Measurement Methods for Phenomena Associated with Immersion, Engagement, Flow, and Presence in Digital Games

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ABSTRACT

We present a review on methods used to assess phenomena related to immersion, engagement, flow and presence. These concepts are used to describe the perceived quality of the interaction with digital media and games. However, they are commonly ambiguous, as they can refer to similar phenomena. We approach this ambiguity by focusing our study on measurable phenomena, like the subject's performance in objective tasks and the galvanic skin resistance. Additionally, we highlight the limitations and underlying assumptions of the discussed measurement methods. Finally, we show the factors and game characteristics that can influence on the measured phenomena.

Keywords: Digital games, immersion, flow, engagement, presence, intimacy.

1 INTRODUCTION

The concepts of immersion, engagement, flow and presence recurrently appear in scientific literature as measures of one's level of involvement with an interactive system. Such a measurement is relevant to game developers because it can highlight aspects that impact on the user's motivation. Thus, a deeper understanding on this matter can indicate adequate techniques for game design and development.

However, these important concepts are often used ambiguously or redundantly. Measurable phenomena, like the self-reported level of fun, is commonly associated with different concepts. This leads to difficulties in the analysis of user interactions.

In this paper, we present a review on the measurement of immersion, engagement, flow and presence, focusing on the measured phenomena that related to them. This approach allowed a more objective understanding of the motivations behind revised work.

This paper is organized as follows. Section 2 presents the concepts of immersion, engagement, flow and presence, as well as related concepts. In Section 3, we present a brief discussion of the experimental work analyzed during this review. Section 4 highlights similarities in measured phenomena, and further discussion in conducted in Section 5. Finally, Section 6 presents conclusive remarks.

2 CONCEPTS

This section presents definitions for immersion, engagement, flow and presence. They are used inconsistently in scientific literature. Thus, we present the meaning of each concept as discussed by different authors. We also highlight key differences and similarities between them. In addition, we also present definitions for other related concepts, such as game experience and psychological absorption.

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2.1 Immersion

Brown and Cairns [5] defined immersion as one's *degree of involvement* with a game. They argue that immersion can be divided into three levels: engagement, engrossment and immersion itself. Engagement is the lowest level of immersion. It starts with the player's interest and understanding about the game control, causing the loss of track of time while playing playing. The next level, engrossment, is linked to the player's perception of the game realism. Engrossment is related to the desire to keep playing and the deeper loss of awareness of one's surroundings. The highest level, total immersion, is reached when the player describes the sensation of being cut off from the real world, as well as feeling empathy towards the game's fictional characters [5].

Ermi and Mäyrä [10] define immersion as a component of gameplay experience. Such experience has an active participation component, and an immersion component. Immersion itself can be defined as "the sensation of being surrounded by a completely other reality (...) that takes over all of our attention, our whole perceptual apparatus". It has many similarities with the presence component, and they argue it is often used as a synonym. Conditions like matching user's expectations, having meaningful interactions and a consistent game world may increase player's sense of immersion.

Witmer and Singer [34] use the word immersion to define a psychological state linked to the perception of being included in and interacting with an virtual environment. They argue that isolation from the physical environment and natural modes of interactions affect the level of immersion.

Oliveira *et al.* [26] investigate the possibility of immersion for visually impaired individuals. They argue that such immersion can be achieved using 3D spatially-located sounds.

Brockmyer *et al.* [3] argues that that immersion is the engaging in game-play while, to some extent, being still aware to one's surround. They also define it as the potential to induce feelings of being part of the game environment, and that most video game players report experiencing some degree of immersion.

2.2 Engagement

Martey *et al.* [22] define engagement as the degree of activity or attention that someone gives to a person or object during a period of time. The authors also conceptualize engagement as the increase of arousal and attention.

Bianchi-Berthouze, Kim and Patel [2], when describing their experiments, assume that engagement is the first step towards immersion. It can be described as well in terms of participation, narration and co-presence of others, relating to a social aspect of engagement. They also state that body movements might play an important role in engagement.

Hamari *et al.* [13] describes engagement as the simultaneous occurrence of elevated concentration, interest and enjoyment, encapsulating the experience of flow.

Wiebe at al. [33] also points that beyond encompassing the elements of flow, engagement definitions also contains aesthetics, pleasure and novelty aspects. In addition, it also is influenced by usability aspects and rational aspects, such as the will to re-engage with the experience in the future.

Brockmyer *et al.* [3] uses engagement as a generic indicator of involvement with a game. They also state that terms like immersion, presence and flow can be understood as levels in a continuous scale of engagement during gameplay.

2.3 Flow

Jackson and Marsh [16] define the state of flow as a positive experiential state that occurs when the participant is completely connected to the performance. Also in this situation the participant feels that his personal skills are balanced with the required challenges.

Csikszentmihalyi coined the term *flow*, describing it as being “in a condition of high challenges and skills” [7].

Berta *et al.* [1] describes flow as a “high enjoyable mental state where the player is fully immersed and engaged in the process of activity”. They also state that users experience positive emotions associated with their current task. In their paper, they also classify the player as being in one of three states, namely “boredom”, “flow” and “immersion”, as degrees in a scale.

Douglas and Hagardon [9] argue that flow is a state in which users of interactive media can be both immersed and engaged simultaneously. They state that ”where immersion involves identification with characters and narrative elements [...] engagement involves deciphering the author’s or game designer’s intentions”.

Brockmyer *et al.* [3], based on Csikszentmihalyi’s work, describe flow as “the feeling of enjoyment that occur when a balance between skill and challenge is achieved, in the process of performing an intrinsically rewarding activity”. Hamari *et al.* [13] and Ijsselsteijn *et al.* [14] use a similar description for the flow experience, highlighting the importance of balancing challenge and skills to achieve it. Brockmyer’s definition of flow include feelings of being in control, being one with the activity and experiencing time distortions.

2.4 Presence

Witmer and Singer [34] define presence as the subjective experience of being in the virtual place or environment. Such an involvement depends on focused attention on virtual environment tasks and immersion depends on perceiving oneself as a part of the virtual environment stimulus flow. For this reason, they argue that immersion and engagement are necessary conditions for the existence of presence.

Schubert, Friedmann and Regenbrecht [31] argue that the construction of a mind model and the allocation of attention focus are two processes related to presence. This agrees Witmer and Singer’s [34] ideas on presence. Additionally, both of their studies distinguish the attention component of involvement from a spatial cognitive component called psychological immersion.

Ijsselsteijn *et al.* [15] use the concept of presence to define telepresence as feeling physically present at a remote or mediated environment. They also argue that there are two types of presence: physical and social.

Jin [18] describes a model for presence that includes spatial, physical, social and self identification components. Both interact with environmental factors to generate flow.

2.5 Other related concepts

Other concepts used to describe player’s interaction with digital games were encountered in some of the review material. Concepts such as user experience, player experience, and usability were considered as included in the four main concepts described in this work. Also, concepts like Fel’s intimacy and embodyment [11] bear resemblance to presence and usability. Still, some of those are proposed in specific contexts, and need further investigation on its relevance in digital games.

Brockmyer *et al.* [3] describe psychological absorption as total engagement in the present experience, arguing that it is similar to flow. However, they point differences between the two states. In special, psychological absorption can include negative aspects like anxiety and frustration, whereas flow can not.

Ermi and Mäyrä’s [10] proposed the gameplay experience model as comprising three dimensions of immersion: sensory immersion, challenge-based immersion and imaginative immersion. Sensory immersion relates to the audiovisual aspect of the video game. Imaginative immersion is closer to other definitions of immersion, as it is related to an psychological and emotional connection with the game. Their definition of challenge-based immersion is when one is able to achieve a balance of challenges and abilities, being very close to the the notion of flow.

Ijsselsteijn *et al.* [14] state that concepts such as engrossment and total immersion share a number of important features attributed to the flow experience, such as focused attention, diminished sense of self and losing track of time.

3 Experiments and Results

As it was show in Section 2, the concepts of immersion, engagement, flow and presence are used inconsistently in scientific literature. Hence, there is also divergence on the experiments and conclusions that can be made based on those concepts. This section briefly discusses experiments that aim at measuring the user’s interaction with digital games.

Berta *et al.* [1] developed a simple plane battle game with three levels. Each level was designed with aims to induce boredom (level 1), flow (level 2) and anxiety (level 3). Each subject was analyzed while playing the game. The researchers measured the electrical using an EEG, the heart beat and the galvanic skin resistance. Also, the authors applied the Game Engagement Questionnaire (GEnQ) [3] on the players to measure the level of flow. Berta *et al.* [1] results showed that the most informative frequency bands for discriminating among gaming conditions are the low beta, which it’s wavelength, according to the authors are 12-15 Hz. The authors argue that the signals from the peripheral nervous system had a marginal contribution to measure of flow. The questionnaire was used to help to understands the brain’s wave and to corroborate the EEG results.

Bianchi-Berthouze, Kim and Patel [2] describe two experiments in which subjects are asked to play the game Guitar Hero for 20 minutes. Before the play session, they answer a revised version of the ITQ questionnaire [34], and after each session they answer a revised version of the GEnQ questionnaire [3]. The researchers also recorded body movement using a video camera. The results showed that players in the guitar controller condition showed a greater amount of movement measured from the upper-body joints, as well as a greater engagement score from the GEnQ, when compared with players using gamepad controllers. It also suggests that body movements may increase the player’s level of engagement.

In attempt to measure Engagement in video game playing, Brockmyer *et al.* [3] developed the GEnQ questionnaire, that is largely used by other authors to measure engagement. After developing the questionnaire, the authors applied it in participants after playing the first person shooter game *S.T.A.L.K.E.R: Shadow of Chernobyl*. The GEnQ results was compared to other questionnaires results (like the Dissociative Experiences scale that measures the individual’s tendency to have experiences that are consistent with dissociation, and the Aggressive Questionnaire that can measure hostility and aggression). Results show that psychological engagement is positively related to trait aggression. Also the GEnQ and DES measure similar constructs. Finally the GEnQ provides preliminary support for short-term test reliability.

In Gerling, Klauser and Niesenhaus’s experiment [12], subjects were asked to play Battlefield Bad Company 2. After collecting data about user's previous experience with gaming, subjects were split into four groups, regarding player's assigned platform (PC or XBox) and player's familiarity with the assigned platform (familiar or unfamiliar). After playing the game until completion of a level, or after a maximum of twenty minutes, the users were asked to answer the GExQ, the GEnQ and an ISO-Norm questionnaire. Information about number of deaths during a level and completed parts of the level were also collected to evaluated player's efficiency. Gerling, Klauser and Niesenhaus's [12] experiment results indicate that all 45 subjects had an above average gaming experience, according to GEnQ and GExQ scores, and players with their comfort platform had lesser issues with usability. No significant results were found relating particular platform choice and its affect in player's experience, efficiency and perceived usability.

In attempt to understand the impact of flow and immersion on learning ability, Hamari *et al.* [13] proposed two experiments. In the fist one, 134 high school students played Quantum Spectre, a puzzle-style game in which the player directs lasers to a target using a set of different mirror types and other optical devices. On the second experiment, undergraduate-level mechanical engineering students played Spumone, a game in which players command a two-dimensional vehicle, but have to employ principles learned in the engineering course to be successful. After playing the game, the participants answered a psychometric survey. The results showed that the conditions of flow (challenge and skill) accounted for almost half of the variance of engagement and half of the variance of immersion. Challenge also had a direct effect on the perceived learning, as well as a mediated effect from increased engagement. However, skill didn't have a significant positive effect in perceived learning, neither did Immersion.

Jennett *et al.* [17] argue that an immersed player has sensible difficulty on switching from an immersive task to a non-immersive one, hence harming performance in the latter. To test this hypothesis, the authors describe two experiments. In the first one, the participants played a first person shooter, Half-Life. Before and after the game session, the participants should solve a tangram puzzle. After ten minutes of playing the game, the participants were interrupted to fill an immersion questionnaire (IQ), and then played for additional ten minutes. On a control group, instead of playing Half-Life, participants should perform a simple computer task, that involves to click on a square that should appear anywhere at the screen. The subjects of the control group also solved the tangram puzzle. The authors also used eye tracking devices to measure the subjects' level of immersion. Jennett *et al.* [17] results showed that the time to complete the tangram task was effectively longer on the second time than the first time, supporting the idea that being immerse in a game decrease the player's ability to return to the "real world". On average, the tangram task took 33 seconds to be completed on the first time and 61 seconds on the second time. The control group did not present a significant differences between the time to complete the first and second task. Regarding the second experiment, the authors conclude that the eye tracking reveled that the participants' eye movement in immersion condition tends to decrease over time. This finding support the idea that for a non-immersive game, the player's eye movement will increase, as they become more likely to be distracted by other items not relevant to the game. Finally, the third experiment results show that the pace increase of the task did not affected the level of immersion on the control group.

Based on work by Jennet *et al.* [17], Zhang and Fu [36] proposed an experiment to measure the influence of background music of video games on a player's immersion. They compared the experience of playing with and without background music. The subjects were separated into categories related to the time they spent playing weekly ("low gamer" and "high gamer"). Also, the puzzle task proposed was a task based on naming colors (based on the Stroop Effect), instead of a tangram. Zhang and Fu [36] applied the same immersion questionnaire as Jennet *et al.* [17]. They detected that low gamers tended to obtain a higher score with background music turned on when compared to background music turned off. All participants underestimated the session duration, indicating that a distorted perception of elapsed time occurred. Interaction between the perceived time and background music was found, again with low gamers underestimating the elapsed time more when experiencing the game with background music then without it. Also, they found a significantly inverse correlation between the immersion score and the player's estimation of the session duration. Zhang and Fu [36] experiment indicated an interaction between the Stroop task performance and the presence or absence of background music, since all participants performed better with the music turned off. They argue that this indicates a higher level of immersion. However, the immersion questionnaire score was not significantly correlated with the performance in the Stroop task.

Jin's [18] study aimed to examine the influence of flow across different video game genres (medical simulation, driving, and avatar-based narrative-driven). The games select for the experiment were Trauma Center, Need for Speed and Godfather. They found that a balance between skill and challenge induces a greater flow.

Jin [19] investigated predictors of flow in digital games. They showed that successful performance in shooting and medical simulation games resulted in greater flow. A second study showed an interaction between skill and challenge level in racing, violent and social games, similar to those results in [18]. A third study envolving an exergame[1] and a music game also showed playfulness having an effect on flow.

Lessiter *et al.* [20] invited participants to watch 2D and 3D movies in a IMAX cinema to measure presence. After the movie, participants should complete the ITC questionnaire. Subjects presented the highest average scores in the IMAX 2D group, followed by IMAX 3D and computer game. These results show that media affects engagement (consequently, also affecting presence).

Martey *et al.* [22] proposed measuring immersion using the galvanic skin resistance and the scores of engagement given by a questionnaire (TPI) during a session of a simple 2D puzzle-based point-and-click game. Mota and Marinho [8] performed a similar experiment, but to measure immersion, using a FPS-style game, and evaluated the impacts of sound effects and graphic textures in the measurements. To measure the level of immersion the authors used the GEnQ questionnaire. Martey *et al.* [22] results show that the GSR was used to successfully measure the arousal, that is related to engagement. Mota and Marinho [8] results show that the the skin temperature tends to increase before the enemy's attack, when the game sound is activated. However, the texture activation or deactivation did not change significantly the skin temperature.

Nacke and Lindley [24] measured immersion and engagement on a Half-Life 2 game session. The authors designed three levels to assess three conditions: boredom, immersion and flow. In addition, the authors measures the changes in facial expressions using EMG and changes in the galvanic skin resistances using electrodes attached to the participant's left hand. Nacke and Lindley [24] results show that flow condition can be measured through the zygomaticus major muscle, which draws the angle of the mouth superiorly and posteriorly to allow one to smile [4], and through the measurement of arousal, by the galvanic skin resistance. The results for immersion indicates that this condition can be measured through the Orbicularis oculi muscles, which control the eyelids [4].

Mendonça and Mustaro [23], attempting to measure immersion and emotional response in video games, developed an three-part experiment. In the first part, they collected and analyzed data on the degree of immersion in digital games of the action adventure

[1] An exergame is a game involving some degree of physical activity, like Wii Sports for Nintendo Wii.

style. In the second part, a system was developed to analyze the data collected on the first part to relate the emotion with immersion. Finally, in the third part groups the games studied according to degree of emotion they have. The results show that narrative, gameplay, video, audio, social relation and artificial intelligence affect the immersion on video games. The authors conclude that immersion is directly related to the areas of emotion.

Procci, James and Bowers [27] studied the effects of gender, ange and experience on Engagement in video games. The authors invited the participants to play an online browser-based game and respond a survey (GEnQ) to capture their subjective experience. They calculated Low Game Engagement by summing scores from immersion and presence subscales (GEnQ) and High Game Engagement by summing itens from the flow and absorption subscales (GEnQ). The results show that the age was a significant predictor of high-level engagement. Older people tends to be less engaged. The authors also couldn't find a relationship between game experience and game engagement.

Qin, Rau and Salvendy [28] measure the Immersion in computer game narrative. They developed a questionnaire (CGNQ) that assess six factors on a game narrative that impact the immersion: curiosity, concentration, challenge and skills, control, comprehension, empathy and familiarity. The results show that the curiosity can effectively increase immersion.

Qin, Rau and Salvendy [29] studied the game difficulty on player's Immersion. They invited the participants to play the game Warriors of Fate, a horizontal-scrolling beat 'em up game. The difficulty was classified by the number of diversified enemies. After the playing session, the participants responded a questionnaire (CGNQ). The results show that participants had better immersion when the game difficulty is medium. Also the results indicates that if the difficulty exceed the player skill, the player immersion tends to decrease.

Ronimus *et al.* [30] studied the effect of varying the level of challenge (high vs. low challenge) and the reward system (present vs. absent) in children's game-based learning of reading. The children played a web-based game called GraphoGame, in which they connected letters to sounds, supervised by their parents, for a period of 8 weeks. Children's engagement was measured by session duration and frequency, and by a self-report in-game survey at the end of each session. The results showed that the reward system increased the duration of sessions, but after a few sessions that effect no longer took place. No significant effect was found for the level of fun. At the end of the period, all children performed better on testing and in-game, but no significant effect from varying game features (challenge and reward system) was found.

Schubert, Friedmann and Regenbrecht's [31] experiment surveyed users of Virtual Environments through self-reports about presence and immersion experiences, as well as a "realness" component linked to presence. Their results showed a distinction in factors related to presence, immersion and interaction factors. Based on those results, the authors proposed and verified a 13-item presence scale consisting of three independent components: spatial-constructive, attention and sense of realness.

Witmer and Singer [34] measure presence in a virtual environment. The participants wore the Virtual Research Flight Helmet for displaying the virtual environment. The participants should perform simple tasks on the environment, like moving an object and walking through doors using a joystick. After the task the authors applied two questionnaires (PQ and ITQ). According to the authors, the results indicate that control affects immersion, therefore impacts on presence.

Wood, Griffiths and Parke [35] studied the time loss phenomena on video game players. The participants responded an online survey containing open questions about the player's experience on time loss. The results show that complex and immersive games, goals, levels and scores to beat, plot-driven stories and exciting game are associated with time loss.

Wiebe *et al.* [33] measure engagement on video games. The authors developed a questionnaire (UES) and compared the results to the Flow State Scale questionnaire. The participants were invited to play an online strategy game called Block Walk. After that, participants responded the UES and FSS questionnaires. The results show that the scores obtained in UES questionnaires was greater than the scores obtained in FSS when using in a video game context.

4 Phenomena and measurements

Section 3 presented different experiments that were applied to the measurement of users' experience when using interactive systems. Since *interaction* is not a measurable quantity, it is necessary to use related – but measurable – phenomena as observations. Therefore, the experiments assume that there are measurable phenomena that are linked to the underlying concepts of immersion, flow, presence and engagement.

We discuss these phenomena in this section, along with the methods that have been used to measure them. Such phenomena were divided into three groups: emotional (how a user feels towards something), rational (linked to the learning ability and performance) and biological (which can be measured with electronic sensors). The rationale behind this is further detailed as follows.

4.1 Emotional

The phenomena manifested by Immersion, Engagement, Flow and Presence are commonly measured by questionnaires through the literature. In this way the participant can evaluate himself about what did he think he was feeling. Each questionnaire have multiple questions to measure the same phenomena, thus this research grouped the phenomena in Sense of being there, Confusion between virtual world and reality, physiological and psychological adverse reactions, distorted perception of elapsed time, Level of fun, focused attention, emotional attachment, unawareness of real world and feeling interactions as natural.

The Sense of being there can be verified by questions like "How much did your experiences in the virtual environment seem consistent with your real-world experiences?" or "I felt I was visiting the places in the displayed environment." [20].

Confusion between virtual world and reality are related to questions like "To what degree did you feel confused or disoriented at the beginning of breaks or at the end of the experimental session?" [34], or "I lose track of where I am" [3], "I had a strong sense that the characters and objects were solid." [20].

The questions to verified Physiological and psychological adverse reactions can be "I feel scared" [3], or "I felt dizzy" [20], "I felt I had a head- ache" [20].

Distorted perception of elapsed time is related to "Were you involved in the experimental task to the extent that you lost track of time?" [34], or "I lose track of time" [3], "Time seems to kind of stand still or stop" [3], "I play longer than I meant to" [3].a

Level of fun can me measured with questions like "I enjoyed my-self" [20] or "I enjoyed playing the game." [17].

Focused attention related to "How well could you concentrate on the assigned tasks or required activities rather than on the mechanisms used to perform those tasks or activities?" [34] or "My attention was focused entirely on what I was doing." [16].

Emotional attachment is linked to questions such as "I felt that I really empathized/felt for with the game." [17].

Unawareness of real world can be verified by questions like "How aware were you of events occurring in the real world around you?" [34], or "If someone talks to me, I don't hear them" [3], "I was aware of the real world" [20].

Feeling interactions as natural is related to questions like "How natural was the mechanism which controlled movement through the environment?”, “How aware were you of your display and control devices?” [34], “I play without thinking about how to play” [3], “I became unaware that I was even using any controls.” [17]

Table 1 shows all phenomena classified as emotional, on the left-most column. For each phenomenon, Table 1 also shows the related concepts according to each work (e.g. the phenomena sense of being there is related to flow in Gerling, Klauser and Niesenhaus' study).

4.1.1 Questionnaires

Many of the experiments' measurements regarding emotional phenomena resorted to questionnaires proposed in the literature, with each questionnaire covering multiple phenomena. However, some experiments only measure some isolated emotional phenomena. Thus, we point out this distinction in Table 2.

The Game Engagement Questionnaire (GEnQ) was developed by Brockmyer *et al.* [3] as a way to measure the engagement in video game-playing. This questionnaire proposes that the main phenomena related to engagement are the confusion between virtual world and reality, physiological and psychological adverse reactions, distorted perception of elapsed time, unawareness of real world and feeling the interactions as natural.

The Presence Questionnaire (PQ) was designed by Witmer and Singer [34] to measure presence in virtual environments. The main phenomena possible to note are the sense of being there, confusion between virtual world and reality, distorted perception of elapsed time, focused attention, unawareness of real world and feeling interactions as natural.

Lessiter *et al.* [20] proposed the Sense of Presence Inventory (ITC-SOPI). It focuses on users' experiences of media. The main phenomena measured by this questionnaire are the sense of being there, confusion between virtual world and reality, physiological and psychological adverse reactions, fun and unawareness of real world.

The questionnaire used by Martey *et al.* [22], and developed by [21], Temple Presence Inventory (TPI), measures the level of engagement. This questionnaire is used to measure the phenomena sense of being there, confusion between virtual world and reality, and fun.

Jin [19] used the Flow Questionnaire (FQ), proposed by Webster *et al.* [32], to measure flow. It contains nine questions measured with a 7-point Likert scale, and from the questions, it is possible to highlight three phenomena: fun; focused attention; and feeling interactions as natural.

The Flow State Scale (FSS) was developed by Jackson and Marsh [16] in an attempt to measure flow, and it was applied by Wiebe [33]. The main phenomena noticed are the distorted perception of elapsed time, fun, focused attention and feeling interactions as natural.

The Immersion Questionnaire (IQ), proposed by Jennett *et al.* [17], aims to measure the immersion in games and it is based on others questionnaires related to flow and presence. The IQ highlights the following phenomena: sense of being there, confusion between virtual world and reality, distorted perception of elapsed time, fun, focused attention, emotional attachment, unawareness of real world, and feeling interactions as natural.

Witmer and Singer [34] developed the Immersive Tendency Questionnaire (ITQ) as a complement when evaluate the presence. This questionnaire assess the one tendency to be immersed other contexts, like reading and watching TV. The phenomena verified by the ITQ are very similar to those from PQ. We can highlight confusion between virtual world and reality, distorted perception of elapsed time, emotional attachment, unawareness of real world and feeling interactions as natural.

In attempt to measure immersion on narrative game-based, Qin, Rau and Salvendy [28] developed the Commputer Game Narrative

Table 1: Measurement of emotional phenomena by citation

Phenomena	Concepts	Citations
Sense of being there	Presence	[18] [20] [31] [34]
	Flow	[12]
	Immersion	[17] [36]
	Engagement	[22]
Confusion between virtual world and reality	Presence	[20] [31] [34]
	Flow	[1]
	Immersion	[2] [17] [8] [34] [36]
	Engagement	[3] [12] [22] [27]
Physiological and psychological adverse reactions	Presence	[20]
	Flow	[1] [12]
	Immersion	[1] [23] [8]
	Engagement	[3] [12] [27] [33]
Distorted perception of elapsed time	Presence	[31] [34]
	Flow	[1] [13]
	Immersion	[2] [17] [8] [34] [35] [36]
	Engagement	[3] [12] [13] [27] [33]
Level of fun	Presence	[20]
	Flow	[19] [24]
	Immersion	[17] [23] [36]
	Engagement	[22] [33] [30]
Focused attention	Presence	[18] [34]
	Flow	[19]
	Immersion	[17] [28] [29] [36]
Emotional Attachment	Presence	[18]
	Flow	[19]
	Immersion	[2] [17] [34] [36]
Unawareness of real world	Presence	[20] [31] [34]
	Flow	[1]
	Immersion	[2] [12] [17] [8] [28] [29] [34] [36]
	Engagement	[3] [27] [33]
Feeling interactions as natural	Presence	[31] [34]
	Flow	[1] [12] [19]
	Immersion	[2] [12] [17] [8] [28] [29] [34] [36]
	Engagement	[3] [12] [27] [33]

Table 2: Questionnaires and related phenomena.

Phenomena	GEnQ	PQ	ITC	TPI	FQ	FSS	IQ	ITQ	CGNQ	UES	GExQ
Sense of being there		X	X	X			X				X
Confusion between virtual world and reality	X	X	X	X			X	X			
Physiological and psychological adverse reactions	X		X							X	X
Distorted perception of elapsed time	X	X				X	X	X		X	
Level of fun			X	X	X	X	X			X	
Focused attention		X			X	X	X		X		
Emotional Attachment							X	X	X		
Unawareness of real world	X	X	X				X	X		X	
Feeling interactions as natural	X	X			X	X	X	X	X	X	X

Questionnaire (CGNQ). The following phenomena are highlighted: focused attention; emotional attachment and feeling the interactions as natural.

Wiebe *et al.* [33] revised and applied the User Engagement Scale (UES), originally designed by O'Brien and Toms [25], as a psychometric tool to measure engagement during video game-play. This questionnaire assesses physiological and psychological adverse reactions, distorted perception of elapsed time, fun, unawareness of real world and feeling interactions as natural.

The Game Experience Questionnaire (GExQ) was designed by Ijsselsteijn *et al.* [14] to measure the user experience in digital games. The main phenomena this questionnaire measure are the sense of being there, distorted perception of elapsed time and feeling interactions as natural.

Table 3 highlights the questionnaires used in each work. Researches that developed other specific questionnaires are grouped in the "others" category.

Table 3: Questionnaires and citations.

Questionnaire	Citations
GEnQ	[3] [1] [8] [12] [27]
PQ	[34] [31]
ITC	[20]
TPI	[22]
FQ	[19]
FSS	[33]
IQ	[17] [36]
ITQ	[2] [34]
CGNQ	[28] [29]
UES	[33]
GExQ	[12]
Other	[13] [18] [19] [23] [24] [28] [30] [35]

4.2 Rational

Immersion, engagement and flow can also be measured using phenomena related to players cognitive processes and actions, labeled in this work as "rational phenomena". We divided the rational phenomena into groups related to changes in body movement, variation in learning ability, in-game task performance, off game task performance, time spent looking at the screen, mouse activity, duration of play session, and frequency of play session. Also, they were classified by measurement method: direct measurement (extracted parameters) or self-reported (by asking the participant).

Changes in body movement are measured by Bianchi-Berthouze, Kim and Patel [2] and Ronimus *et al.* [30] to assess engagement, and by Nacke and Lindley [24] to measure flow. The authors defend that when the player is immersed he tends to move his body more then regularly [2], specially for games like Guitar Hero. This phenomena can be evaluated directly, through a exoskeleton that is placed on player's body or through the video recording.

Hamari *et al.* [13] noticed variation in learning ability while evaluating flow and engagement with self-reported measurements. Ronimus *et al.* [30] also noted this phenomena when evaluating engagement, however the authors measured the variation in learning ability by direct measurement using metrics in game (like score).

In-game task performance (usually, number of deaths or final score) was measured by Gerling, Klauser and Niesenhaus [12] through direct measurement, by Jennett *et al.* [17] and Procci *et al.* [27] through self-reported measurement. This phenomena was also assessed through direct measurement by Jin [19]. Qin, Rau and Salvendy [28] and Jennett *et al.* [17] evaluated immersion through direct and self-reported measurement respectively.

Off game task performance was used by Jennett *et al.* [17] and Zhang and Fu [36] to directly measure immersion. The authors defend that when the player is immersed, his performance in an off game task will be worse. Jennett *et al.* [17] used the performance in a tangram task and Zhang and Fu [36] used the performance in a "naming colors" Stroop task.

Time spent looking at the screen can be used to measure engagement through direct measurement, and it was used by Martey *et al.* [22]. The authors recorded the faces of participants during the game session, since the participant will look more often to the screen when he is engaged [22].

Martey *et al.* [22] also used mouse activity to measure engagement through direct measurement, arguing that the increase of mouse movement is related to engagement.

Duration of play session was used as a phenomena to measure immersion by Qin, Rau and Salvendy [28], and by Ronimus *et al.* [30] to measure engagement, both through direct measurement. The authors state that when player is immersed or engaged he will spend more time playing the game.

Frequency of play session was also used by Ronimus *et al.* [30]

through direct measurement to measure engagement, as the authors related the player's feeling of engagement with him being likely to play more often.

Table 4 shows all phenomena that was classified as rational. Each phenomena is related one or more concepts, that in turn is related to what kind of measurement (direct or self-reported) and to the referenced works that use it.

Table 4: Measurement of rational phenomena by experiment.

Phenomena	Concepts	Measurement	Citations
Changes in body movement	Engagement	Direct	[2] [30]
	Flow	Direct	[24]
Variation in learning ability	Flow	Self-reported	[13]
	Engagement	Self-reported	[13]
		Direct	[30]
In-game task performance	Engagement	Direct	[12]
		Self-reported	[17] [27]
	Flow	Direct	[19]
	Immersion	Direct	[29]
		Self-reported	[17]
Off game task performance	Immersion	Direct	[17] [36]
Time spent looking at the screen	Engagement	Direct	[22]
Mouse activity	Engagement	Direct	[22]
Duration of play session	Immersion	Direct	[29]
	Engagement	Direct	[30]
Frequency of play sessions	Engagement	Direct	[30]

4.3 Biological

The present research suggests that it is also possible to assess immersion, presence, flow and engagement through measuring biological responses from users. Beyond self-reported psychological and performance metrics, the reviewed works also assessed the quality of the user's experience analyzing data as the following: changes in heart rate, changes in galvanic skin resistance, changes in cerebral electrical activity and changes in facial expressions.

Changes in heart rate were used by Berta *et al.* [1] in attempt to measure flow. The authors use this feature to distinguish the flow state from boredom and frustration. Chanel *et al.* [6] argue that the heart beat rate can predict emotional states like anxiety.

The change in galvanic skin resistance was also used by Berta *et al.* [1] to measure flow. This feature measures the changes in the sweat and gland activity on the surface of the skin. Nacke and Lindley [24] use the GSR to measure the arousal, since the production of sweat is controlled by the human sympathetic nervous system. Mota and Marinho [8] use this measurement to assess immersion, while Martey *et al.* [22] use it to assess engagement.

Changes in brain electrical activity was used by Berta *et al.* [1] in an attempt to find a correlation between the EEG signal and flow.

Changes in facial expressions were used by Nacke and Lindley [24] to measure flow by recording activity from the face muscles. Jennett *et al.* [17] used a similar method in which eye movement was applied on the measure of immersion. The authors defend that when the player is immersed, the eye's movements tend to decrease over time.

Table 5 shows all phenomena that we classified as biological. Each phenomenon is related to the concepts it aims to measure, and the references to work that use each relation.

Table 5: Measurement of biological phenomena by experiment.

Phenomena	Concepts	Citations
Changes in heart rate	Flow	[1]
Changes in galvanic skin resistance	Flow	[1] [24]
	Immersion	[8]
	Engagement	[22]
Changes in cerebral electrical activity	Flow	[1]
Changes in facial expressions	Flow	[24]
	Immersion	[17] [24]

5 Discussion

Figure 1 depicts a graphical representation of the concepts and phenomena discussed in this work. It allows the visualization of the relationships that were previously discussed in text.

As it can be seen, the figure shows how the concepts of engagement, flow, immersion and presence are linked to all phenomena described in this work. Each arrow represents a relationship in which its cited authors link the concept to that phenomena. The groups of rational, biological and emotional phenomena have each their own color.

The presence concept has more connections with emotional phenomena, and flow seems more connected to rational and biological phenomena. At first glance, this seems to suggest that all studies regarding the presence concept are linked only to emotional phenomena. This, however, doesn't mean that there are no rational or biological phenomena associated with presence. As shown in the Section 2 and in Section 4, there is a great amount of overlap in what group of phenomena each author associate with each concept.

Engagement and immersion also overlap greatly with each other, and to some extent with flow as well. This can be attributed to the similarity in descriptions regarding both immersion and engagement models, and that in some models described above both are proposed as components of a flow experience.

Regarding Gerling, Klauser and Niesenhaus' study [12], we classified their efficiency measure as a rational phenomena In-Game Performance related to Engagement. However, one can argue that their focus was on the concept of Player Experience, and such concept is more encompassing than just engagement, including immersion, flow and presence.

There is a significant amount of ambiguity regarding all concepts. However, measurable phenomena are well defined and discussed. Therefore, we believe that an interesting research practice for future work is to focus more on measurable phenomena than on the concepts of Immersion, Engagement, Flow, and Presence.

The next section presents conclusive remarks.

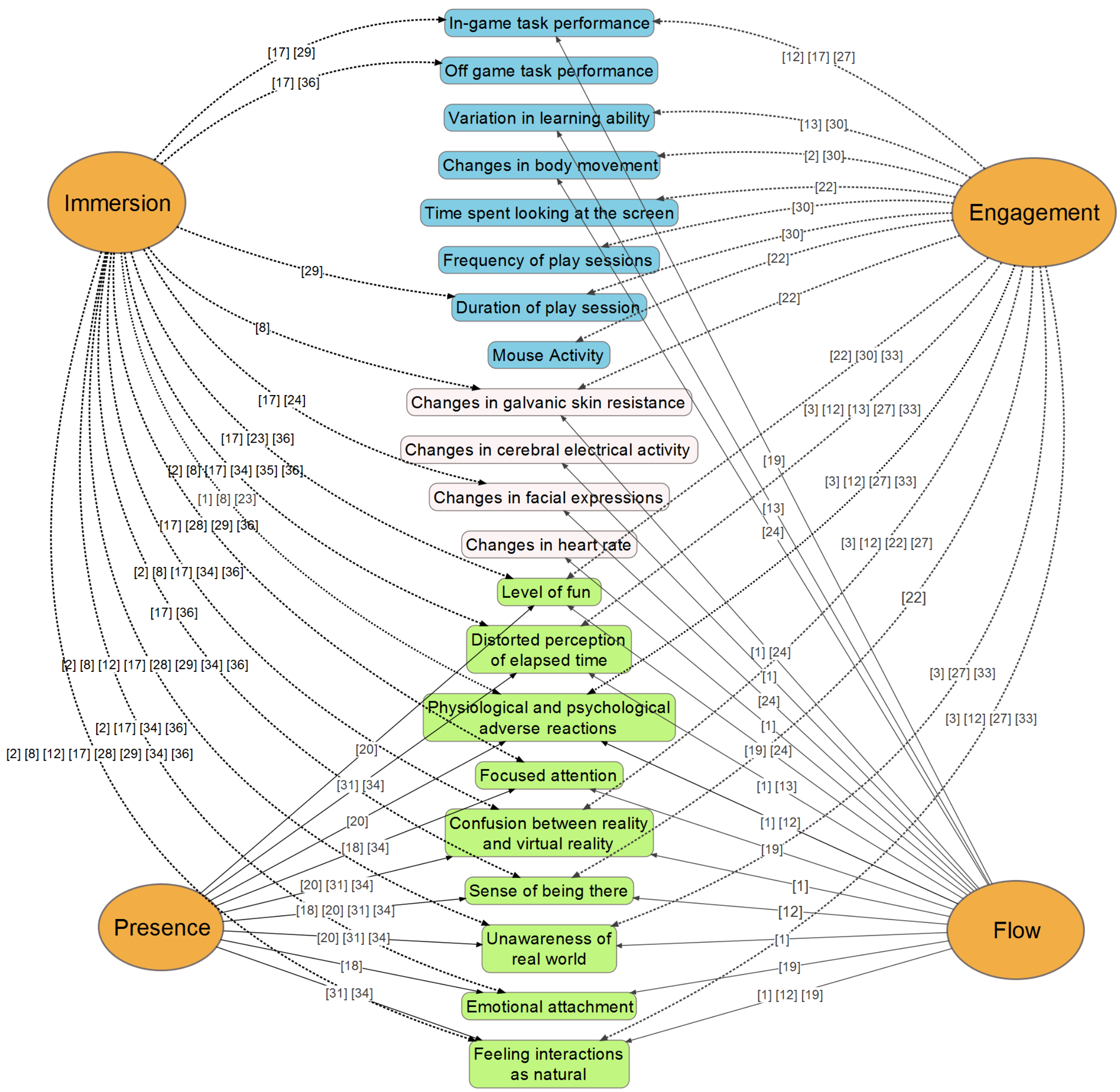

Figure 1: Concept-phenomena links made by study.

6 Conclusion

We presented a review on the concepts of immersion, engagement, flow and presence, aiming at their disambiguation. For such, we organized our review using the measurement methods for phenomena associated with those concepts. As a result, we showed that there is no clear definition on the relationship between concepts and phenomena due to the overlapping concept-phenomena associations.

We grouped measured phenomena into three groups: emotional (e. g., how a user feels towards a particular aspect), rational (e. g., performance in tasks) and biological (e. g., heart rate). This showed that presence and immersion are more commonly linked to emotional phenomena, while engagement is related to rational phenomena. Also, it showed that biological phenomena is frequently related to flow and immersion.

This work has shown that it can be more effective to focus future research on measurable phenomena than on the definition of concepts that are very abstract and can easily be confounded with each other. Also, it detected difficulties in developing adequate measurement methods, which are inevitable due to the nature of the concepts. As such, it presents a contribution to the game development community.

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