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Effects of industrial design properties of game controllers on player experience

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ABSTRACT

Researchers frequently state that game controllers, affect the Player Experience (PX). We also conducted this study to examine the effects of controllers on PX dimensions, including industrial design features that are missing in the field. In our study with 34 participants, we implemented four directionally mapped controllers using a PC game. We also used controller-specific experience questions in our study, using Player Experience Inventory (PXI) and Core Elements of the Gaming Experience (CEGE) models. In addition, we conducted a comparative analysis of all data using AttrakDiff2 to evaluate the designs of the products. Implications of the results regarding controllers' design features are discussed regarding PX. The participants' experience level and familiarity with the device were effective in evaluating their experience. A correlation was observed between the controller's enjoyment and the game's enjoyment. There is also a relationship between enjoyment and the hedonic qualities of the controllers. The features of the controllers, such as ease of use and challenge are related to PX dimensions.

1. Introduction

Like other productivity applications, video game systems contain software and hardware elements, and both can be designed according to principles and methods [59] Nevertheless, video games primarily focus on player enjoyment [67]and recreational and not functional interaction [55]. video games are successful because they can draw people in, eliminate their daily troubles, and immerse them in the game [37]. In addition, the design of the control devices and interaction styles are among the factors that affect the Player Experience (PX). Depending on how they fit into the game mechanics, different control input devices affect the PX differently [24,25]. The studies in which directionally mapped traditional gamepads are examined in the context of PX are generally considered together with other types of naturally mapped game controllers. Such studies are often evaluated within the framework of the superiority of natural mapping styles over each other in dimensions such as presence, immersion, and flow [47,51,64,66,73]. When it comes to the industrial design features of game controllers, it is seen that these studies make limited comments or do not include these features in their studies. However, we need more information on controllers' effects in providing or hindering the optimal PX [48].

User interfaces gain importance to establish the relationship between game layers. The relationship between the control/input devices and the user is starting to turn into a point that needs to be explored. Game controllers create a layer in the virtual game world and make sense within the framework of game mechanics. In addition, these controllers create a layer in the real world for the user in terms of their physical properties and an interaction interface with the game. Based on these facts this study aims to examine the effects of industrial design properties of game controllers on PX. Industrial design is "a *trans*-disciplinary profession that harnesses creativity to resolve problems and co-create solutions with the intent of making a product, system, service, experience or a business, better" [70]). According to definition made by Industrial Designers Society of America "a product's appearance, functionality, and manufacturability are generally the focus of industrial designers" IDSA [35]. In our study we focus to the physical appearance and functionality of the product. The relationship between the hedonic qualities (HQ) and pragmatic qualities (PQ) of the products and the concepts related to the PX will be examined using product-oriented experience and interaction research from the design perspective. Therefore in parallel with the aims stated above the research questions are defined as follows: (1) What impact do user characteristics have on game and controller experience dimensions?; (2) What impact do game controllers' HQ and PQ have on PX dimensions?

Besides the fact that the effect of the game controller on the PX is not entirely known, the impact of users' preferences on the interaction and,

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thus, on the experience are also unknown. Studies need to be carried out in this area to obtain the necessary information for designing by eliminating the unknowns. In PX, the experience arising from the interaction between the player and the physical peripherals, can be also considered in the context of product experience. For this reason, this study includes design features of game controllers and their effects on PX.

2. Experience

2.1. Product experience

Game controllers are essential to playing and as a product of design because of their physical design properties and the diversity in their use. The diversification of video game controllers in many ways also creates diversity in users, but we still need more information about which interaction styles the player populations prefer and why[47,48]. Further studies are also needed to learn more about user expectations, preferences [20,46] and characteristics in the context of the PX [52,66]. Although there are studies that show the relationship between gamepads' comfort and ease-of-use features and experience [44,59,75], our knowledge on which industrial design features are decisive in providing these features is quite limited.

There are several studies focusing on video games' physical peripherals −including game controllers-. It is possible to group these studies under the main title of user/player experience under three sub-titles: Product-oriented, user-oriented and design-oriented.

In product-oriented studies, it is usability measurement and evaluation studies that focus on the ergonomic capabilities of both the act of playing and the control device [4,12] and performance [74,8,19,40]. There are also studies which include prototype of a new game controller design [13,34,42].

On the other hand, user-oriented studies focus on cognitive characteristics related to users' preferences, performance, emotions, and intuitiveness about game controllers [49,65]. Many studies show that the players' demographic characteristics or previous gaming experience significantly affects the gaming experience [3,43,47]. Studies on immersion, presence and flow can also be evaluated under this title [47,51,66,76].

In design-oriented studies, concepts such as aesthetics, realism, similarity [38,42], metaphor, natural mapping [49,66] communication skills within the framework of representation are discussed.

As in Cockton's [14] means-ends theory-based model value-centered design, Hassenzahl [29,33] distinguishes between the product features intended by the designer and the way the product is perceived and experienced by the user. Hassenzahl [29,33] talks about the PQ (i.e., a subjective assessment of usability) and HQ (the ability to produce "pleasure" when used.) of products that cause certain emotions in people. Hassenzahl et al. prepared the AttrakDiff2 scale to measure these apparent product properties [77].

2.2. Player experience

A person's dialogue with all the elements of the video game world through their actions [31], p.8) creates the PX. The PX, which covers the gameplay and aftermath of the game, basically examines the qualities of the player-game interactions [56],Wiemeyer et al. [71]. Users actively create the gameplay experience by shaping their current experiences through their desires, expectations, and previous experiences [20].

Blomberg [7] states that there are two different approaches in the field of PX research. There is the "immersionist" approach, in which the game world is taken as the primary phenomenon, and the main aim is to immerse themselves in the game within the framework of the player's cognitive abilities [7]. Another perspective considers the experience of playing video games as a split process involving the real and virtual worlds together [7,41,68]. Thus, the playing experience has been detached from the player's cognitive abilities and expanded to include the physical appliances of the interrelationship between the game and the player [7].

From a similar perspective, Abeele et al. [1] state that there are two approaches to PX research. The first approach considers experience as a need satisfaction or a psychological state attainment. In the second approach, there is the assumption that the PX is the result of the player's actions through the decisions of the game designer. This distinction is made both in the game literature [17,18,62,63,67] and in UX research, which focuses on the relationship between product design features and UX studies [15,29,33].

3. Game controller design

The interaction between the player and a video game in terms of the PX is significantly influenced by the game input and output devices. Desurvire et al. [16] argued that the controller impacts the evaluation of the game through its consistency, learnability, and ease of use. The player must be engaged not just through a functional and useable product but also by addressing her/his emotions by creating a pleasurable experience through product [39].

Within the scope of the game industry, some studies show that game controllers impact the PX (See [5,25,48,50,54,72,57]. Early studies in the field of PX focused on performance and participants' preferences [8,38,40] along with studies examining the ergonomic properties [4,12] and usability [26] of controllers. Afterward, the researchers searched for a classification title to generalize the control devices with various features regarding their effects on experience. In this context, there are studies on the classification related to the level of body movement requirement [54] and the mapping style within the scope of natural interaction [53,61]. On the other hand, based on the natural mapping style, Skalski et al. [66] classified the game controllers under four titles: *directional, motion-based, incomplete-tangible, and realistic tangible.*

There are also studies investigating the effects of game controllers on the experience through the product's appearance characteristics of the interaction. For example, Johnson et al. [38] conducted a study showing the effects of the level of realism in the context of the game counterpart of the controller. Krekhov et al. [42], on the other hand, evaluated the level of realism through a formally transformable weapon controller. They revealed that this degree of realism contributes to the PX in appearance, originality, efficiency, experienced realism, and flow. Some studies also included aspects such as image schemas [36] and familiarity [6,21] that enable or facilitate intuitive use in the context of product features. They also discuss whether intuitive use affects how people perceive the aesthetics of such products.

Contrary to the prevailing view that a controller should be invisible in order not to affect immersion in the game, Nielsen et al. [57,72] worked on a more "visible" controller that would become a physical part of the game without breaking the immersion. As a result of their studies with customized game controllers, they saw that the feeling of immersion was positively affected.

Controllers can be seen as an important facilitators that can have a strong effect whether to be successful in the game or not, to be able to enjoy the game by performing complex perceptual-motor tasks [59]. It is essential that we can easily use our skills while using the controllers, that we do not make mistakes, and that we stay within the total game flow. Even when using the same type of controller, button position or size, and the access to the buttons depending on the grip style can affect our gaming performance and, therefore, our positive experience. Colors, shapes, or technologies of products may cause us to prefer them or give them different values. We have seen that current studies have focused heavily on the different effects of different types of mapped game controllers on the PX. Would the results of these studies remain similar if they were performed again with devices of different design features in the same mapping type? For this reason, our study, aims to find an answer to this question by comparing devices mapped of the same type but with different design features.

4. Research design

A total of 34 (11 Female, 23 Male) participants contributed in the experiment. Participants, based on the selection criteria to be over the age of 18 and have prior experience playing video games on game consoles, were recruited from the Sakarya University.

Directionally mapped game controllers were chosen as the device to study because of two main reasons: first, these devices are highly compatible with game types and game systems and are available in a wide variety of forms and features in the market; second, they are more widely used when compared to naturally mapped game controllers.

The game controllers used in the study were selected from the study with 11 designers, as explained in detail in previous study[2]. We use Sony Playstation DualSense (C1) Nintendo Joy-Cons (C2) 8BitDo SN30 Pro (C3) and Steam Controller (C4) in our study. From previous study the 8BitDo SN30 controller has been replaced with the Pro model considering the game and control scheme to match.

The experiment consisted of one-on-one sessions, and each participant was asked to play games using selected game controllers in random order. Playing sessions over the computer interface was preferred to keep the game variable constant. Sessions were held in a fixed chair arrangement in front of a 25″ screen positioned in accordance with the natural line of sight. We used the video game "DCL – The Game" [78] as the stimulus material. The game is designed to fly drones on five different routes in various places. The game was set to the "beginner difficulty level" and control schema. All subjects used the same drone, and no customization was permitted.

4.1. The experiment session

In the pre-play phase, we informed the participants about the process. We then asked questions about the participant's age, gender, education level, average playing time, level of experience, and previous experience with the products used in the study.

In the playing phase, the participant was given preliminary information about the game and get used to the game and the controller. After, we asked the participant to complete the route 3 times in a row. Participants played the game with selected controllers in paths both in a randomized order.

4.2. Data collection methods

Each participant was asked to fill out two different survey tools immediately after each controller gaming session. The first survey tool is short version of AttrakDiff2 questionnaire [30,33,29] which is a method developed in the UX literature to discuss the relationship between PX and product's PQ and HQ, specifically to evaluate the user's experience and feelings about interactive products and, thus, the overall attractiveness of a product.

The second survey tool is designed for evaluating the game as well as the gaming process including the controller. The first model we refer is the Core Elements of the Gaming Experience (CEGE) model [10,11]. CEGE is based on the premise that a video game is realized around two elements: the gameplay (e.g., rules, scenario) and the environment (the way the game is presented to the player). To explain the player's interaction with the video game, i.e., access to the game and how the game is played as a result of the player's actions, they use the concept of puppetry, which is influenced by three conditions: control, ownership, and facilitators [79]. CEGE model was preferred because it contains items that focus on the way the game is controlled. CEGE is considered to be helpful in obtaining initial immersion or engagement but does not include evaluative dimensions of higher immersion levels [9]. For this reason, the Player Experience Inventory (PXI) created by Abele et al. [1] has been selected as the second reference model for the design of the survey tool. PXI model constructs the PX over functional and psychosocial outcomes. PXI originally had 30 items, but there are also studies to create a shorter version of PXI [27,28]. The factors of the PXI were also cross-validated with the PENS[60] (competence, presence, autonomy, and intuitive interaction) and AttrakDiff [33,29,30] (pragmatic qualities, attractiveness, and beauty) scales and showed high overlap. The ODE was evaluated and validated in five studies (N = 529), proving its validity. In addition, since there is consistency between the sub-headings of ODE and Fokkinga, Desmet, and Hekkert's [23] product experience model, it is possible to make a comparative analysis with the product experience literature in the evaluation of the results of the product study.

Using the methods mentioned above, we created two separate surveys. First one is an 18-item *Gaming Experience Evaluation* (GEE) survey. The GEE questionnaire consists of a 10-item mini-version of the PXI questionnaire and questions related to Puppetry: Control, control/ownership, and facilitators sub-concepts in the CEGE model. GEE was filled at the end of the first and fourth playing session to allow comparison. Second one is a 14-item *Game Controller Evaluation* (GCE) survey. The GCE includes adapted versions of questions of the CEGE and PXI items that used in GEE to the game controller. GCE was filled at the end of every game session to evaluate the device on which the game is played at the end of the session. All questionnaires were evaluated on a 7-point Likert scale.

5. Findings

5.1. Demographic results

Statistical analyses were performed using SPSS 25.0. 29 of the participants are between the ages of 18–25. Gaming frequency varied from 0 to 1 h (26,5%), 2–4 h (29,4%), 5–7 h (20,6%), 8–13 h (8,8%), +14 h (14,7%) weekly. All participants have experience playing video games with a PC and mouse. 70,6% used PlayStation 4, 29,4% used the C4, 29,4% used at least one of the Xbox One, X, or S models, 14,6% used Nintendo Wii, 8,8% used Nintendo Switch consoles before the experiment. All of the participants never played the selected video game. 19 participants stated that they had experienced C1. 12 of them have yet to use any of these controllers before.

Participants were asked to rate their skills in using game controllers on a 7 point Likert Scale. The scale was adapted to a 7-point Likert scale consistent with Dreyfus and Dreyfus' (1986) 5 stages of skill acquisition (1-novice, 2-beginner, 3-advanced beginner, 4-competent, 5-proficient, 6- advanced, 7-expert). 9 participants defined themselves as less experienced (1–3 points), 13 as moderately experienced/competent (4 points), and 12 as highly experienced, with a score of 5 or more.

5.2. Experience surveys results

Internal consistency measures of reliability (Cronbach's α) for the GEE1 (0.832) and GEE4 (0.806) yielded high levels of internal consistencies. GCE1 used in C2 evaluation (0.834), GCE2 used in DualSense (0.824), GCE3 used in C3 (0.822), and GCE4 used in C4 (0.754) also indicate high internal consistency. Assumptions of normality were satisfied in all GEE and GCE scales [69]. One exception was for GEE1 *winning actions* item adapted from CEGE.

Means, standard deviations, the average ranking for each game and rating difference per construct, t score, significance (one-tailed), and effect size (Cohen's d) for each construct of PXI and CEGE are detailed in Table 1.

In paired sample *t*-test, we found significant difference (t (33) = -3,035, p = .019) between first game session A (M = 3.56, SD = 1.56) and fourth game session B (M = 4.50, SD = 1.69) for *Mastery*. Similarly, the difference was significant (t (33) = − 3.018, p = .010) for the construct of *Ease of Control*, between A (M = 4.47, SD = 1.33) and B (M = 5.21, SD = 1.34). The difference was also found significant (t (33) = − 2.421, p = .005) for the *Enjoyment* construct, between A (M = 4.88, SD = 1.59) and B (M = 5.47, SD = 0.93). Based on these data, the PX after

Table 1
Means, SD, t score, significance (one-tailed), and effect size (Cohen's d) for GEE for each construct from PXI and CEGE.

		1st Session (A)		4th session (B)		Paired Sample *t*-test (A-B)			
		Mean	SD	Mean	SD	*t*	df	*p*	*d*
	Meaning (MEA)	4.29	1.43	4.74	1.52	−1.590	33	0.019	.304
	Mastery (MAS)	3.56	1.56	4.50	1.69	−3.035	33	0.025	.577
	Immersion (IMM)	3.91	1.60	4.35	1.45	−1.713	33	0.002	.288
	Autonomy (AUT)	3.79	1.84	4.21	1.79	−1.421	33	0.000	.231
	Curiosity (CUR)	4.94	1.70	4.79	1.74	0.502	33	0.002	.087
	Ease of Control (EC)	4.47	1.33	5.21	1.34	−3.018	33	0.010	.554
	Challenge (CH)	4.94	1.39	5.06	1.61	−0.487	33	0.000	.079
	Progress Feedback (PF)	5.29	1.51	5.91	1.33	−2.627	33	0.001	.435
PXI	Audiovisual Appeal (AA)	5.06	1.39	5.32	1.30	−1.246	33	0.000	.193
	Goals and Rules (GR)	5.97	1.14	5.91	1.16	0.442	33	0.000	.052
	Enjoyment (ENJ)	4.88	1.59	5.47	0.93	−2.421	33	0.005	.452
CEGE	PC Actions K (AK)	4.38	1.91	5.53	1.35	−3.244	33	0.179	.695
	PC Screen (SC)	4.91	1.62	5.50	1.19	−2.539	33	0.000	.415
	PC Viewpoint (VP)	5.56	1.64	5.74	1.24	−0.521	33	0.673	.123
	PC Winning A (WA)	5.53	1.42	5.94	1.25	−1.748	33	0.004	.306
	PC/O Manipulation (MP)	3.82	1.90	4.82	1.66	−3.165	33	0.005	.560
	PF Appeal (AP)	4.85	1.50	5.12	1.47	−1.391	33	0.000	.181
	PF Type of Game (TG)	3.97	1.87	4.12	1.57	−0.842	33	0.000	.086

using four different devices is evaluated with higher scores than the experience after using one device. The only exception here is the assessment of curiosity; as expected, scores based on playing the game less indicate that the participants are more "felt eager to discover how the game continued.".

In the context of *Enjoyment* from the game, with one-sample *t*-test we found significant differences. Game enjoyment after using C4 (t (33) = 28,601, p = .000, M = 5.55, SD = 1.13) controller was rated with the highest score. The C1 (t (33) = 30.669, p = .000, M = 5.52, SD = 1.05) is also rated very close to C4. C3 (t (33) = 16.123, p = .000, M = 4.61, SD = 1.66) was evaluated in the third place and closely the C2 (t (33) = 13,947, p = .000, M = 4.42, SD = 1.84), in the last.

We also saw significant differences when we compared the *Enjoyment* of the controllers used in the game sessions. *Controller Enjoyment* from C1 (t (33) = 34.189, p = .000, M = 5.94, SD = 1.01) was rated with the highest score, followed by C4 (t (33) = 21.037, p = .000, M = 5.29, SD = 1.46) and C2 (t (33) = 10.240, p = .000, M = 3.61, SD = 2.05). The lowest score was C3 (t (33) = 10,689, p = .000, M = 3.55, SD = 1.94).

When the scores of the participants according to their level of experience are examined, those who define themselves as inexperienced (1–3 points, N = 9) and moderately experienced (4 points N = 13) participants tend to give higher scores in GEE4 than the experienced (5–7 points, N = 12). We found that inexperienced (M = 5.56, SD = 1.13), moderately experienced (M = 5.38, SD = 0.87), and experienced (M = 5.50, SD = 0.90) participants reported similar levels of enjoyment. In terms of devices, we saw that the inexperienced participants experienced *Enjoyment* of the game (M = 5.89, SD = 1.05) and controller (M = 5.78, SD = 1.20) with the highest score in the use of the C4. Experienced participants evaluated game *Enjoyment* (M = 5.83, SD = 0.39) and controller *Enjoyment* (M = 6.08, SD = 1.00) through the highest score over C1 usage. According to the one-way ANOVA analysis performed in the evaluation of GEE4 data, no significant difference was observed according to the age, gender, education level and weekly playing time.

Correlation relationships between the GEE4 data and the mean values of all the GCE questionnaires were examined in Table 2. As a result, it was seen that the *Meaning*, *Ease of Control*, and *Enjoyment* items related to the game experience correlated with many controller experience questions. *Meaning* and *Control* (r = .586, p < .01), *Reaction* (r = .642, p < .01), and *Distraction* (r = -.529, p < .05) items have a large effect correlation relationship [80]. Also with *Enjoyment*, *Control* (r = .575, p < .01), *Ease of Control* (r = .527, p < .01), and *Challenge* (r = .582, p < .01) show a large effect correlation. *Autonomy* and *Control* items also show large effect correlations (r = .528, p < .01).

5.3. Results of AttrakDiff2

The AttrakDiff2 online platform (https://www.attrakdiff.de/) has been used to analyze the participant's answers. According to the Fig. 1 the C2 is a "neutral" object with a "self-oriented" tendency. C1 values as "desired" object. This controller's HQ and PQ are relatively higher than others. C4 values as "self-oriented" and represent similar HQ levels with C1. Moreover, C1 and C3 controllers had a smaller confidence interval for PQ and HQ than others, indicating a greater level of certainty for the users. All the PQ values are higher than HQ except the C4. C3 values as "too task-oriented" with lower values for HQ (−1.30).

Analysis of word pairs results is shown in Fig. 2 Word pairs are in the vertical axis listed according to PQ, HQ, and ATT. The zone between 0–1 is accepted as the neutral zone where the product achieves its purpose without any adverse effect.

According to the description of word pairs in Fig. 2, the PQ of the C2 had neutral results, which indicates this product tends to have poor PQ. The data on the HQ dimension mostly tend to be positive but "dull-captivating," indicating that the perception of the product is close to "dull." In ATT dimensions, "ugly-attractive" valued as 0 means users are not attracted nor disgusted by the product. Accordingly, it tends to be valued as "good" rather than "bad." For the C1, all the values are represented positively, indicating that participants felt highly willing to play video games with it. C1 was seen as the most attractive controller among others. For the C3, the values have been highly heterogeneous. The product is represented in PQ dimensions as the most "simple," "predictable," and "clearly structured" but seen as almost "impractical." HQ and ATT values are all negative. For the C4, PQ values are close to 0, but HQ and ATT values are positive (zones 1 to 2). C4 is seen as the most creative controller due to the touchpad design as an alternative to the joystick.

In Table 3, we can see that participants who have experienced C1 tend to score higher on all HQ (stylish, creative, and captivating). They also define C1 as premium, clearly structured, and attractive. Participants who have not experienced C1 describe it as more simple, practical, and predictable. Evaluation differences are marked more decisively in predictability and creativeness.

When the participants' scores according to their experience level about controller usage are examined, those who define themselves as inexperienced (1–3 points, N = 9) tend to describe all controllers as more simple and practical than others. The experienced participants (4–7 points, N = 25) gave more dramatic ratings than the inexperienced ones when evaluating the device they liked less.

Table 2
Table of correlation of GEE4 and mean values of GCE1,2,3 and 4.

		GCE Controller Enjoyment	Mastery	Control	Reaction	Action Recall	Distraction***	Restriction***	Curiosity	Ease of Control	Challenge	Feedback	Appeal	Clarity
	Meaning	,434*	,450**	,586**	,642**	0,250	−,529**	−0,306	,388*	,443**	,362*	,361*	0,231	,370*
	Mastery	,392*	,434*	,449**	0,326	0,158	−0,222	−0,315	0,301	0,278	0,287	0,324	0,189	−0,047
	Immersion	0,271	0,206	,346*	0,226	0,122	0,038	0,119	0,148	0,082	0,059	0,121	0,222	0,131
	Autonomy	0,251	0,295	,528**	0,310	−0,074	−0,212	−0,058	,392*	0,214	0,321	0,291	0,194	0,136
	Curiosity	0,137	0,144	,397*	0,214	0,086	−0,067	−0,111	0,338	0,149	0,132	,358*	−0,003	,354*
	Ease of Control	,386*	0,307	0,296	0,254	0,242	−,481**	−0,297	,386*	,549**	,483**	0,191	,392*	0,225
	Challenge	0,111	0,106	0,159	0,104	−0,012	−0,330	−0,145	0,095	0,064	,510**	0,156	,430*	0,121
	Progress Feedback	0,169	−0,068	0,022	0,085	,385*	−0,248	−0,164	0,039	0,188	0,179	0,027	0,287	0,084
PXI	Audiovisual Appeal	0,193	0,243	0,314	,529**	0,206	−0,233	−0,308	0,337	0,190	0,195	0,211	0,183	,358*
	Goals and Rules	0,068	0,064	−0,074	0,061	,464**	−0,040	−0,002	0,126	0,142	0,102	−0,006	0,092	0,168
	Enjoyment	,444**	,358*	,575**	,459**	0,110	−,457**	−,438**	,461**	,527**	,582**	0,306	,340*	,434*
CEGE	Actions K	0,197	0,132	0,233	0,119	0,314	0,045	−0,055	0,189	0,206	0,290	0,129	0,261	0,268
	Screen	−0,072	−0,097	0,003	0,043	0,322	−0,078	−0,056	−0,020	0,012	0,027	0,084	0,000	0,174
	Viewpoint	0,054	0,088	−0,197	−0,219	−0,026	−,357*	0,107	0,105	0,149	0,237	0,030	−0,047	0,000
	Winning A	0,005	0,076	0,059	0,124	,395*	−0,225	−0,260	−0,072	0,043	0,287	0,023	0,297	−0,088
	Manipulation	0,198	0,216	0,178	0,034	0,164	0,103	−0,197	0,110	0,071	0,071	0,101	,345*	−0,073
	Appeal	0,112	0,159	0,236	,396*	0,086	−0,182	−0,165	0,231	0,193	0,220	0,173	0,203	0,190
	Type of Game	0,129	0,131	0,107	0,241	0,025	−0,294	−0,276	0,095	0,190	0,324	0,049	0,048	0,049

*Correlation is significant at the 0.05 level (1-tailed).
**Correlation is significant at the 0.01 level (1-tailed).
***Negative items.

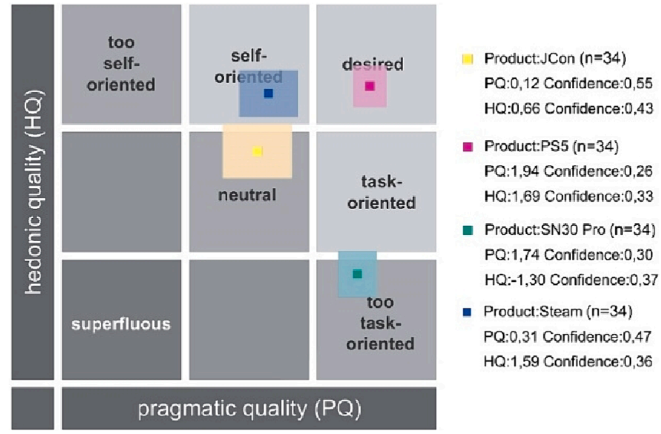

Fig. 1. Mean values of confidence dimensions and rectangles of portfolio-representation of PS5 DualSense (C1), Nintendo Joy-Con (C2), 8BitDo SN30 Pro (C3), Steam controllers (C4).

5.4. Other results

Participants gave verbal feedback about the products during the study. They ranked products based on *ergonomics* (or *comfort*), *button sensitivity*, *button layout*, *ease of use*, *familiarity*, *feedback*, *material quality*, or *general design features*. Of the 32 participants who ranked, 18 placed the C1 in first place. The C1 rankers stated that they do this ranking mainly based on *ergonomics* ($N = 13$) and *button sensitivity* (*feedback*) ($N = 6$). Participants reported that *familiarity* was essential in their choices, especially for the C1. They generally rated the C2, placed last by 12 people, as *uncomfortable*. Overall, all participants rated C2′s button layout as asymmetrical as opposed to familiarity. In addition, C2 was rated negatively regarding sensitivity and feedback due to the button size and especially the shortness of the joysticks. The C3 was evaluated as negative by 18 people because it does not fit comfortably in the palm due to the absence of handle parts. The C3 was generally rated positively regarding button sensitivity and feedback. The touch mouse-like joystick on the C4 was considered innovative. Regarding weight, C1 and C4 controllers were described as suitable and balanced, while the lightness of the C3 was seen as a disadvantage.

6. Discussion

The aim of this study was to reveal the effects of user characteristics and design elements of game controllers on interaction and PX. We contribute with an instrument that builds mainly on PXI [1] and CEGE [11] and enables researchers and game designers to investigate PX with a focus on product design features. We also crosscheck the player and product experience data with AttrakDiff2 and revealed the relationship between product features and experience.

Studies focused on controllers are generally compare different types of naturally mapped controllers [38,45,47,49,65]. It is also challenging to compare the design features of controllers from different mapping levels and relate them to the experience due to the difficulty of finding a common denominator of comparison.

Studies examining the same level of mapped controllers with a focus on ergonomics [4] and performance [74] often ignore the HQ of products and do not include user studies in the context of PX. Bhardwaj [4] stated that the design weaknesses of the controllers caused problems for the users in his study of four controllers covering 25 years. Young et al. [74] focused primarily on performance in their study involving two naturally mapped controllers of the same type. However, after the game session with the controllers, they asked open-ended questions to the participants to measure their experience. The experience has been examined within the titles such as movement, aiming, button

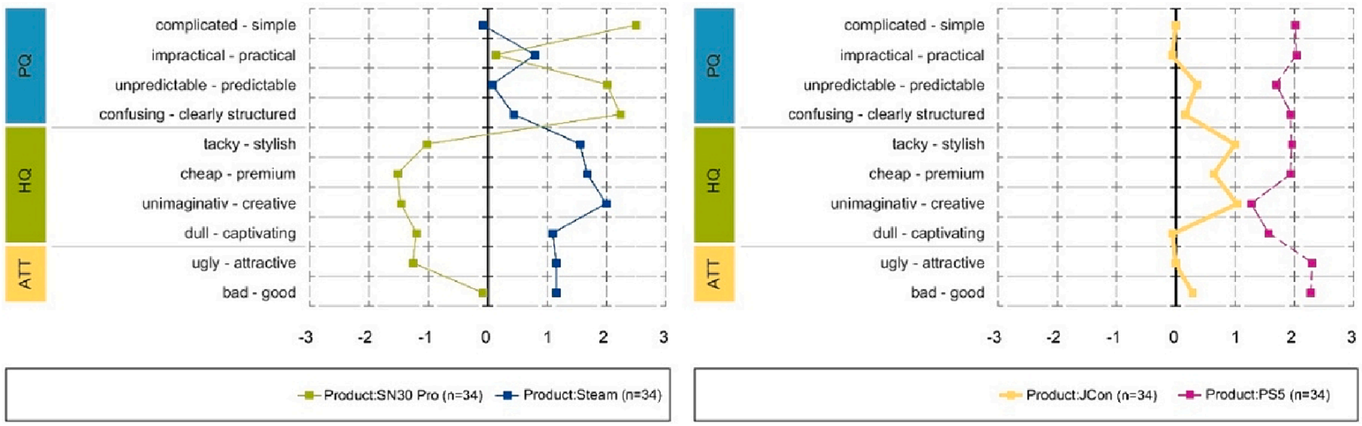

Fig. 2. AttrakDiff – Description of word pairs.

Table 3
Attrakdiff2 comparison of participants who had and had not experienced the C1 before the study.

Participant who experienced C1 Before						Participant who did not experience C1 Before					
	N	Min.	Max.	M	SD	N	Min.	Max.	M	SD	
Simple	19	1	4	2,11	0,99	15	1	4	1,87	0,92	Complicated
Ugly	19	6	7	6,53	0,51	15	3	7	6,00	1,20	Attractive
Practical	19	1	7	2,00	1,70	15	1	6	1,93	1,39	Impractical
Stylish	19	1	7	2,00	1,67	15	1	6	2,13	1,55	Tacky
Predictable	19	1	6	2,79	1,62	15	1	3	1,60	0,63	Unpredictable
Cheap	19	4	7	6,16	0,96	15	3	7	5,60	1,30	Premium
Unimaginative	19	3	7	5,79	0,98	15	2	7	4,53	1,73	Creative
Good	19	1	2	1,58	0,51	15	1	6	1,93	1,39	Bad
Confusing	19	4	7	6,00	0,82	15	3	7	5,80	1,32	Clearly Structured
Dull	19	4	7	5,79	0,98	15	3	7	5,20	1,08	Captivating

arrangement, and ergonomic form and does not include the concepts within the PX literature.

In this context, our work fills a gap in the literature by combining video game studies and industrial design with its structure that includes both PX and design features. Additionally, the presence of a fully featured retro controller and controllers of the latest game consoles in our study also contributes to the literature in order to make a design comparison in wide range.

Our results confirm a link between user characteristics, game controllers' HQ and PQ, and PX dimensions. We analyzed data according to user characteristics in response to the first research question. We saw that the age, gender, education level, and weekly playing time of the participants did not make any significant difference in evaluating the PX. On the other hand, the comparisons made regarding experience levels and experience of the devices used in the study showed differences. In particular, inexperienced participants tended to describe controllers as simple and practical since they did not have enough knowledge of the capabilities of game controllers. This was described similarly by participants who did not experience C1 and at various controller experience levels, based on *Simple, Practical,* And *Predictable* items. Israel et al. [36] reports that familiarity is insufficient to classify a product as aesthetically appealing directly, but they also say familiarity encourages a more positive evaluation. Participants who have used the C1 before ($N = 19$) evaluated this device more positively on *Stylish, Creative, Captivating, Premium, Clearly Structured*, and *Attractive* items than participants who did not experience the device. According to our results, familiarity impacts the evaluation.

Video games focus primarily on player enjoyment. Within the framework of the CEGE model's approach to understanding the game experience, we have determined differences in the level of *Enjoyment* for each game controller. In parallel with this fact, there are differences in the level of *Controller Enjoyment* for each game controller. We have seen that the controllers whose *Controller Enjoyment* was evaluated with a high score also have high scores in the *Enjoyment* evaluations of the game. This situation affects the *Enjoyment* we get from the game controllers and the perception of the game. The *Enjoyment* data are also similar to the devices' HQ and PQ evaluations. Both the game and controller *Enjoyment* values of C1 and C4 controller, which are evaluated with high scores in terms of HQ, are high. We can also see that the C2, defined as "*Neutral,*" and the C3, defined as "*Too task-oriented,*" - whose HQ evaluations are lower than the other two devices, have lower game and controller *Enjoyment* associations.

When the GEE4 results are examined, there is a difference in experience evaluation after using a single game controller and using four different game controllers. Different devices affect the perception and interpretation of the game, and the playing time increases the evaluation scores. The correlations of the GEE4 items belonging to the PXI and CEGE, we saw that the game's meaning and feeling capable while playing are directly related to *Enjoyment.* Feeling capable is also about knowing what needs to be done to win the game. Knowing what needs to be done to win is directly related to the *Ease of Control* of the game. Being clear about the goals of the game is related to mastering the actions that can be done in the game. The feeling of mastering the control of the game is related to *Immersion, Autonomy*, and *Curiosity*. In addition, it is essential for *Immersion* that the controller reacts within the user's expectations.

Looking at the relationship between GEE4 and the mean values of GCE1,2,3 and 4, we can see that meaning of the game is related to having control of the game, a device that gives the expected responses and reactions, and not being distracted by the device. *Autonomy* and *Enjoyment* are also directly related to having control of the game. *Ease of Control* is directly related to the ease of using the controller, and *Challenge* is directly related to the difficulty level of using the device. *Enjoyment* is also related to the ease of using the controller and the difficulty level of using the controller.

Attrakdiff2 has been involved in various studies on evaluating the game [1] and the controllers [26,34]. However, no reviews exist on the relationship between AttrakDiff2 evaluations of controllers and PX dimensions. We analyzed the GCE4 data evaluated after the last game session by dividing them according to finishing with different devices compared it with AttrakDiff2 mini data. Accordingly, the *Clearly Structured* values of the devices are inversely proportional to the *Restriction* values. While the C3 device is evaluated as the most *Clearly Structured,* it is the device that restricts the user the least. The *Curiosity* value of the C4, defined as the least *Predictable* was evaluated higher than the other devices. The C4, rated as the most *Creative* was also rated higher in *Appeal* than the others. In the remaining items' mean values, the C1 has the highest values compared to other devices. C1′s condition is consistent with the fact that this device is defined as *Desired* in the Portfolio Representation and has the highest values in the Diagram of Values. By comparing the two survey questions, we can get an idea about which experience dimension the HQ or PQ of the products are related to.

In addition to the AttrakDiff2 data, in which the HQ and PQ of the devices are evaluated when the verbal feedbacks given by the participants are examined, we see that ergonomics is the main criterion in the evaluation. Controllers defined as *Neutral* or *Too-task oriented* are classified as non-ergonomic. The positive evaluation of these devices in button sensitivity and feedback considered an important criterion, does not contribute to their positive evaluation in general. Participants tended to discuss familiarity with ergonomics and button layout. We can see that this results in positive evaluations, especially for C1, the most experienced device.

Gerling et al. [25] reported that the participants had a similar level of positive experience due to playing the same game with different platforms and control interfaces but felt more challenged (on the platform they were unfamiliar with). Similarly, in our study positive evaluations were made for the C4, which has a low familiarity level and is seen as the most innovative device. The HQ and attractiveness values of the C4, defined as *Too-self oriented*, were high. Also participants gave the highest evaluation score for *Game Enjoyment* in the session they used C4.

Experience is the personal process we go through when interacting with products or systems. As a result of the experience, it is possible to make various judgments about the game system and product, which are likely to affect future use. For this reason, obtaining a positive experience as a result of interaction with systems and products is one of the factors that indicate the success of the product design process.

Designers have essential tasks when it comes to the design of game controllers, which constitute an important part of game control. It has been revealed that the compatibility of the game design with the controller and the physical, visual, and feedback-related features impact the experience, as well as taking into account the physical and mental limitations of the human in using the controller. Game designers often consider game controllers in the context of game mechanics, and the extent of the user's relationship with the product remains quite limited. In the context of game controllers, the issue goes beyond constructing primary and secondary control groups by associating the button size and distance with the time to reach the target, as indicated by Fitts [22]. Here, industrial designers are expected to blend the goals and values they will reach by researching user needs and expectations with human capacity. Managing a design process by giving importance to the visual, tactile, and semantic equivalents of the design together with the hardware features should be prioritized since the features related to form, material, texture, and feedback that give pleasure to the user affect the enjoyment of the game.

Familiarity is considered an essential consideration because, as Hassenzahl [32] points out, the apparent product character is influenced by product features, personal standards and expectations, and the individual's experience with the product over time. However, technological innovations are appreciated, as in the C4 example; familiarity with the key layout, which provides ease of use, dominates the evaluation. After the prioritization of ease of use, vibration feedback, adaptive triggers, or, as in the case of C1, modular use is influential in the evaluation. Especially in the case of the C2 controller, Hideaki Nishino, one of the PlayStation platform bosses, says this was deliberately used in the design process [58]. Nishino [58], while talking about the importance of having innovative details, points out that during the design process of the C2, players tended to keep the familiarity element constant by keeping most of the details they liked in previous controllers. With the design style of the Super Nintendo controller and the button layout of the Nintendo Wii Classic controller, the C3 receives positive reviews for ease of use, again based on familiarity. The retro look of the C3 controller deserves a separate parenthesis. People who have used Super Nintendo or similar devices in their childhood or youth tend to rate the design more positively.

In contrast, people who have not used a similar device tend to rate the design as old and negative. The lack of prior experience with a retro device such as the C3 causes the device to be evaluated highly in terms of PQ, while it is evaluated largely negatively regarding HQ and ATT. This coincides with the structure of the user experience field that covers user emotions and values beyond functionality and usability. As stated by Hassenzahl [32], people may prefer to interact with technology that is inadequate in terms of performance because alternative sources of attraction beyond usability may attract them. On the contrary, a device with satisfactory features in terms of usage needs may not be attractive to the user if its other features do not appeal.

For the future studies, increasing the number of participants would be beneficial to provide more meaningful data with separate devices. Keeping the playing platform and the game constant has helped make device comparisons; however, comparing four different devices needs to be clarified to discuss the effects of the data obtained on each other. On the other hand, using controllers on PC also does not allow for thoroughly evaluating haptic and auditory feedback features and control with the gyroscope. In future studies, examining a smaller number of devices within the framework of different types of games will diversify the reviews in the context of user and device design features. Expanding the range of participants in future studies will also allow us to examine the relationship between experience characteristics in more detail.

As future work, we point out three essential topics. First of all, the design features of game controllers should be examined more comprehensively. In this study, the HQ and PQ, considered in the short version of AttrakDiff2, should also be examined with various constructs, and their relationship with the PX should be examined. In addition, we aim to carry out the work also with other naturally mapped interfaces. These mapping styles will also be effective in design feature classification. Finally, we find it essential to transform the design and experience data obtained into a data set designers can use during the new product design process.

7. Conclusion

In this study, which we carried out to contribute to exploring the PX field, we examined the directionally mapped game controllers, design, and experience relationship. Based on the findings of the study we conducted to answer our research questions, it can be said that user characteristics and HQ and PQ of game controllers have an effect on PX dimensions. The positive correlation between game- and controller-related indicators of the PX demonstrates the potential of the proposed method to offer a more holistic evaluation perspective on all aspects of the gaming experience.

While PXI items provide information about the PX in a general context, they explain them within the framework of the game. It needs to be more comprehensive to explain the effects of controllers on PX. With the CEGE model, which considers the PX as a video game and puppetry, the effects of how the game is controlled on the experience can be discussed. In our study, we can see a correlation between both models and experience dimensions can be discussed over each other. In addition, we used the Attrakdiff2 method to represent the PX from the product experience perspective. With Attrakdiff2 mini, the HQ and PQ of the products are evaluated in the context of their design features, also allowed us to examine the relationship between device features and experience dimensions from a different perspective. In particular, it confirmed the relationship between the models and the verbal feedback given by the participants throughout the study. As stated before by many researchers [24,25], different control input devices affect the PX differently. Although the “different” here is usually perceived as a natural mapping style, our study shows that the same type of controllers can affect the gaming experience differently due to different design features. As a result, we create an experience of the game as a result of our dialogue with the non-game elements of the video game [31], p.8), including the controller.

CRediT authorship contribution statement

Serefraz Akyaman: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Ekrem Cem Alppay:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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