Emotional Agent Based Game Setting: In Accessing Science Self-Efficacy

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Abstract— Current research in affective computing shows that agents are more effective if they have emotions. Emotional agents are able to simulate and express emotions as well as make decisions to achieve intended goal based on emotional status. This undergraduate research project focuses on designing simulated emotional agents in a game engine. Self-efficacy has been proven to be one of the determining factors in students' academic achievements. In this research we model agents' characteristics or behaviors that promote students' interest in education by improving their science self-efficacy. The Blender Game Engine is used to design, test and evaluate the designed agents and strategies that can aid students in improving their perceived self-efficacy in the Science Technology Engineering and Mathematics (STEM) area. The educational game scenario is based on existing study and theory of self-efficacy. We intend to use this research as a new approach to improve students' science self-efficacy and to promote the use of emotional intelligent agents for education purpose.

Keywords— Self-Efficacy, Educational virtual Environments, Emotional agents, Affective Computing, K-12 Education.

I. INTRODUCTION

Current research on educational software is focusing on how to improve the current educational virtual environments (EVEs) that are used for teaching and learning purpose. Productive researches by psychologist and education specialist have developed theories that explain students' academic behaviors. Researchers and developers to create effective EVEs which can positively impact students' academic behaviors, in order to improve academic achievements then use these theories. Mikropoulos and Natsis in their review of EVEs state that learning theories are important in developing effective learning environments since they are pedagogical approaches followed to achieve educational goals and to reach the desired outcomes. [1].

In this research we focus on how emotional intelligent agents can be used to improve students perceived science self-efficacy. Self-efficacy is a theory developed by psychologist Albert Bandura. Bandura explains self-efficacy as a person's belief in his or her ability to perform a task [2]. Studies on impacts of self-efficacy show that students with the same level of cognitive skill development have different intellectual performance based on the strength of their perceived self-efficacy [3, 4]. Other researchers of science self-efficacy believe that improving young students science self-efficacy may lead to increase in overall interest in STEM and also boost students interest in STEM related careers [5].

In this research we also sought to understand how self-efficacy develops, how current EVEs affect students science self-efficacy and how emotional intelligent agent can contribute to improve students science self-efficacy. It is worthy to note that self-efficacy and perceived self-efficacy has been used interchangeably in this paper. I implement suggestions from previous researcher on how to make educational virtual environments effective as pedagogical tools. I also show why emotional intelligent agents would be the most ideal agents to help students improve on their self-efficacy.

II. RESEARCH BACKGROUND

With many significant research and developments in the area of STEM, it is necessary to ensure that more students are interested in these areas of study. Studies have shown that the number of United States students who graduate with degrees in sciences has decreased in the recent years compared to other countries [6]. This decline has been attributed to students' low perceived self-efficacy in Science and mathematics [5, 7]. Through various research and studies on Self-efficacy, it is known that high self-efficacy can positively influence performance on task and outcome measures [8], and that finding ways to reduce the impact of low self-efficacy is vital for science education [9].

In order to develop efficient intelligent emotional virtual agents that can help in improving students' self-efficacy I first looked at why science self-efficacy is crucial in STEM and effects of educational virtual environments on science self-efficacy. Through various literature reviews we are able to understand how emotional agents can improve science self-efficacy.

A. Science self-efficacy

Academic self-efficacy is an important predictor of students' performance beyond their ability and previous performance as well as a determinant of their career interest. [5, 7]. The study of self-efficacy has been able to explain

why students with the same skill and ability perform differently in various tasks. Rittermayer and her colleagues' study on STEM self-efficacy highlighted some important aspects of self-efficacy and why it is important in STEM education. They pointed out that it predicts performance, persistence in completing a task and is positively related to students' interest and engagement in learning activities [7]. Other researchers have also argued that it is related to self-regulation such as problem-solving and cognitive strategies and time management when carrying out a task [3,7,10]. Through the review of different research on self-efficacy and performance [2, 3, 7, 9,10] a simple flowchart can be drawn to represent how self-efficacy can help improve performance.
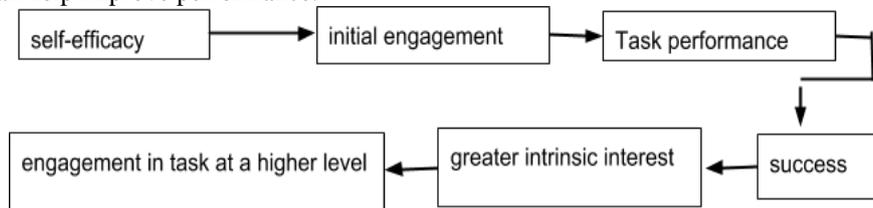
Fig 1: Flowchart of how self-efficacy improves performance.

Science self-efficacy develops through: previous or mastery experience where success of outcomes increases self-efficacy and failure lowers it, Vicarious experience; learning through others performing a task and believing that you can perform the same task, social and verbal persuasion that is others feedback and support when performing a task and emotional reaction or arousal for instance fear and nervousness in task preparation may led to doubt in one's ability to perform the task [2, 7]

Currently there are significant intervention programs to promote development of students academic self-efficacy, for instance there are after-school programs, workshops, and summer camps that enable students acquire skills in STEM as well as mentorship programs and social engagements that persuade students to participate in STEM learning activities [7]. Gaming based learning software programs and other virtual environments have also been proven to improve students' self-efficacy for instance a study revealed a significant difference in student's science self-efficacy and learning gains when it investigated students with high game performance and compared them with others with low game performance in CRYSTAL ISLAND [11]. Although this studies have shown significant result in how educational software's and programs can improve self-efficacy there is still a great need for the development of emotional virtual agents that not only improve students self-efficacy but also their cognitive and learning skills [5].

B. Educational Virtual Environments and Self-efficacy

Recently educational software programs have been developed to complement other pedagogical activities. These programs include computer games and other virtual software programs that are believed to be effective on students' academic achievements. In a ten-year (1999-2009) review of empirical research on educational virtual environments (EVEs), [1] point out that virtual reality is a "mature technology appropriate for pedagogical use". Other researchers such as Conati and Klawe [12] also support the use of educational gaming virtual environments for education purpose especially those with socially intelligent agents. Meluso and her colleagues [5] support the use of game based virtual environments as a way to enhance 5th grades science content knowledge and self-efficacy.

Although the use of EVEs has gained support from researchers and teachers as pedagogical tools, they also suggest that improvements need to be made on the current EVEs more effective and interactive. Conati and Klawe [12] state that although "educational games are highly engaging, they do not always trigger the constructive reasoning necessary for learning". They suggest that intelligent agents used in EVEs especially in educational games, should monitor students interaction with the game, model students cognitive and emotional states and triggers constructive reasoning and reflection. Research on low engagement of students in multiuser virtual environments (MUVEs) [9] showed the open-endedness and interactivity of MUVEs distracted students from the process and tasks related with scientific inquiry and thus they suggest that reflective guidance in MUVEs should focus on aiding students metacognition by asking them to reflect upon their learning and also describe how they intend to proceed to achieve a goal. They also suggest the use of graphics and or text, to map out students growing understanding of knowledge content and to make sure that while doing so they do not give overt answers or make judgments on students' actions which may negatively affect their self-efficacy.

In their review of empirical research of EVEs, Mikropoulos and Natsis [1] findings conclude that EVEs with standard interfaces such as keyboard, mouse and joystick are effective in that they support knowledge acquisition and that motion platforms should be used since they are appealing, motivational, and effective. They also conclude that immersive EVEs foster positive results concerning students' attitudes and learning [1].

In order to improve students' self-efficacy studies have suggested that embedding guidance in EVEs is associated with improved learning outcomes and that low self-efficacy students who use guidance systems employed in EVEs, improve their self-efficacy [9]. Since emotional reaction and arousal affect the development of self-efficacy [2, 7], EVEs should include emotional intelligent agents that interact with students to analysis their emotional states as well as express emotions that do not cause nervousness in students. As research by Hudlicka and Eva, [13] in the research area of affective Human- Computer Interaction (HCI) have shown that emotional agents behave in a way that appears to reflect a particular emotion or may induce emotional reactions in the human user and this makes them significant in EVEs and development of self-efficacy. Research on emotional (affective) intelligent agents in a tutoring system show that they are necessary in EVEs since affection has been supported by researchers to have a "perturbing role in learning" [14].

Emotional agents also provide motivation and supporting feedback that necessary for the development of self-efficacy in students using EVEs.

In this research project we use knowledge gained from the study of EVEs and emotional agents to develop emotional intelligent agents in a game engine that can support the teaching and learning by improving students' self-efficacy. I implement some of the suggestions by previous researches that I thought were necessary in developing efficient emotional agents that can improve self-efficacy.

III. COMPUTATION MODEL FOR IMPROVING PERCEIVED SELF-EFFICACY

For this project we developed an educational game based on the American second grade math curriculum. We modeled and useda semiautonomous emotional agent in our game to assist the playerto interact with the virtual environment. The game, developed using the Blender Game Engine, acts a pedagogical tool to improve academic self-efficacy by capitalizing on children's interests in playing games as well as assisting them with goal setting. The aim of the game is to:

- Create a fun and engaging educational environment that will help the students' master core concepts in their curriculum.
- Provide an environment that discourages nervousness when performing the required tasks.
- Provide verbal persuasion that motivated the student to complete the assigned task

For this project we also develop a self-efficacy evaluation app using MIT App Inventor 2 to evaluate the self-efficacy levels of the player. We use the app to evaluate the perceive self-efficacy level of the participants before and after playing the game.

A. *Emotional Agents Model*

Emotional virtual agents play an important role in educational virtual environments. As previous studies have shown, [14], emotions affect the learning processes. Emotions also affect self-efficacy since emotional arousal such as fear and nervousness in task preparation may led to doubt in one's ability to perform the task [5,7].The emotional virtual agents in our game setup act as the students' avatars as well as assistants who help the students achieve the assigned tasks.

The model used for the agent is aimed to help the student (player) complete the task and attain a high score in the game. The Emotional agent is intelligent and semiautonomous; the player controls the movement of the agent within the environment only. The agent stores emotions in its memory and use it to influence the decision making process. Fig.2 illustrates the processes that take place within the emotional agent to affect the agent's reaction to the environment.
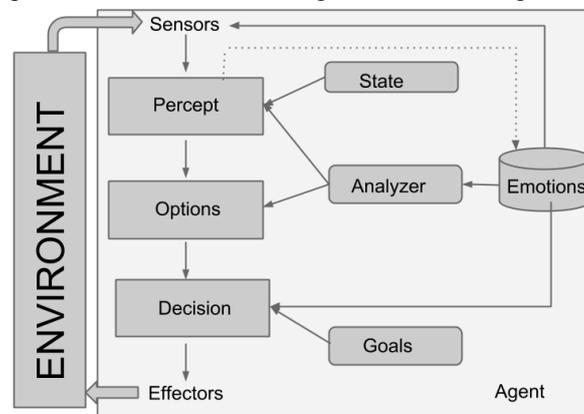

Fig.2: The Emotional Agent Model

This model was derived from the classical goal based agent architecture and in cooperates the role the emotions play in our agent decision-making process. First the agent perceives the stimuli in the environment through its sensors, which can be the occurrence of an action (such as collusion), a change in the state of its environment or a message passed from other objects or agents in the environment. This percept may determine the experience of emotions that are analyzed to help the agent in the decision making process. After perceiving what the world looks like and how it evolves, the agent then examines its options and makes a decision based on its desires or goals as well as emotions. After making a decision the agent executes its decision though the effectors (actuators).

B. *Game Design*

In designing our game we aimed to develop subject-related knowledge in a purposeful. For this project we developed an educational games based on the American second grademath curriculum.This game aims to create an interactive and emotionally engaging environment in which to teach math concepts, in an approachable mode that appeals to children's sense of curiosity and play. In one of the scenes the student is required to use an agent and navigate a virtual world in search of the required elements (treasures), for instance even numbers. The student earns points for finding the required treasures. This game setup can be easily modified to achieve the intended objective. For instance, a

teacher who wants to teach geometry, by requesting the student to collect certain shapes, can change to the code. The student uses the computer's keyboard directional arrows to navigate the space land as well as to avoid enemies and other obstacles. Emotional agents in the game assist the student by warning them when enemies are approaching and celebrating when the required elements are collected.

```
from bge import logic
cont = logic.getCurrentController()
own = cont.owner
scen = logic.getCurrentScene()
cross = scen.objects['crosshair']
looker = scen.objects['look']

Near = cont.sensors['Near']
Track = cont.actuators['Track']

#Gets the list of objects near the sensor
if Near.positive:
    hitObjs = Near.hitObjectList
    dist = 0
    obj = None
#Iterate to get closest object
    for item in hitObjs:
        if item.getDistanceTo(own) < dist or dist == 0:
            dist = item.getDistanceTo(own)
            obj = item

#Assign actuator track to object
    Track.object = obj
    if Near.positive:
        cross.worldTransform = obj.worldTransform
        cross.visible = 1
        looker.worldTransform = obj.worldTransforsm
```

```
import bge
def main():
    cont = bge.logic.getCurrentController()
    own = cont.owner
    nearpurp = cont.sensors['nearpurp']
    purpSound = cont.actuators['purpSound']
    if nearpurp.positive:
        cont.activate(purpSound)
main()
```

Fig.3: Some python scripts used to track the nearest objects to the agent

The blender game engine was used in this project. The emotional agent's model and decision-making process were written in python. Fig.3 shows some of the scripts used to define the agents tracking sensors as well as the sensor for color purple. The first set of code is imports the blender game engine then initializes the sensors, controllers and actuators. We the get a list of objects near the sensors 'Near' and then get the closest object to the sensor by iterating through the list. After getting the closest object we assign the 'Track' effector to it. In the second set of code we assign variables to controllers, sensors and actuators or effectors. We then check if the nearest object has a property of the color purple and if the object has the property we use a sound actuator to inform the player. Fig.4 shows the game design during the development process in Blender game. Blender is free and open source software that supports the development of scalable games and animations that are able to compete with other games developed in other commercial software.

C. Self-efficacy Evaluation

To evaluate the students' perceived self-efficacy we developed a second grade students' self-efficacy evaluation within the blender game engine. As seen in fig.5, the player has an option to take an evaluation, play the game or exit the menu. In test set up we would require the participants to take the evaluation before playing the game and after playing. This would be idle to evaluate the difference in the self-efficacy level before and after playing the game.
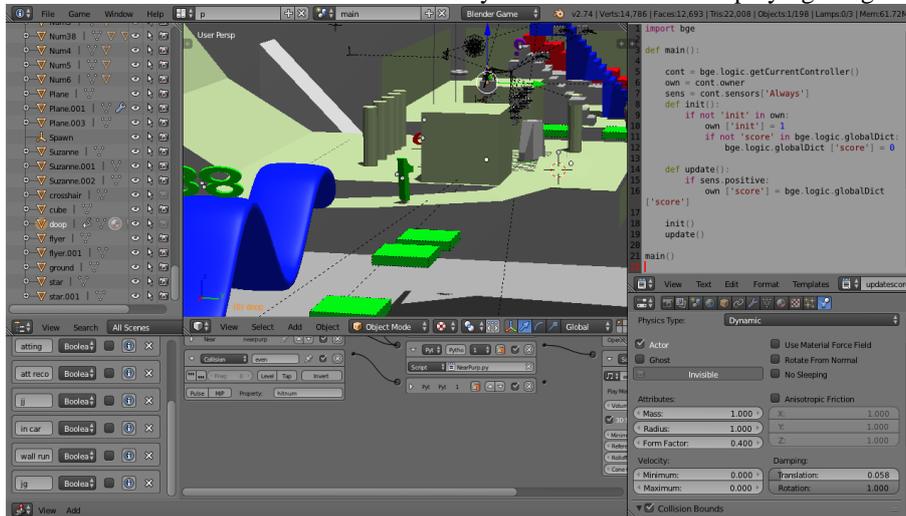

Fig.4: Blender Game Engine Interface

In developing the self-efficacy evaluation questions we used the second grade math curriculum outline as well as the expected learned concepts from the game. We used a four-point liker-type response[15, 16]where 1= **not true**, 2 = **a little true**, 3 = **pretty true** and 4 = **very true**to evaluate the students' self-efficacy level. The evaluation requires the student to answer five questions, which gauge their perceived self-efficacy, by submitting answers in the scale indicated. The points are summed up and the self-efficacy level is evaluated on a scale of one to twenty, one being the lowest self-efficacy level, and twenty being the highest self-efficacy level.
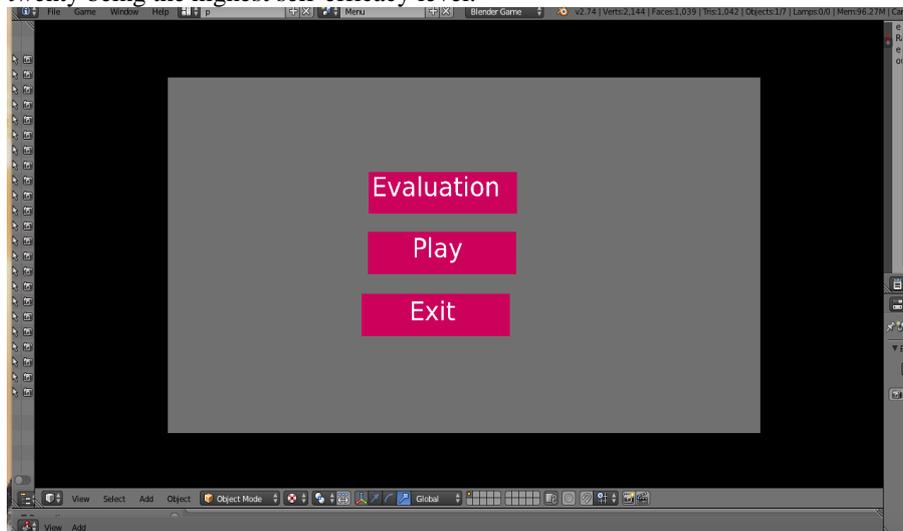

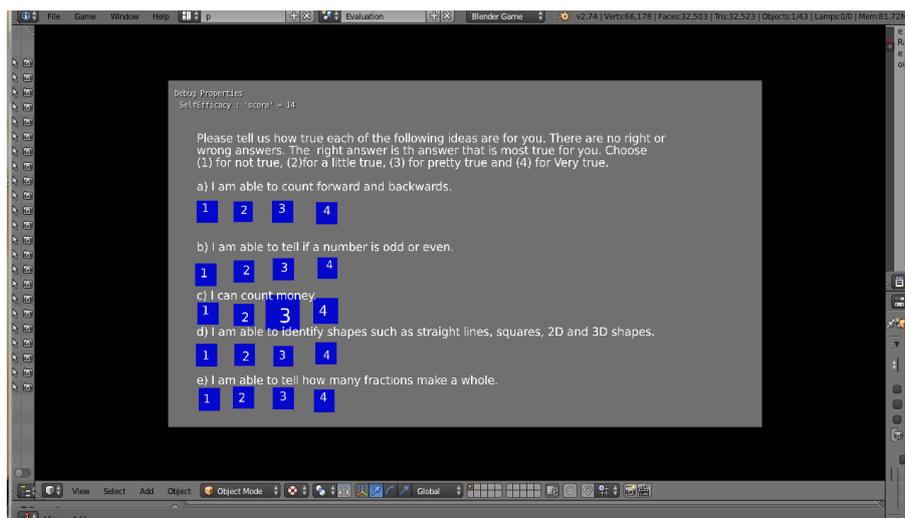Fig. 5:Menu interface in the Blender Game Engine

Fig. 6: The self-efficacy evaluation questionnaire

The questionnaire is designed in such a way that is easy for the participants to use. At the top we explain to the participants what they are required to do. The user selects the answer to the question by clicking on the number that has the option that is most true to them. We use the four-point scale in our evaluation to ensure that the self-efficacy level is clearly distinguished, that is its either high or low. The questions asked in the evaluation are based on the concepts assessed in the game.

IV.   CONCLUSIONS AND FUTURE WORK

The goal of this research was to design and simulated emotional agents a game setting in order to model characteristics or behaviors which promote students' interest in education by improving their science self-efficacy. We developed a game setting where the participants learn as they play and also a self-efficacy evaluation app to access the self-efficacy level of the participants. In the developed game setting the emotional virtual agents help improve the students' self-efficacy by provide positive feedback and support as well as lowering anxiety and reducing stressful situation when performing simple tasks. We hope to test the developed game and evaluation app on second grade students in order to evaluate their effectiveness.

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