types of emotional experiences are likely to carry students through difficult tasks, and students with high self-efficacy are also less likely to experience negative emotions such as discouragement and despair which may cause them to avoid learning tasks. The experience of these negative states can also result in further decreases in confidence and self-efficacy while positive experiences improve student confidence in their ability to succeed [24]. Additionally, negative states experienced during learning may decrease student motivation to learn and pursue more difficult tasks, while positive affective states can improve student motivation [25].

While there are very clearly some strong examples of the interplay between personal traits and affective experiences, these are not understood in depth, nor is it clear how these findings carry over to interactive learning environments. Because these traits, and the experiences associated with them, have such strong impacts on learning, developing a clear understanding of their interaction is a critical next step in developing affective support strategies.

## 2.3 ACHIEVING OPTIMAL EXPERIENCE

While understanding the affective experiences learners encounter and the interplay of these experiences with personal traits is interesting in its own right, developing strategies that take advantage of these findings is the ultimate object of this research. Pedagogical interventions that focus on individual student needs and provide affective support throughout the learning process are likely to show increased learning immediately as well as have positive impacts on student attitudes toward learning in the future. Since a student's emotional state can strongly impact how the student learns [12] and interacts with learning environments [21], it is important to develop a clear understanding of what types of interventions create positive affective experiences. Additionally, with the insight gained from investigating the impacts of affect on long-term personal traits, these interventions have the potential to produce lasting results. Unfortunately, it is not yet clear how the variety of social and pedagogical strategies can be used to provide optimal affective support for individual students.

To date, a broad range of strategies has been suggested for improving student affect. Chaffar and McLaren [13] propose an Emotional Intelligent Agent which utilizes guided imagery, music and presented images in an attempt to induce optimal emotional states for each student. D'Mello *et al.* [14] have also proposed methods for responding to student affect using empathetic and tutorial dialogue acts accompanied by visual facial expressions and emotionally synthesized speech. Alternatively, Murray and VanLehn provide affective support without directly encouraging or displaying emotional states [26]. Instead, they use a decision theoretic approach to determine when the delivery of hints may hinder or improve student morale and independence.

Though each of these strategies has the overarching goal of encouraging students to remain in emotional states that are conducive to learning, they utilize very different approaches. Understanding the effects of these types of approaches on individual students will support more precise affective intervention. This line of investigation constitutes the final component of the research agenda proposed for delivering optimal affective support. Together with a deep understanding of the affective tendencies of students and how these emotions affect lifelong learning, these intervention strategies will enable us to design interactive learning environments that directly address improved affect-informed learning experiences.

## 3 PROGRESS TO DATE

Work has begun on each of the research directions outlined above. These efforts have centered on empirical studies of the affective experiences of students interacting with the narrative-centered learning environment, CRYSTAL ISLAND [19, 27, 28]. This environment is being created in the domains of microbiology and genetics for middle school students. It features a science mystery set on a recently discovered volcanic island where a research station has been established to study the unique flora and fauna.

The user plays the protagonist, Alex, who is attempting to discover the source of an infectious disease at the research station. The story opens by introducing the student to the island and the members of the research team. As members of the research team fall ill, it is her task to discover the cause and the specific source of the outbreak. She is free to explore the world and interact with other characters while forming questions, generating hypotheses, collecting data, and testing her hypotheses. She can pick up and manipulate objects, and talk with characters to gather clues about the source of the disease. In the course of her adventure she must gather enough evidence to correctly identify the type and source of the disease that has infected the camp members.

To date, two studies have been completed to understand the affective experiences of students within the CRYSTAL ISLAND environment and examine the impacts of character-delivered affect support. The first of these studies (**Study 1**) focused on character empathetic behaviors in response to student affect. The subjects of the study consisted of 35 college students ranging in age from 21 to 60 ( $M = 24.4$ ,  $SD = 6.41$ ) including 9 females and 26 males. Among these students, 60% were Asian ( $n = 21$ ), approximately 37% were Caucasian ( $n = 13$ ) and one participant chose not to respond. The second study (**Study 2**) supplemented the empathetic feedback of agents with task-based support. The subjects of this study consisted of 41 college students ranging in age from 19 to 38 ( $M = 24.0$ ,  $SD = 3.96$ ) including 12 females and 29 males. Among these students, approximately 73% were Caucasian ( $n = 30$ ), 17% were Asian ( $n = 7$ ), and 10% were Other ( $n = 4$ ).

Both studies followed a similar paradigm for measuring and responding to student affect. In each case, affective support was provided through text-based character dialogue. When subjects decided to interact with the agents, the agent would begin the conversation by asking the question, “Hi Alex, how are you feeling?” The subject would then self-report on their affective state by selecting one of the available emotions (*anger, anxiety, boredom, confusion, curiosity, delight, excitement, flow, frustration, sadness, fear*). The agent then responds to the subject’s reported affective state with a randomized feedback response. In Study 1, feedback responses varied between parallel and reactive empathetic statements. In Study 2, these responses were varied between empathetic statements (both parallel and reactive) and task-based feedback. More details on these feedback strategies are presented in Section 3.3. The dialogue would then continue with the regular narrative content. At the conclusion of the interaction, the agent again asks the subject how she feels by asking “How are you feeling now?” to which the subject provides a second self-reported emotional state.

### 3.1 CHARACTERIZING STUDENT AFFECT (STUDY 1)

Initial work at characterizing the affective experiences of students in CRYSTAL ISLAND has shown some interesting similarities and differences from the results found in other learning environments [19]. For instance, the optimal learning emotion *flow* was reported most frequently (42% of self-reports) both in the CRYSTAL ISLAND environment and in different types of environments such as the 2-dimensional games and dialogue-based tutorial systems used by Baker *et al.* and D’Mello *et al.*, respectively [20, 21]. Interestingly, *boredom* (3%) was reported less frequently and positive emotions such as *excitement* (14%) and *delight* (11%) were reported more often in the narrative-centered learning environment. Perhaps it is the interactive narrative nature of this environment that facilitates the occurrence of these emotions.

Analysis of the affective transitions experienced by students in CRYSTAL ISLAND also mirrored those of the other learning environments [19]. In general, students have a strong tendency to remain in the same affective state across time. However, when transitions to alternate affective states did occur, they followed interesting patterns. For instance, frustrated learners were very likely to transition to *confusion* or *fear* and were particularly unlikely to enter a positive state such as *flow* or *excitement*. Students experiencing the positive state of *flow* were likely to transition to *confusion*, which is still considered positive for learning and were unlikely to transition to the more negative state of *frustration*. Interestingly, confused learners were equally likely to transition to *flow* and *frustration*[19]. These findings suggest that the affective state of *confusion* and its antecedents and consequences are worth additional study to determine which factors contribute to a positive transition to *flow* or a negative transition into *frustration*.

### 3.2 IMPACT OF STUDENT TRAITS ON AFFECTIVE EXPERIENCE (STUDY 1)

Similar work has also been done to investigate how personal characteristics impact the affective experiences of students in CRYSTAL ISLAND [27]. The personal characteristics examined for this investigation include personality, goal orientation and gender. Personality was measured using the Big 5 Personality Questionnaire, which indexes student personality across five dimensions: openness, conscientiousness, extraversion, agreeableness and neuroticism [29]. Goal orientation measures students’ objectives when engaged in learning activities and is measured in terms of mastery or performance approaches [22].

Interesting results were found across these dimensions both in the frequency of emotions experienced by students and their affective trajectories throughout the learning process. For example, extraverted students reported emotions such as *delight* ( $t(34) = 1.82$ ,  $p = .07$ ) and *anger* ( $t(34) = 2.77$ ,  $p = .009$ ) more frequently than introverted students who were more likely to report being in *flow* ( $t(34) = 2.14$ ,  $p = .04$ ). This suggests that extraverted students may focus more on the characters and narrative components of the environment while introverted students are more focused on the learning tasks. Interestingly, boredom was reported only by male students.

Students who were focused on their performance in the environment reported significantly more *anger* ( $t(34) = 2.28, p = .03$ ) and *anxiety* ( $t(34) = 1.71, p = .09$ ) than students who were focused on the educational content. These students reported significantly more *flow* ( $t(34) = 2.25, p = .03$ ). Goal orientation also had significant impacts on the type of emotional trajectories experienced. For instance, contrary to the typical trend, mastery oriented students were unlikely to remain in a state of *confusion* or *boredom*. Instead, they quickly resume engagement in learning activities and transition into *flow*. Performance oriented students in these cases are more likely to stay *bored* or *confused* or alternatively transition to *frustration* or *anxiety*. This distinction may provide additional insight into how *confusion* is experienced and explain the interesting findings reported in Section 3.1.

In order to consider how affective experiences may affect student learning and motivation, the notion of presence was also measured. Presence refers to students' active engagement within the environment and is hypothesized to impact motivation and willingness to utilize these types of environments for learning in the future [30]. Interestingly, *frustration* was reported more frequently ( $t(34) = 1.70, p = .09$ ) by students who were not engaged in the environment and perhaps could be the source of this disengagement. Alternatively, students who reported high levels of presence reported more *anxiety* ( $t(34) = 2.23, p = .03$ ), perhaps because of their increased level of involvement. These students were also unlikely to remain *bored* and had a higher tendency to transition to *confusion*, *excitement* or *flow*. Students reporting low levels of involvement were more likely to remain *bored*.

### 3.3 INTERVENTION STRATEGIES (STUDIES 1 AND 2)

In addition to understanding the types of emotions experienced by students, several intervention strategies have been investigated in order to help maintain positive student affect. These strategies include affect-based empathy and task-based hints and suggestions. Empathy is defined as an awareness of another's affective state that generates emotions in the empathizer that reflect more than her own situation in attempt to foster a feeling of understanding or to motivate a more positive affective state [31]. Empathy can be further distinguished by two subtypes: parallel and reactive empathy. *Parallel* empathy typically involves an individual displaying an emotional state similar to that of the target of an empathetic response. In this case, the empathizer will demonstrate an understanding of the target's emotional state with a focus on the relevant situational factors. For instance, a parallel empathetic response to a frustrated student could be, "I'm frustrated too! This material is very difficult." Alternatively, in *reactive* empathetic responses, individuals exhibit a deeper level of understanding and focus on bringing about the optimal affective state of the target. Often this will manifest itself as a demonstration of a different affective state from the target. For example, "Don't worry, I'm sure you'll figure this out soon!" would be a reactive response to a frustrated student.

In CRYSTAL ISLAND, characters were given the capability of responding empathetically to students. Investigation of student responses indicated some interesting differences in how students react to exhibitions of parallel and reactive empathy. Students met with parallel empathy had a strong tendency to remain in the same or similar affective state [19]. This was true whether the student was in a positive or negative state. Alternatively, students who received reactive responses tended to transition to very different states. If the student was exhibiting a negative state, a reactive response would successfully encourage them to enter a more positive affective state. Unfortunately, reactive responses would bring students in a positive state down to a more negative state, often *confusion*. It appears that attempting to further motivate a student who is already feeling positive has unfortunate side effects.

These findings were used in a follow-up study, which sought to examine the instances in which students preferred affective feedback or task-related feedback to their emotional states [28]. In this study students were asked to rate the helpfulness of empathetic responses and task-based hints. In the case of empathetic responses, students received a parallel empathetic statement in response to positive emotion and reactive responses to negative affective states. For task-based feedback, students would receive a summary of current progress when they reported a positive emotional state and would be given additional hints to help them overcome a negative state if it was reported. In general, task-based feedback was rated more helpful by students than the empathetic responses. While in most cases the ratings for task-based feedback were significantly higher than empathetic responses ( $M_1 = 2.88, M_2 = 2.33, p < 0.001$ ), this was not the case for the emotions that were not directly associated with learning. These emotions, which tie more closely with the narrative plot of the environment, were best met with empathetic responses. The emotional impact of these strategies is currently being examined to determine if they can effectively promote positive affect.

## 4 RESEARCH AGENDA

While current results are promising and provide some insight into how to properly support students' affective experiences, there are many areas that are yet to be explored. For instance, initial work has examined *which* affective

states students report while engaging in learning activities. Future work will examine *when* and *why* these states occur. If a student is experiencing frustration it is likely very important to understand the source of that frustration in order to properly respond to it. The student may be experiencing difficulties with the learning material, the controls of the environment or may simply be irritated by characters who are attempting to provide feedback. Understanding the sources of affective states will not only help identify the most appropriate interventions but will also contribute to better designs that will enable negative emotions to be effectively managed.

Current work has shown how goal orientation, personality and gender can affect emotional experiences and how these emotional experiences relate to student involvement within the environment. Work to date covers only a small subset of personal traits and beliefs that could impact learning and emotional experiences. Examining the impact of self-efficacy, confidence and beliefs about learning on emotional experiences represents a very promising direction for future work. Additionally, it will be important to determine how affective experiences in the environment affect students immediately following the interaction and in the future. Correlations of emotions with learning gains will provide valuable information regarding ideal affective states. Further, it will be important to determine if inducing positive affect increases students' motivation and willingness to learn in the present and in the future.

While several strategies for affective intervention have been examined, there are still many more that may impact students' affective experience. For instance, perhaps the physical appearance or narrative role of characters impacts students' perceptions of their responses. It has been shown that these factors can greatly impact students' affective states and feelings about learning [32], and it would be useful to understand how these factors interact with the use of intervention strategies. Additionally, there are other areas of investigation outside of agent feedback for providing affective support. Introducing companion agents may promote a more enjoyable experience for students and foster social emotions in addition to those currently experienced. There may also be methods of intervention through modifications to the environment itself. Perhaps the best way to help a frustrated student is to simplify the task they are trying to accomplish.

Finally, the current strategy for detecting and analyzing student affect is through self-report with character dialogue. To increase the fidelity of analysis and reduce invasiveness, alternate methods should be investigated. This line of investigation will include using facial, posture, and physiological analyses to determine student emotional states when characterizing student experience. Another promising area of work will be creating models of affect detection that can be run in real time to inform intervention strategies.

To pursue the research goals noted above, the following studies will be conducted:

- **Study 3** will focus on developing informed models of affect detection and understanding. During this study, middle school students will interact with the CRYSTAL ISLAND environment without interruption or affective intervention. Students will be monitored using video and physiological and posture sensors. Students' interactions with the environment and their personal characteristic traits will also be logged. Following the interaction, students will be presented with videos of themselves and their experience with the environment and asked to retrospectively report on the emotions they have experienced and their sources. This information will be integrated with assessments by trained judges and used to develop a comprehensive model of student emotions within the environment. These models will then later be used at run-time for student affect detection to replace self-reports.
- **Study 4** will utilize the models produced from the results of Study 3 to inform agent affective interventions. In this study agents will respond to student affect using task-based, empathetic or alternative feedback strategies. The effectiveness of these strategies will then be measured by students' immediate affective experiences and learning gains and future impacts on motivation and self-efficacy. The objective of this study is to develop decision-theoretic models which can utilize a broad range of information sources including student characteristics, affective experience and prior knowledge to estimate and weigh the consequences of each affective intervention.
- **Study 5** will supplement Study 4 by focusing on the image and role of the agents delivering affective feedback. In this study, agent age, gender, race and narrative role will be varied, along with the type of affective intervention strategies utilized. The goal of this study is to determine if agent traits have an impact on the effectiveness of intervention strategies and how student traits may interact with these effects.
- **Study 6** will represent the capstone of this line of work and will utilize the results of all previous studies. This study will compare versions of CRYSTAL ISLAND with and without informed affective support models. These models will include the automatic detection of affect as learned by Study 3 as well as the decision-theoretic models developed from results of Studies 4 and 5. Students will be exposed to the CRYSTAL ISLAND environment with variations of these models and the utility of each model will be determined through measures of student learning gains, motivation and self-efficacy.

## 5 CONCLUSIONS

Affect permeates every aspect of human experience including learning. The types of emotions we associate with learning influence how likely we are to actively engage in learning activities and perceive learning as a positive experience. Because of this significant impact on learning, it is important to develop an understanding of students' emotional states during learning experiences. The objective of the research agenda presented in this paper is to provide affective support for students in narrative-centered learning environments. These environments offer a broad range of opportunities for motivating students and encouraging positive affective experiences. Providing appropriate affective support requires a clear understanding of how students experience emotions within narrative-centered learning environments, how these emotions impact (and are impacted by) student traits and beliefs, and discovering strategies for affective intervention that can promote effective learning experiences.

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## REFERENCES

- [1] Conati, C., and McLaren, H. (2005) Data-driven refinement of a probabilistic model of user affect. *Proceedings of the 10th Intl. Conf. on User Modeling*, Springer-Verlag, New York, NY, 40-49.
- [2] Bursleson, W. (2006) *Affective learning companions: Strategies for empathetic agents with real-time multimodal affective sensing to foster meta-cognitive and meta-affective approaches to learning, motivation, and perseverance*. PhD thesis, Massachusetts Institute of Technology.
- [3] McQuiggan, S., Lee, S., and Lester, J. (2007) Early prediction of student frustration. In Proc. of the 2<sup>nd</sup> Intl. Conf. on Affective Computing and Intelligent Interaction, Portugal.
- [4] André, E., and Mueller, M. (2003) Learning affective behavior. In *Proceedings of the 10th Intl. Conf. on Human-Computer Interaction*. Lawrence Erlbaum, Mahwah, NJ, 512-516.
- [5] Graesser, A., Person, N., Magliano, J. (1995) Collaborative dialogue patterns in naturalistic one-to-one tutoring. *Journal of Applied Cognitive Psychology* 9: 495-522.
- [6] Johnson, L., and Rizzo, P. (2004) Politeness in tutoring dialogs: "run the factory, that's what I'd do". *Proceedings of the 7th Intl Conf. on Intelligent Tutoring Systems*. Springer-Verlag, New York, NY, 2004.
- [7] Paiva, A., Dias, J., Sobral, D., Aylett, R., Woods, S., Hall, L., and Zoll, C. (2005) Learning by feeling: Evoking empathy with synthetic characters. *Applied Artificial Intelligence*, 19:235-266.
- [8] de Vicente, A., and Pain, H. (2002) Informing the detection of the students' motivational state: an empirical study. *Proceedings of the 6th International Conference on Intelligent Tutoring Systems*, 933-943.
- [9] Beal, C. and Lee, H. (2005) Creating a pedagogical model that uses student self reports of motivation and mood to adapt ITS instruction. *Workshop on Motivation and Affect in Educational Software, in conjunction with the 12th Intl. Conf. on Artificial Intelligence in Education*.
- [10] Kort, B., Reilly, R., & Picard, R. (2001) An affective model of interplay between emotions and learning: Reengineering educational pedagogy—building a learning companion. *Proceedings IEEE Intl. Conf. on Advanced Learning Technology: Issues, Achievements and Challenges*. Madison, WI: IEEE Computer Society.
- [11] Picard, R., Papert, S., Bender, W., Blumberg, B., Breazeal, C., Cavallo, D., Machover, T., Resnick, M., Roy, D., and Strohecker, C. (2004) Affective learning – a manifesto. *BT Technology Journal*, 22(4).
- [12] Schwarz, N. (2000) Emotion, cognition, and decision making. *Journal of Cognition and Emotion*, 14(4):443-440.

- [13] Chaffar, S. Frasson, C. (2004) Using an emotional intelligent agent to improve the learner's performance. *Proceedings of the Workshop on Social and Emotional Intelligence in Learning Environments in conjunction with Intelligent Tutoring Systems*, Maceio, Brazil.
- [14] D'Mello, S., Jackson, T., Craig, S., Morgan, B., Chipman, P., White, H., Person, N., Kort, B., el Kaliouby, R., Picard, R., Graesser, A. (2008) AutoTutor detects and responds to learners affective and cognitive states. *Proceedings of the Workshop on Emotional and Cognitive issues in ITS in conjunction with the 9<sup>th</sup> International Conference on Intelligent Tutoring Systems*
- [15] Forbes-Riley, K. and Litman, D. (2007) Investigating human tutor response to student uncertainty for adaptive system development. *Proceedings the 2nd International Conference on Affective Computing and Intelligent Interactions*, Lisbon, Portugal.
- [16] Boyer K., Phillips R., Wallis M. Vouk, M. and Lester, J. (2008) Balancing cognitive and motivational scaffolding in tutorial dialog, in *Proceedings of the 9<sup>th</sup> International Conference on Intelligent Tutoring Systems*, 239-249.
- [17] Shute V. (2007) *Focus on Formative Feedback*, ETS, Princeton, NJ.
- [18] Malone T. and Lepper, M. (1987) Making learning fun: a taxonomy of intrinsic motivations for learning. *Aptitude, learning, and instruction: III. Cognitive and affective process analyses*, 223-253.
- [19] McQuiggan, S., Robison, J., and Lester, J. (2008) Affective transitions in narrative-centered learning environments. *Proceedings of the 9th International Conference on Intelligent Tutoring Systems*, 490-499.
- [20] D'Mello, S., Taylor, R.S., Graesser, A. (2007) Monitoring affective trajectories during complex learning. *Proceedings of the 29th Annual Meeting of the Cognitive Science Society*, Austin, TX, 203-208.
- [21] Baker, R., Rodrigo, M., and Xolocotzin, U. (2007) The dynamics of affective transitions in simulation problem-solving environments. *Proceedings the 2nd International Conference on Affective Computing and Intelligent Interactions*, Lisbon, Portugal, 666-677.
- [22] Elliot, A., and McGregor, H. (2001) A 2 x 2 achievement goal framework. *Journal of Personality and Social Psychology*, 80(3):501-519
- [23] Steele-Johnson, D., Beauregard, P., Hoover, P., and Schmidt, A. (2002) Goal orientation and task demand effects on motivation, affect and performance. *Journal of Applied Psychology*, 85(5):724-738.
- [24] Bandura, A. (1977) Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, 84(2):191-215
- [25] Pekrun, R. (1992) The impact of emotions on learning and achievement: towards a theory of cognitive/motivational mediators. *Journal of Applied Psychology*, 41(4):359-376.
- [26] Murray, C. and VanLehn, K. (200) DT-Tutor: a decision-theoretic, dynamic approach for optimal selection of tutorial actions. In *Proceedings of the 5<sup>th</sup> International Conference on Intelligent Tutoring Systems*.
- [27] Robison, J., McQuiggan, S., and Lester, J. (2008) Differential affective experiences in narrative-centered learning environments. *Proceedings of the Workshop on Emotional and Cognitive issues in ITS in conjunction with the 9<sup>th</sup> International Conference on Intelligent Tutoring Systems*.
- [28] Robison, J., McQuiggan, S. Lester, C. (2009) Modeling task-based vs. affect-based feedback behavior in pedagogical agents: an inductive approach. *Proceedings of the 14th International Conference on Artificial Intelligence in Education (AIED)* Brighton, England.
- [29] McCrae, R. and P. Costa (2003). *Personality in adulthood: A five-factor theory perspective*. New York: Guilford Press.
- [30] Rowe, J., McQuiggan, S. and Lester, J. (2007) Narrative presence in intelligent learning environments *Working Notes of the 2007 AAAI Fall Symposium on Intelligent Narrative Technologies*, 126-133.
- [31] Davis, M. (1994) *Empathy: A Social Psychological Approach*. Brown & Benchmark Publishers, Madison, WI.
- [32] Baylor, A. (2005) The impact of pedagogical agent image on affective outcomes. *Proceedings of the Workshop on Affective Interactions: Computers in the Affective Loop in conjunction with the International Conference on Intelligent User Interfaces*