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A generic classification of learner's emotion in educational serious games into positive vs. negative dimension

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Abstract— In educational Serious Games (SGs) context, a pre-requested step to enable emotion-based adaptation during player-game interaction is the classification of the player's emotional states into positive vs. negative dimension. Positive emotions are desirable emotional states that encourage play and have positive impact on the gaming and learning outcomes. Negative emotions are undesirable emotional states that discourage play and have negative impact on the gaming and learning outcomes. Hence, in order to keep the player engaged, the emotion-based adaptation should be tailored to maximize positive emotions and reduce negative ones. In both education and video game literature, there are many works that studies positive and negative dimension of emotion. However, the most of studies on SGs do not take into account the classification of the player's (learner's) emotions as positive or negative dimension. This paper presents a generic classification of learner's emotion in educational SGs into positive vs. negative dimension. We start by analyzing positive and negative emotions of the learner under educational context. Then we inspect player's emotional states in the context of video games. Finally, we examine emotion in both education and video games contexts in order to identify positive and negative emotions at the learner-player when playing an educational SG.

Keywords— *Serious games, learning context, video games, learner's emotions, positive and negative emotions.*

I. INTRODUCTION

According to Vail [1], "Emotion is an on/of switch for learning...the emotional brain, the limbic system, has the power to open or close access to learning, memory, and the ability to make connections.". Thus, the understanding of emotion related to educational context is the focus of an extensive literature for several years. Simultaneously, research on emotion in video games is becoming increasingly important because games can elicit many different emotional states at players. In the last few years, there has been a growing interest in serious games as a field of academic research. A serious game (SG) is a way to incorporate an educational scenario in a video game [2]. There is an interplay between emotions, learning and playing games. In learning context, positive emotions have a positive relationship with student engagement and academic success, while negative emotions have a negative relationship with academic success. In video game context, positive emotions have a positive influence on player's behavior and engagement, while negative emotions have a negative influence on them.

Although several studies have explored positive and negative aspect of emotion, in both video game and educational context, little attention has been given, in SGs context, to classify emotions of the learner-player as positive

or negative. However, based on our best knowledge, there is not yet researches that discuss the issue of positive and negative emotions of the learner in SG and their relationship with learning and playing performance. From our point of view [5], in SG positive emotions are emotions that reinforce learning and improve performance during player-game interaction. Negative emotions are emotions that negatively affect learning and reduce performance during game play. The main objective of this paper is to identify learner-player's positive and negative emotion in serious games by analyzing emotions literature research in the both learning context and in the games field (see Fig 1).

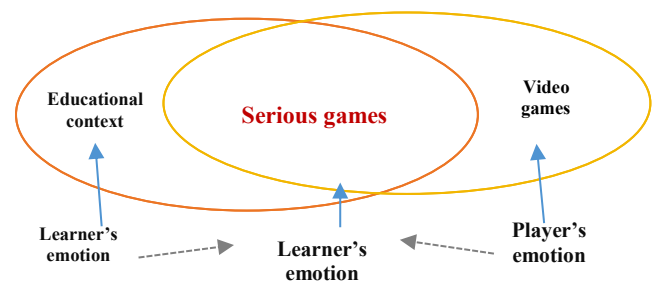


Fig. 1 Interplay between emotions, learning and playing games.

II. LEARNER'S EMOTIONS IN EDUCATIONAL CONTEXTS

Generally, it is recognized that learning will be enhanced when negative emotions are minimized and positive emotions are maximized. This idea is not always correct, as shown in several studies by Pekrun [3][4]. The learning can be improved by some negative emotions as in the case of some positive emotions. In an inverse manner, some positive emotions are not likely beneficial for learning. In this section, we analyse learners' positive and negative emotion under a different aspect: academic emotions, and emotion-related learner engagement. The term academic emotions denote: "emotions that are directly linked to academic learning, classroom instruction, and achievement (e.g., enjoyment of learning, pride of success)" [3]. Therefore, the domain of academic emotions would include learners' achievement emotions (emotions that are directly linked to achievement activities or achievement outcomes.) experienced in school or university settings [3]. Achievement emotions are defined as emotions that are directly linked to achievement activities or achievement outcomes. In the control-value theory [4], achievement emotions are defined as emotions that are tied directly to achievement activities (e.g., studying) or achievement outcomes [6]. Thus, we need to identify principal achievement emotions suggested in the control-value theory

of achievement emotions and in the relationship between emotions and the learner engagement in learning activities.

A. Control value theory of achievement emotions

Pekrun [4] has developed control-value theory, a comprehensive, integrative approach to understanding emotions in education. Control-value theory groups achievement emotions on three dimensions: Valence (positive emotion vs. Negative emotion); Degree of activation (activating vs. Deactivating) and Object focus (activities, outcomes). Using these three dimensions, control-value theory proposes, as shown in Fig 1., a three-dimensional taxonomy of achievement emotions with differentiation of activity emotions versus outcome emotions, the differentiation pertains to the object focus of these emotions.

Object focus	Positive (or pleasant)		Negative (or unpleasant)	
	Activating	Deactivating	Activating	Deactivating
Activity	Enjoyment	Relaxation	Anxiety Anger Frustration	Boredom
Outcome	Hope Joy Pride Gratitude	Relief Contentment	Anxiety Anger Shame	Hopelessness Sadness Disappointment

Fig. 2 A three-dimensional taxonomy of achievement emotion [7].

The observation of activation's degree of positive or negative emotions in the above figure allows us only to find out that: (1) Positive and negative activating emotions are likely beneficial for motivation, learners' engagement and learning. (2) Negative deactivating emotions are likely detrimental for learners' engagement and learning. (3) and Positive deactivating emotions have any beneficial consequences for most learner engagement and learning. However, those emotions are positively correlated with activating emotion.

From these findings, we resumed, in TABLE I. , positive and negative emotions inferred from the control-value theory.

TABLE I. positive/negative emotions of learner deduced from control-value theory of achievement emotions.

Positive Emotions	Negative emotions
Hope, joy, Enjoyment, Gratitude, Pride, Anger, Frustration, Shame, Anger, anxiety, Relaxation, Relief & Contentment	Boredom, Sadness & Disappointment, Hopelessness

B. Relationship between engagement and positive and negative emotions

The engagement is defined as learner behavior and effective teaching practices [8]. Pekrun et al. [9] suggest that engagement mediates the relationship between emotions and learning. Learner engagement is widely recognized as important in higher education. A growing body of research shows engagement is positively associated with desirable learner outcomes such as achievement, satisfaction and retention. Reference [10] explored the relationships between academic emotions and learner engagement, findings highlight that different emotions have different links to engagement: as important elements in emotional engagement,

as inhibitors of engagement and as outcomes that reciprocally influence engagement.

TABLE II. Emotion and learner engagement (inspired from [10]).

Emotional states	Effect on learner's engagements
Interest and enjoyment.	Emotions enhances learner engagement
Pride and disappointment.	Emotions inhibitors of learner engagement.
Boredom, worry and frustration.	Outcomes emotions reciprocally influence future learner engagement.

As show in TABLE II, they are the reciprocal relationships between learner, emotions and engagement. Furthermore, a growing body of research shows engagement is positively associated learner 'emotions in learning context, In [11] it was shown that Interest and enjoyment influence engagement, leading to positive outcome emotions, and these cycle back to further increase motivation and self-efficacy, which further increase engagement. Similarly, frustration and anxiety can trigger disengagement, leading to poor outcomes and disappointment that reduce motivation and subsequent engagement. Based on that, we resume in TABLE III. the correlation between learner's engagement and learner's positive/negative emotions.

TABLE III.: Positive and negative emotion related learner engagement.

Positive emotion	Negative emotion
interest , enjoyment & pride	Boredom, frustration, worry & disappointment

III. PREPARE PLAYER'S EMOTIONS IN GAMES

Research on the player's emotion is one of most relevant dimensions for game assessment. Emotions can affect attention, creation, and the formation of memory channels. Detection, induction and assessment of emotion in games is an area that has provided most research studies thus far, leaving, however, large unexplored spaces and development [12]. Games can elicit many different emotional states, but knowing all of them is not necessary to maintain involvement in the game [13]. Thus, many studies have been interested in some player's affective state in games. In next sections, we will discuss how positive and negative emotional state of player are linked to many aspect and features of video games and educational games.

A. Main player's emotions in video games

Ravaja et al. [14] examined whether there are reliable differences in the emotional response patterns elicited by video games. They found six player's emotions in video games: fear, anger, relaxation, pleasure, joy, and depression. Perron [15] attempted to characterize some prototypical video game's emotions. He identified the following seven emotions: interest, enjoyment, worry, fear, surprise, anger, and frustration. Previously cited studies examined only the presence of player's emotions, they had not studied the link between emotion and success or failure of the player. Other studies have tried to measure the player's involvement in the game by looking at the change of emotions compared different difficulty levels of the game.

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B. Emotional changes according the difficulty's level of game

In [13], researchers have a study focused on emotion assessment from physiological signals to estimated emotion in different level's difficulty of a game. Their study enabled to verify the validity and usefulness of the three defined emotional states (boredom, anxiety and emotion-related engagement) by using a Tetris game where the challenge is modulated by changing the level of difficulty. In the following, we will explain the results found from this study. In a game, the change from an emotional state to another can occur due to two main reasons. First, the difficulty is increased by progressing in the different levels, but too fast compared to the competence increase of the player (potentially giving rise to anxiety). Secondly, the competence of the player has increased while the game remained at the same difficulty (potentially giving rise to boredom). In both cases, the challenge should be corrected to maintain a state of pleasure and involvement.

In this research, positive-excited emotion related engagement in medium difficulty level game art not identified exactly. Thus, we can consider emotions (interest and enjoyment, pride) that enhance student engagement in the learning context that identified in [10] (see TABLE IV.) as the player's positive-excited. We show, in the below table , player's emotions related to three difficulty's level of game and with their dimension positive or negative.

TABLE V Positive and Negative emotion realted levels' difficulty of game

difficulty levels game	Estimated emotion	Dimension of emotions
easy	Boredom	Negative emotions
medium	interest , pride and enjoyment	Positive emotions
hard	Anxiety	Negative emotions

These results demonstrate the importance of adapting the game difficulty according to the emotions of the player in order to maintain his / her engagement. Relatively similar

TABLE VII. . Correlation patterns among educational games' design features and players' emotion.

	Emotional Dimension			
	Positive emotions		Negative emotions	
	Positive activating emotions	positive deactivating emotions	Negative activating emotions	Negative deactivating emotions
	pride, enjoyment, hope	satisfied, calm, relaxation	anxiety, shame, anger	boredom, helplessness, dejected, tire
Concentration	+1	0	0	-1
clear goals	0	0	0	0
feedback	0	0	0	0
challenge	0	0	-1	0
Control	+1	0	-1	0
Immersion	0	0	-1	-1

result was obtained in [16] where the researchers, concluded, by using both physiological and self-report analyses, that playing at the same level of difficulty several times elicits boredom.

C. Emotions related the educational games' design features

In [Zhang & al., 2012], researchers studied the relations between the educational games' design features and the students' academic emotions. They tried to consider how and what types of educational games' design features would most influence players' academic emotions. To do this, educational game design features were assessed using Learners' Psychological Pleasure Scale as defined in [17]. This scale was developed based on eight factors of the GameFlow Model proposed by [18]. Subscales of design features are : concentration, clear goals, feedback, challenge, control, and immersion (see TABLE V.).

TABLE VI. GameFlow Criteria for Player Enjoyment in Games (adapted from [18]).

Criteria	Meaning
Concentration	Players should be able to concentrate on the game
challenge	Games should be sufficiently challenging and match the player's skill level
Control	Players should feel a sense of control over their actions in the game
clear goals	Games should provide the player with clear goals at appropriate times
feedback	Players must receive appropriate feedback at appropriate times
immersion	Players should experience deep but effortless involvement in the game

In TABLE VI., we resumed the results found in [19]. We show the correlation between six subscales of design features and the player's emotion. For each subscales, we indicate the valance correlation: Positively correlated (+1), unrelated (0), negatively correlated (-1). Emotions are classified into 04 dimensions as defined in [3]: positive-high arousal, positive-low arousal, negative-high arousal, and negative-low arousal emotions. These four dimensions of emotions correspond respectively Positive activating emotions, positive deactivating emotions, Negative activating emotions, Negative deactivating emotions.

Based on TABLE VI, we can infer this rule that we can use in a serious game: "If the game provided the player with the appropriate control elements then the player can concentrate better and control the game". This allows the induction of positive emotions in the player". Well, the game engine can bring up or make disappear some control elements in the game for adjusting the game interface according to the player's emotional state or for inducing target emotions in the player.

IV. POSTIVE AND NEGATIVE EMOTIONS OF THE PLAYER IN SGs CONTEXT

In previous section, we analysed separately emotions in various studies that have shown the most important positive and negative emotions in education context and games field, we will now compare these results in order to identify positive and negative emotion of learner-player emotions in

SG. We combine the results from previous tables (TABLE I., TABLE III., TABLE IV and TABLE VI.) for constructing TABLE VIII. In this table, we show the relationship between each emotional state and its dimension (positive / negative) in relation to the different aspects. The relationship takes the following values:

- +1 : If the emotion is positively related to the parameters studied.
- -1 : If the emotion is negatively related to the parameters studied.
- "?" : If the emotion is not considered in the study of this parameter

To show the importance of each emotion. We counted the number of times where an emotion was classified in positive/negative dimension.

TABLE IX. Positive /Negative correlation between emotional state and different aspects of learning and game.

Emotions	Emotion as component of				Frequency of Emotion	
	Education		Games			
	academic success	Engagement	Difficulty level	Design future	Positive	Negative
<i>Hope</i>	+1	?	?	+1	+2	0
<i>joy</i>	+1	?	?	?	+1	0
<i>Enjoyment</i>	+1	+1	+1	+1	+4	0
<i>Gratitude</i>	+1	?	?	?	+1	0
<i>Pride</i>	+1	+1	+1	+1	+4	0
<i>interest</i>	?	+1	+1	?	+2	0
<i>Frustration</i>	+1	-1	?	?	+1	-1
<i>Shame</i>	+1	?	?	-1	+1	-1
<i>Anger</i>	+1	?	?	-1	+1	-1
<i>anxiety</i>	+1	?	-1	-1	+1	-2
<i>Boredom</i>	-1	-1	-1	-1	0	-4
<i>Sadness</i>	-1	?	?	?	0	-1
<i>Disappointment</i>	-1	-1	?	?	0	-2
<i>Hopelessness</i>	-1	?	?	-1	0	-2
worry	?	-1	?	?	0	-1
dejected	?	?	?	-1	0	-1
Tire	?	?	?	-1	0	-1

How to identify positive and negative emotions, which could be considered in serious games? to answer this question, we have distinguished two cases:

How to identify positive and negative emotions, which could be considered in serious games? to answer this question, we have distinguished two cases:

- Cas 1: positive and negative emotional states of learner-player in SG are the union of all emotions identified at students in education context and learner in game field. Fig 3. shows positive emotions and negative emotions of the learner-player in SG in this case.

- Cas 2 : positive and negative emotional states of learner-player in SG are the intersection between emotions identified at students in education context and learner in game field. Fig 4. shows positive emotions and negative emotions of the learner-player in SG in this case. In each case, we present the position of each emotion on an emotional state axis. In positive side of the axis, we represent positive emotions, while in negative side we represent negative emotions. The emotion's frequency column, as shown in the above table, let us to determine the position of each emotion or a set of emotion on axis.

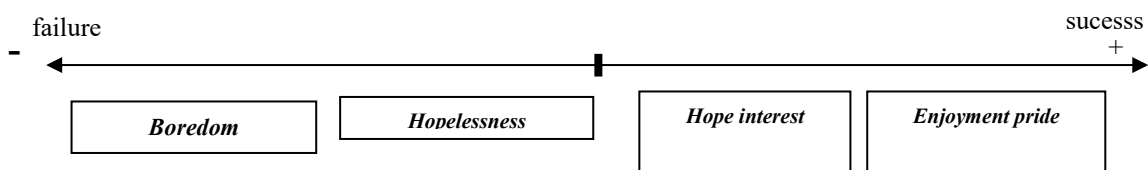


Fig. 3. A generic classification of most important postive/negative emotions in SGs context.

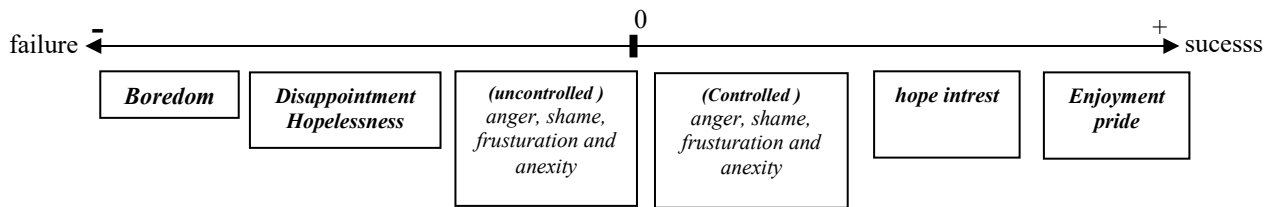


Fig. 4. A generic classification of all positive and negative emotions in SGs context.

In Fig 4, citing the same emotions on both opposite sides (failure vs. success) can be explained by the dependency between player's personality and his/her-emotional states [5]. Generally, the emotional response to a stimulus differs from one person to another according to their personality types [20]. Thus, in the context of educational SGs, we suggest that an emotional state is classified as positive (mentioned as "controlled" emotion in Fig 4.) for some players with specific personality types. The same emotional state can be classified as negative (mentioned as "uncontrolled" emotion in Fig 4.) for other players with other personality types.

V. CONCLUSION AND FUTURE WORK

The purpose of this paper is to classify positive and negative emotions of the player-learner during player-game interaction in educational SGs context. From our analytic study, we have shown that learner's emotion may be concluded by studying emotions in both education and video games's contexts. Indeed, for the educational context, we outline results for the study of Pakrun. In the last fifteen years, Pakrun supervised many research studies in [3][4][6] and [9] about the relationship between learner's emotions and the academic success. In the video game context, we focused on the most important studies that exploring different aspects related the positive and negative dimension of player's emotions. Finally, based on the finding in the two previous analytic studies, we identify and classify the most important learner-player's positive and negative emotions in educational SG.

Clearly, further research will be required to validate our findings. Therefore, in our future research, we intend to concentrate on an experimental study to examine the dependency between the player's personality types and the different emotional responses in the context of educational SGs.

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