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Article

A taxonomy of learner-player's emotions in serious games

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Abstract

The future of video games lies in Affective Games, as the future of learning lies in Affective Learning that due to the proven role of human emotions in how we think and behave. The main goals behind studying emotions in all areas other than psychology and neuroscience are to maximize beneficial emotions, reduce detrimental ones and to develop adaptive systems. The combination of this concept and recent progress in technology has spurred researchers across various fields to focus on incorporating an emotional aspect into human-computer interaction. In Serious Games context, learner-player can experience two types of emotions, the first is related to the learning elements and the second is referred to video games elements. In both learning and video games contexts, recent studies have introduced affective models to conceptualize the influence of emotions within these spheres. However, a discernible trend emerges in the realm of Serious Games research. Notably, the majority of recent studies within this domain exhibit a notable inclination towards prioritizing aspects such as personalized emotion recognition, adaptive gameplay, real-time feedback mechanisms, emotion regulation training, immersive experiences via mixed reality, longitudinal studies, and collaborative cross-disciplinary initiatives. As a result, the nuanced pursuit of affective modeling for learners-players often experiences relegation, yielding precedence to these innovative trajectories. Within this conceptual framework, this article endeavors to examine the interconnection between the emotional experiences of learner-players and the educational and interactive components inherent in serious games.

1. Introduction

The study of human emotional state has been the domain of psychologists and neuroscientists for well over a century. They proved the great influence of human emotion on the cognitive process. These involve: attention [1], perception [2], memory [3], decision making [4][5], and associative learning [2]. As well, their research has revealed that cognition and emotion are not

opposing forces, conversely, they are closely interlaced [6]. Due to the critical role of emotions in decision making, the study of emotional states has gained much interest in many fields other than psychology and neuroscience since the last two decades. One of these fields is learning [7][8]. Numerous academics concur that emotions hold significant influence in the process of learning, and in fact, may even serve as its foundation. Pekurn [9][10] stands out among prominent researchers who have given notable consideration to the influence of emotions in the learning process. Their exceptional theoretical framework and collection of empirical data provide compelling evidence for the crucial role of emotions in education. He indicated in his handbook [11] that students can experience a range of emotions such as excitement, hopefulness for success, feelings of pride in their accomplishments, surprise upon discovering new solutions, anxiety about failing exams, shame over poor grades, or boredom during lessons. In addition, he delved into the characteristics and variety of academic emotions, as well as their role in the process of learning. Some other studies have focused on the classification (positive and negative) of student's emotions and their impact on learning. Positive emotions have been shown to facilitate learning and contribute to a learner's motivation and self-regulation. Indeed, when learners experience positive emotions such as joy, interest, and curiosity during the learning process, they are more likely to engage with the material, retain information more effectively, and find motivation to sustain their learning journey. Positive emotions can also enhance learners' self-regulation by increasing their persistence, effort, and willingness to take on challenges [12] [13]. Conversely, low motivation and reduced engagement among students can be caused by negative emotions such as boredom and frustration [14]. However, some recent studies reported that negative emotions such as confusion can be beneficial in the learning process. When a person experiences confusion, it can indicate that they are encountering a challenging concept or problem that requires further exploration and understanding. Accordingly, D'Mello et al. [15] stated that confusion can improve learning by increasing focus on learning material which leads to better performance. In addition to the learning context, research on emotions has flourished in many other contexts, including the domain of human-machine interaction. Although the study of affective computing has increased considerably during the last two decades, relatively few researchers have extended their investigations to the domain of video games, despite the potential manifold advantages such studies could offer to enhance the overall gaming experience. Most of these works were focused on analyzing the consequences (post-consumption emotions) [16], but in recent years, there has been a shift in focus towards exploring in-game emotions and the behavioral impact preceding gameplay [17]. The main reason for studying a player's emotions during the game was to control his engagement, increase his motivation, generate success sensations and avoid detrimental emotions. Advancements in Affective Computing technology have enabled the development of more sophisticated approaches that allow users to interact with computers using their body posture and gesture, facial expressions, and even physiological signals [18]. As a part of these approaches, it has also recently been applied to the video games industry and hence the appearance of a new discipline: Affective Games [19]. As a subfield within Affective Computing, Affective Games refers to the new generation of games which use a player's emotions to create a more immersive experience. For example, the game's soundtrack may change to reflect the player's emotional state, or the graphics may become more vivid or surreal to match the player's mood. Additionally, affective games can be used as a tool for emotional expression and learning, as they can help players develop their emotional intelligence and regulate their emotions more effectively. Serious Games as video games in which education is the primary goal, rather than entertainment [20], can trigger a mixture of learning emotions and gaming emotions in learners-players (see Fig. 8). Likewise, serious games contain features and elements that increase the probability of experiencing positive emotions and adequately regulating emotions compared to traditional learning and video games environments. Despite various studies examining emotions in learning and video games, the

analysis of emotions in the context of Serious Games has been relatively neglected, except for the past ten years, during which there has been an unparalleled rise in the interest to investigate the affective elements of Serious Games. [21] [22] [23].

The main objective of this paper is to analyze emotions and survey affective models of learner-player from the literature of both learning and video games context, then to propose a new affective model which determines beneficial and detrimental learners-players' emotions in a serious game context.

2. Learner's emotional state modeling in context of learning

Having an understanding of the nature and function of emotions within the context of learning, similar to other human behaviors and introspection, can facilitate the process of learning. In educational psychology, motivation, especially achievement motivation related to academic performance, has long been associated with emotion [24]. In this section, we analyze learners' emotion through two models.

2.1 Academic emotions and Student Engagement

An affective model was suggested by Feldman Barrett and Russell [25] to illustrate the distribution of emotions across two dimensions. The Circumplex Model of Affect [25] which is a theoretical framework, describes emotions as points on a circular graph, with arousal on the vertical axis and valence on the horizontal axis. The model proposes that all emotions can be plotted along these two dimensions, with high arousal emotions (such as excitement or anxiety) at the top and low arousal emotions (such as relaxation or depression) at the bottom, and positive emotions (such as joy or contentment) on the right and negative emotions (such as anger or sadness) on the left. The model suggests that emotions that are close to each other on the circle share common features and may have similar behavioral or physiological responses. The Circumplex Model of Affect has been used in research to understand the structure of emotional experience, as well as to develop interventions for emotional regulation and psychological well-being.

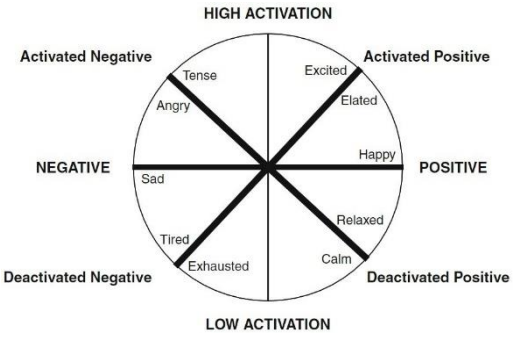

Figure 1. Affective circumplex [25]

We can infer a 2x2 taxonomy from this affective circumplex including four categories of emotions (Table 1).

Table 1. A Two-dimensional taxonomy of emotions (Activation, Valence) deducted from Affective Circumplex

Valence / Activation	Positive	Negative
Activated	Joy, Hopeful, Proud	Angry, anxious, shame
Deactivated	relieved, relaxed	Desperate, bored

Inspired by this model, Pekurn [26] proposed the control-value theory of achievement emotion which explains how emotions arise in achievement situations. According to this theory, two primary factors influence achievement emotions: the degree of control an individual has over the situation and the value they place on the task or outcome. He defined achievement emotions as emotions that individuals experience in relation to their achievement pursuits, such as academic or professional goals. These emotions can include both positive and negative feelings, such as pride, joy, satisfaction, anxiety, frustration, or disappointment. Regarding the process of learning, achievement emotions pertain to academic pursuits and the consequences of those pursuits, such as accomplishment and failure.

Correspondingly, Lisa Feldman Barrett and her colleagues have proposed an expansion of the Circumplex Model of Affect by adding an additional dimension of "objective focus" [25]. In terms of objective focus Pekurn proposed two groups of achievement emotions:

- Activity-related emotions: These emotions are related to the process of engaging in an activity or task, and include emotions such as enjoyment, anxiety, and boredom.
- Outcome-related emotions: These emotions are related to the outcomes or results of an activity or task, and include emotions such as pride, shame, and disappointment.

Pekurn has combined the objective focus dimension with the valence and activation dimensions to obtain three-dimensional classification of achievement emotions (see Fig. 2).

	Positive		Negative	
Object Focus	*Activating*	*Deactivating*	*Activating*	*Deactivating*
Activity Focus	- *Enjoyment*	- *Relaxation*	- *Anger* - *Frustration*	- *Boredom*
Outcome Focus	- *Joy* - *Hope* - *Pride* - *Gratitude*	- *Contentment* - *Relief*	- *Anxiety* - *Shame* - *Anger*	- *Sadness* - *Disappointment* - *Hopelessness*

Figure 1. A three-dimensional classification of achievement emotions [26]

2.2 The Four Quadrant Model

Kort and his colleagues [27] introduced an affective model that outlines the dynamic relationship between a learner's emotional experiences and the learning environment. As a starting point, the researchers propose six distinct, uninterrupted sequences of emotions that learner may encounter while engaging in the learning process. (Fig. 3).

Axis	-1.0		- 0.5		0	+0.5	+1.0
Anxiety-Confidence	Anxiety	Worry	Discomfort	Comfort	Hopefulness	Confidence	
Ennui-Fascination	Ennui	Boredom	Indifference	Interest	Curiosity	Fascination	
Frustration-Euphoria	Frustration	Puzzlement	Confusion	Insight	Enlightenment	Euphoria	
Dispirited-Enthusiasm	Dispirited	Disappointed	Dissatisfied	Satisfied	Thrilled	Enthusiasm	
Terror-Excitement	Terror	Dread	Apprehension	Calm	Anticipatory	Excitement	
Humiliated-Proud	Humiliated	Embarrassed	Self-conscious	Pleased	Satisfied	Proud	

Figure 2. Emotions sets in learning context [28]

In the second stage, the researchers integrate the emotional dimension illustrated in Figure 1 with the cognitive processes involved in the learning experience. Figure 4 demonstrates that as one moves along the horizontal axis (emotional dimension), emotions become increasingly positive and enjoyable in nature, while moving in the opposite direction elicits negative emotions. The vertical axis (learning dimension) indicates that knowledge acquisition occurs in an upward direction, while misconceptions are discarded downward. Based on this model, a typical learning experience triggers a variety of emotions that guide learners through the four-quadrant cognitive-emotional space in a counterclockwise direction as they progress in their learning journey (See Figure 4 and 5).

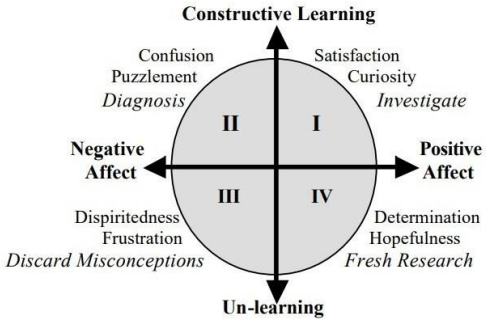

Figure 3. Four Quadrant (emotions, learning) [27]

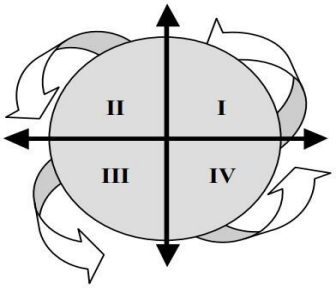

Figure 4. Four Quadrant model (Circular and helical flow of emotion) [27]

As can be seen in Fig. 4, learners would start with constructive learning as they may be fascinated or curious about the topic of interest (Quadrant I). As learners begin to solidify their understanding and feel a sense of progress, they progress into Quadrant I. Alternatively, they may feel confused yet motivated to construct and test new knowledge, which corresponds to Quadrant II in the four-quadrant model. However, during the learning process, learners may encounter educational obstacles, such as failing to solve a problem and recognizing the need for diagnosis and reconstruction. At this stage, they may move downward into the lower half of the diagram (Quadrant III), where negative emotions such as frustration and dispiritedness are experienced along with misconceptions and unproductive ideas (learning axis). Once learners discover how to solve problem and get bright ideas on how to implement the right solution and consolidate the knowledge, advancement to Quadrant IV can take place. After acquiring new ideas and experiences on how to overcome difficulties, the learner can progress to the upper half of the space (Quadrant I), experiencing a variety of positive emotions as they embark on a new learning experience.

Kort and Reilly expanded the model by introducing a third axis, the cumulative knowledge axis, which extends out of the plane of the page, forming a spiral movement from Quadrant I to II to III to IV. The movement between the quadrants is explained as follows: In Quadrant I, the learner is highly motivated and curious about learning, while in Quadrant II, working knowledge construction decreases, and negative emotions emerge due to diminishing progress. Moving to Quadrant III, the learner abandons misconceptions and unproductive ideas, and experiences negative emotions. Finally, in Quadrant IV, the learner becomes aware of unproductive concepts, regains hope and positivity, and the cycle starts again.

The authors aimed to emphasize that the learning process involves both positive and negative emotions, and it is natural for the learner to cycle through different quadrants, including the negative half. Therefore, the ultimate goal of completing a learning exercise is not to remain in Quadrant I but to recognize the inevitability of experiencing negative emotions and misconceptions, and to learn from them in order to progress in the learning process.

Table 2. A Two-dimensional taxonomy of emotions in learning deducted from the Quadrant model

Learning / Emotion	Constructive Learning	Un-Learning
Positive Affect	Satisfaction, Curiosity	Hopefulness, Fresh research, Determination
Negative Affect	Disappointment, Puzzlement, Confusion	Frustration, Discard, Misconception

3. Player's emotional state modeling in video Games

In the video game industry, emotions are an important factor in video game design, as they directly influence player decisions, behavior, and the quality of the gaming experience. Many studies in the field of serious games have indeed focused on analyzing the emotions and behaviors of characters within a game scene as they interact with human users, often prioritizing this aspect over the examination of the player's own emotions. This approach is commonly seen in game design and research, where creating believable and engaging character interactions is a key focus [28]. However, research studies that investigate the emotional state of players during games are scarce due to three primary reasons [29]. Firstly, emotions are commonly studied only in relation to post-consumption states such as entertainment outcomes, rather than during gameplay. Secondly, the investigation of emotions beyond entertainment is restricted to only a few individual emotions instead of a broader range of emotions that can be experienced during gameplay. According to research by Nicole Lazzaro, gameplay can elicit over 30 different emotions, separate from those elicited by the game's storyline [30]. Thirdly, emotion regulation research has been focused on mood repair, despite mood and emotion being distinct.

As the interest in emotions in video games grows, some researchers have started examining the differences in emotional response patterns caused by video games and how various gaming experience aspects can trigger emotions. In this context, the XEOD team conducted a study on 45 people (15 extreme gamers, 15 moderate gamers and 15 non-gamers) to identify the triggers of emotions other than the story in video games [30]. A framework was developed by game designer and Nicole Lazzaro [30] identifiy four types of fun that players experience in video games, and each type of fun is associated with different emotions:

- Hard fun: This type of fun involves challenge, strategy, and problem-solving, and can evoke emotions such as frustration, pride, and relief.
- Easy fun: This type of fun involves exploration and creativity, and can evoke emotions such as curiosity, surprise, awe, and intrigue.
- Serious fun: This type of fun involves repetition and rhythm, and can evoke emotions such as relaxation and excitement.
- People fun: This type of fun involves group play and social experiences, and can evoke emotions such as amusement, sociability, and admiration.

These four types of fun and associated emotions can overlap and interact with each other in complex ways, contributing to the unique emotional experiences of video game players.

Clearly, it would be too ambitious to try to present a model that could accommodate all the emotions a player might experience while playing a video game, because emotions are complex and subjective experiences that can vary greatly between individuals. However, some models have been developed to measure emotions in gaming contexts. Ravaja and his colleagues [31] have

conducted research on emotional response patterns induced by video games. In their studies, they have identified six emotions as the most frequent and reliable emotions experienced by players: pleasure, joy, relaxation, anger, depression and fear. Another study was conducted with the intention of comprehending the manner in which users interact with video games, utilizing Eye Tracking and Facial Expressions Analysis techniques [32]. The participants were equally divided into 3 categories of players, from novice to expert. The chosen game was Call of Duty Modern Warfare 2 on PC. The results showed a taxonomy of players' emotions according to their proficiency (novice, competent, expert). Their emotional analysis showed that novices felt 82% disgust, mid-level players 46% joy, and experts 47% joy. These findings demonstrate the important role of a player's skill in the variation of his emotional state during the game. The presented table offers a comprehensive breakdown of the emotional data collected for the overall emotion category, for participants categorized as novice, average, and expert levels.

Table 3. Players' emotions according to his level deducted from [32]

Player's level	Player's level
Novice	Disgust (82%), Joy (42%), Engagement (16%)
Average	Joy (46%), Contempt (42%), Engagement (23%)
Expert	Joy (42%), Contempt (38%), Engagement (22%)

In their work [33], Chanel et al. employed physiological measures to gauge a player's emotions across different levels of difficulty in the Tetris Game. Their study focused on three distinct emotional states, namely boredom, anxiety, and emotion-related participation. The results show that the game's difficulty level rapidly increases in comparison to the player's abilities, which can negatively affect the player and lead to anxiety. Conversely, at the same level of difficulty, players tend to improve their skills and effortlessly master the challenges, leading to feelings of boredom. Table 4 presents the players' emotional responses based on the game's difficulty level.

Table 4. Players' emotions according to game's difficulty level deducted from [33]

Difficulty game level	Player's emotions
Easy level	Boredom
Medium level	Interest, Pride, Enjoyment
Hard level	Anxiety

Based on the results of the two-above works, it is obvious that the player's abilities and the level of the game on which he plays are strongly related to his emotional state. Regarding the player's level (novice, average, expert), his abilities vary in the same direction as the positive emotions (joy, engagement) and in an opposite direction for the negative emotions (see Fig. 6).

The game's level of difficulty can have a significant impact on a player's emotions, with inappropriate levels of difficulty, whether too easy or too hard, leading to negative feelings such as boredom and anxiety, and ultimately reducing the player's engagement. Nevertheless, medium level (not so easy and not so hard) induces positive emotions (interest, pride and enjoyment) and increases player engagement.

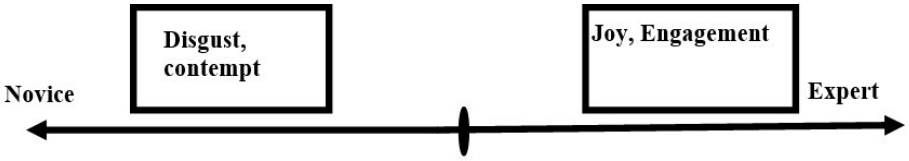

Figure 5. Variations of emotions according to the player's level

According to emotion and flow theories [35] [36], strong engagement in a task occurs when a player's skills align with the difficulty level of the task. If the level of difficulty is too high, it can lead to anxiety, while a difficulty level that is too low can result in boredom. For instance, if the game's difficulty level increases rapidly in comparison to the player's skill improvement as they progress through the different levels, the player may experience anxiety. Also, if the player's competence has increased while the challenges in the game remain at the same level, the player can feel bored (see Fig. 7). Hence, it is imperative to adjust the game's challenges to match the player's competence at each stage to ensure that the player remains engaged and enjoys the game.

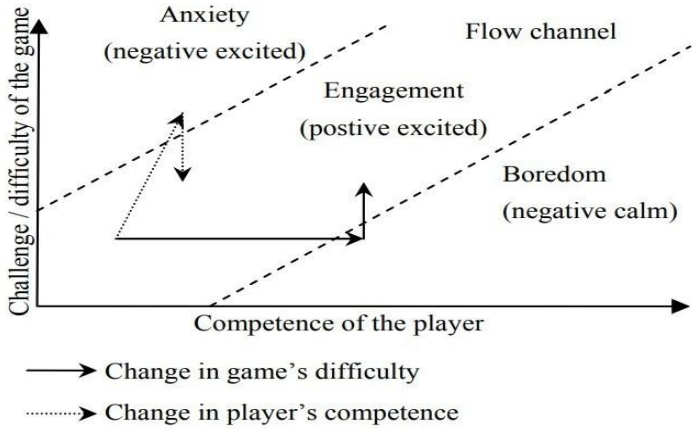

Figure 6. Flow chart and the suggested automatic adaptation to emotional reactions [33]

4. Player's emotional state modeling in Serious Games

Evidently, serious games have the potential to improve the educational process to some extent as they have shown positive results in increasing motivation and providing effective learning outcomes. However, despite the benefits that serious games bring to the educational environment, there are also challenges. One of the significant challenges is maintaining a delicate and crucial equilibrium between the playful aspect (game elements) and the serious aspect (didactic elements) of the game. [37] [38], and how to maintain and increase motivation of the learner-player, and how to use his emotional reactions in a way that facilitates academic functioning. In this current work, we focus on the last challenge mentioned above.

Serious games contain features and elements that increase the probability of experiencing positive emotions and effectively regulating it during learning compared to traditional e-learning environments. According to Aldrich [39], there are three core and integrated components which characterize serious games, i.e., simulation, gaming and pedagogical elements, contribute at different levels to triggering players' emotions.

In the state of the art of serious games, emotions are frequently mentioned. However, the majority of researchers have focused on studying a specific emotion such as the joy of using serious games

[40] [41], anxiety and the fear of being evaluated [42] and the relationship between some emotions (excitement, happiness, anger and anxiety) [43].

4.1. Proposed Model

As Serious games integrate both learning strategies and structures, as well as video game elements (see Fig. 8), we have discussed affective models related to emotions in two contexts, namely, the learning context and the video game context, in the preceding sections.

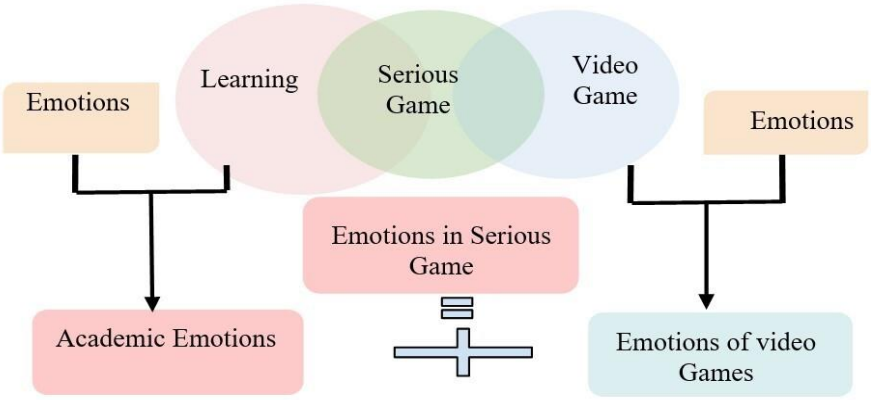

Figure 7 Emotions in Serious Games

The main objectives of studying emotions in both learning and video game context are:

- Firstly, identify the beneficial and detrimental emotions.
- Secondly, enhance and sustain learner-player's level of beneficial emotions and increase the control over harmful emotions through emotion regulation.

In this paper, we will focus mainly on the first objective. To achieve this, we have conducted a comprehensive analysis of existing models and theories in the fields of emotion psychology, game studies, and educational psychology. This analysis involved a review of relevant literature, the extraction of key concepts and components from these models, and the synthesis of these elements to create a new, comprehensive model that describes learner-player's emotions in serious games. Our goal is to provide a clear and well-defined analysis that researchers and practitioners can readily use in their work. In selecting the models for our analysis, we employed a systematic and purposeful approach. The choice of models was based on their relevance and significance in the fields related to emotions and video games:

- Relevance to learning and video Games: We prioritized models that had previously been applied or had the potential to be applied to learning and video games contexts. This ensured that the selected models had direct applicability to our research focus. For example, the Control-Value Theory of Achievement Emotion and the Four Quadrant Model, cited in section 2, hold significant relevance within the learning context. These models offer valuable insights and frameworks that enhance our understanding of the emotional and motivational aspects of learning. Furthermore, emotions and flow theories and Lazzaro's framework, cited in section 3, have clear and notable relevance within the realm of video games, enriching our understanding of both design and gameplay.

- Empirical Support: Models with empirical evidence supporting their validity and applicability in real-world settings were given preference. We wanted to draw from models that had demonstrated practical utility. For instance, experimental evidence supports the effectiveness of the Control-Value Theory. Indeed, in [46] authors demonstrated the applicability of using Pekurn's control value theory in university physical education classrooms. Furthermore, the studied [32] and [32] cited in section 3 supports the applicability of emotion and flow theories.

- Diversity of Perspectives: We sought models that represented diverse theoretical and conceptual perspectives on emotions. This diversity allowed us to consider a broad spectrum of emotional experiences in the serious game context. It is noteworthy to mention that all the selected models successfully fulfilled this criterion, providing a comprehensive and inclusive framework for our analysis.

- Recognized Significance: Models that were widely recognized and cited within the relevant academic communities were included to ensure the credibility of our analysis. For example, the Circumplex Model of Affect, developed by Russell and Barrett, and Pekurn's Control-value Theory of achievement emotion are indeed a well-established and widely recognized model for understanding and categorizing emotions. It's commonly used in the fields of psychology, learning, affective science, and emotion research.

In our proposed model, we developed a comprehensive classification schema for emotions derived from the selected models. This categorization is contingent upon the degree to which these emotions influence the learner-player experience (Beneficial / Detrimental). In addition to these emotional states, our model also considers the significance of ambivalent elements, a term we use to describe emotions that possess both positive and negative attributes. Ambivalent elements are a crucial part of our model, and we acknowledge their role in influencing learner-player experiences. These emotions can bring about both positive and negative consequences, and their effects are more intricate than those of purely positive or negative emotions.

Our proposed affective model is pivotal in elucidating the role of emotions within the realm of serious games, encompassing both learning and video game contexts. It prompts us to question whether we can make a blanket assumption that positive emotions always yield positive effects, while negative emotions inevitably lead to detrimental outcomes.

In our analysis, we delve into the intricate dynamics of emotions within the cognitive processes of serious game players. Both positive and negative emotions can use up cognitive resources by focusing attention on the source of the emotion. This diversion can reduce the availability of resources for accomplishing task objectives and for cognitive processes that demand such resources, ultimately impairing performance [26]. As an example, emotion mentioned in quadrant II of the four-quadrant model (confusion, puzzlement) which can result in reduced motivation and disengagement, and it is not uncommon for the learner at this point to shift towards the lower half of the diagram and encounter more negative emotions, such as dispiritedness and frustration (Quadrant III) [27]. As a consequence, we have categorized them as detrimental. Furthermore, the cognitive resources that are originally allocated to understanding and absorbing the educational content may be momentarily used up by the focus on the positive emotion stemming from student's high score (Relaxation and contentment). As a result, there may be a temporary decrease in the cognitive resources available for engaging with the learning material, potentially affecting their immediate learning performance.

Positive emotions, such as the curiosity and the pleasure of learning (Quadrant I of the four-quadrant model and easy-fun element of Lazzaro's model) and the determination and the

hopefulness (Quadrant IV of the four-quadrant model), are useful to bring leaner-player's attention to the task at hand and help performance.

Empirical studies have consistently demonstrated that numerous research studies exploring the impact of achievements on learner-player motivation, engagement, and learning outcomes consistently indicate their positive influence [44] [45]. According to Pekurn's control-value theory [26], achievement emotions can impact not only the cognitive, motivational, and regulatory processes involved in learning and achievement but also the psychological well-being, contentment, and overall life satisfaction of individuals [34]. We can infer some beneficial and harmful emotions from the three-dimensional taxonomy of achievement emotion of Pekurn [26]:

- Activating positive emotions, such as the enjoyment of learning, boost both intrinsic and extrinsic motivation and encourage the utilization of adaptable and imaginative learning approaches (Beneficial).
- Conversely, deactivating negative emotions, such as boredom, sadness and hopelessness are unproductive as they can result in superficial and inadequate processing of information (Detrimental).
- The interplay of deactivating positive emotions, such as relaxation and relief, and activating negative emotions like anger, anxiety, and shame can be intricate in their effects on learner-players. It can lead to both positive and negative consequences (ambivalent). For instance, anxiety can decrease interest and intrinsic motivation, but at the same time, it can also trigger extrinsic motivation to avoid failure.

These nuanced findings suggest that the relationship between emotions and outcomes is not always straightforward. Positive emotions may not consistently yield favorable results, and negative emotions may not uniformly hinder the learning experience. Accordingly, we can understand the thesis of Kort [27] in quadrant III (Negative affects, Un-learning), the positive effect of negative emotions and how the learner may move to quadrant IV (positive affects) by consolidating their knowledge and awareness of their progress. Hence, it is plausible to categorize these emotions as simultaneously detrimental and beneficial (Ambivalent).

In video games context, we can deduct beneficial and detrimental emotions from both [32] and [33]. The disgust of a novice player, and the boredom and the anxiety experienced by players at easy and hard level respectively are held to be detrimental, and the emotions felt by an intermediate or expert player at a medium difficulty level of a game, such as enjoyment of playing, pride and engagement, are assumed to enhance his motivation and to facilitate players' self-regulation of playing.

To ensure the accessibility and usability of our proposed affective model, we have summarized these insights in Table 5, providing a comprehensive analysis of beneficial, detrimental and ambivalent emotions within the realm of serious games. Table 5 is organized into three main vertical sections: Beneficial elements, Detrimental elements, and Ambivalent elements. Each section is accompanied by relevant axes and corresponding emotions.

- The "Beneficial elements" section includes factors that contribute positively to the player's experience and emotions during serious gameplay. These elements are associated with emotions such as joy, excitement, satisfaction, and a sense of accomplishment. Learners-players may feel motivated and engaged, leading to enhanced learning and overall enjoyment.
- The "Detrimental elements" section addresses factors that may have negative effects on the learner-player's emotions and experience. Emotions like frustration, anxiety, and stress

might arise from challenges that feel overwhelming or insurmountable. These negative emotions can hinder learning and reduce overall enjoyment.

- The "Ambivalent elements" section contains factors that can elicit both positive and negative emotions, depending on the leaner-player's perspective or situation. For instance, a challenging game mechanic might initially cause frustration, but once overcome, it can lead to a sense of accomplishment and satisfaction.

The axes presented in each section represent key dimensions that influence the emotional experience within serious games. These dimensions could include difficulty level, complexity, time pressure, competitiveness, and more. By examining these axes alongside the associated emotions, we gain valuable insights into how various game elements contribute to the players' emotional journey.

Table 5. Classification of learner-players' emotions according to different aspects of learning and gameplay

Beneficial elements		**Detrimental elements**		**Ambivalent elements**	
Axes	**Emotions**	**Axes**	**Emotions**	**Axes**	**Emotions**
Positive, Activating	Enjoyment, Joy, Hope, Gratitude	Negative, Deactivated	Boredom, Sadness, Disappointment, Hopelessness	Positive, Deactivating	Relaxation, Contentment, Relief
Positive Affect, Constructive Learning	Satisfaction, Curiosity,	Negative Affect, Constructive-Learning	Disappointment, Puzzlement, Confusion	Negative, Activating	Anger, Frustration, Anxiety, Shame
Positive Affect, Un-Learning	Hopefulness, Fresh research, Determination	Easy/Hard level of game	Boredom, Anxiety	Negative Affect, Un-Learning	Frustration, Discard, Misconception
Medium level of game	Interest, Pride, Enjoyment	Novice Player	Disgust, Contempt		
Average/Expert Player	Joy				

4.2 Discussions

Based on the comprehensive analysis presented in Table 5, the emotional landscape in the realm of serious games is rich and diverse, encompassing a wide range of affective states from both learning and video game contexts.

On one hand, positive and activating emotions, such as Enjoyment, Joy, Hope, and Gratitude, have been recognized as powerful catalysts for engagement and motivation in the gaming environment. They not only enhance the overall gaming experience but also promote a sense of achievement and satisfaction, driving players to persist and excel. Similarly, Positive Affect linked to constructive learning, as exemplified by emotions like Satisfaction and Curiosity, plays a pivotal role in fostering

learning and skill development within the gaming context. Moreover, emotions categorized as Positive Affect related to un-learning, such as Hopefulness, Fresh research, and Determination, serve as sources of resilience and adaptability, driving players to explore new strategies and overcome challenges. Furthermore, it's worth noting that medium-level games, often associated with emotions like Interest, Pride, and Enjoyment, provide players with a balanced experience, neither overwhelming nor underwhelming, thereby sustaining their engagement. For players who have reached an average or expert level of proficiency, emotions like Joy signify the culmination of their mastery, offering a sense of accomplishment that reinforces continued gameplay.

On the other hand, negative and deactivated emotions, such as Boredom, Sadness, Disappointment, and Hopelessness, can pose significant challenges in the gaming experience. These emotions have been found to be detrimental to player engagement and motivation, often leading to decreased interest and decreased gameplay. Negative Affect linked to constructive learning, as represented by emotions like Disappointment, Puzzlement, and Confusion, can hinder the learning process and inhibit skill development within the gaming context. Moreover, the emotional states associated with the perceived ease or difficulty of a game, such as Boredom and Anxiety, can disrupt the balance between challenge and skill, potentially leading to frustration and decreased motivation. Additionally, novice players may experience emotions such as Disgust and Contempt, which may be related to their limited experience and skill level. These emotions, rather than promoting engagement and enjoyment, can create a barrier to entry and discourage novice players from further exploration and gameplay.

Finally, positive-deactivating emotions, such as relaxation, contentment, and relief, can create a sense of tranquility and well-being, offering moments of respite and relaxation during gameplay. However, these states can also lead to complacency and potentially diminish the player's motivation or engagement. Conversely, negative, activating emotions, including anger, frustration, anxiety, and shame, are recognized for their ability to stimulate heightened levels of arousal and motivation. They can fuel determination, challenge acceptance, and enhance gameplay performance. Yet, these emotions also have the potential to lead to excess stress or demotivation when not managed effectively. Furthermore, negative affect related to un-learning, exemplified by emotions like frustration, discard, and misconception, presents a dual nature. While they may signify the identification of areas requiring improvement and growth, they can also be disruptive and hinder the learning process if not addressed appropriately.

In summary, the spectrum of emotions presents in serious games, ranging from positive activating to medium-level and expert-level states, contribute to a more enriching and rewarding gaming experience. These emotions act as drivers of motivation, learning, and enjoyment, ultimately making video games not only entertaining but also beneficial for cognitive, emotional, and social development. However, the presence of negative deactivated emotions in serious games, including those related to constructive learning, easy/hard level of the game, and novice player status, can have detrimental effects on the gaming experience. These emotions may hinder motivation, learning, and overall enjoyment, potentially leading to disengagement and decreased gameplay. Understanding the impact of these emotions is essential for serious game designers and researchers to create more engaging and satisfying gaming experiences. Nevertheless, the ambivalence of these emotional states within the serious gaming context highlights the complexity of emotional experiences during gameplay. The dynamic interplay between positive-deactivating, negative-activating, and negative affective states related to un-learning underscores the need for a nuanced understanding of how these emotions impact motivation, learning, and overall player experiences in video games. This recognition is essential for game designers and researchers striving to create gaming environments that balance emotional engagement and player well-being.

5. Conclusion

In this paper we discussed different emotions that can be experienced by a learner-player while he is playing Serious Games. As it is widely recognized, serious games utilize learning strategies, content and structure, and gaming elements to communicate particular skills, knowledge, and attitudes. Hence, we have chosen to conclude serious games' emotions from both learning and video games context. We began with the models of Pekurn [26] and Kort [27] about academic emotions and learner engagement. We directed our attention to the video game context and identified the primary factors that can generate beneficial emotions to sustain engagement in the game, namely the game's difficulty level and the player's level of skill. Eventually, based on these researches, we concluded our affective model which conceptualizes the impact of emotions upon serious games and classifies the most important learner-players' emotions into beneficial and detrimental for their motivation and engagement.

While more research is required to confirm the validity of our model, the proposed categorization of emotions experienced by learner-players aligns with existing theoretical viewpoints on emotions in serious games within both the learning and video game contexts.

In the future, research will aim to examine the diverse aspects of serious games, specifically the associations between emotions

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