Chapter 12
Beyond the Gamepad: HCI and Game Controller Design and Evaluation

Michael Brown, Aidan Kehoe, Jurek Kirakowski, and Ian Pitt

Abstract In recent years, there has been an increasing amount of computer game-focused HCI research, but the impact of controller-related issues on user experience remains relatively unexplored. In this chapter, we highlight the limitations of current practices with respect to designing support for both standard and innovative controllers in games. We proceed to explore the use of McNamara and Kirakowski's (2006) theoretical framework of interaction in order to better design and evaluate controller usage in games. Finally, we will present the findings of a case study applying this model to the evaluation and comparison of three different game control techniques: gamepad, keyboard, and force feedback steering wheel. This study highlights not only the need for greater understanding of user experience with game controllers, but also the need for parallel research of both functionality and usability in order to understand the interaction as a whole.

12.1 Introduction

Over its brief history, human–computer interaction (HCI) has developed a multitude of techniques for measuring and evaluating user experience with technology (Kirakowski and Corbet 1993, Nielsen 1993, Rubin 1994, ISO 1998a, Brown 2008). Many of the design considerations and usability issues that arise in game software are significantly different from those encountered in other software genres. For example, a game that allows a player to complete quests quickly and easily might score highly with respect to ISO 9241-11 (1998b) software efficiency and effectiveness measures, but it would probably rate very low with respect to user satisfaction because of the lack of challenge. As a result, in recent years we have seen the emergence of HCI research focused on computer games, addressing the unique

M. Brown (✉)
People and Technology Research Group, Department of Applied Psychology, University College Cork, Cork, Ireland
e-mail: mab@campus.ie

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challenges that this area presents (Desurvivre et al. 2004, Federoff 2002, Jørgensen 2004, Kavakli and Thone 2002).

The visual and audio presentation capabilities of gaming platforms have increased dramatically over the last 20 years, and much of the associated research has focused on these aspects of games. However, the game controller, and how that controller is supported in the game, can have a significant impact on the player's gaming experience. Mastery of the control system is an important part of most games (Johnson and Wiles 2003). In order to have an enjoyable game play experience, it is important that players feel a sense of control over the game interface and the associated game controls.

In this chapter, we describe how McNamara and Kirakowski's (2006) theoretical framework for understanding interactions with technology can be applied to the evaluation of controllers in games. Using this model as a guide, a user study was performed to explore the use of a range of game controllers in terms of functionality, usability, and user experience. The framework is described in Section 12.3, below. The results of this study are presented and discussed in Section 12.4.

12.2 The Evolution of Game Controllers

As far back as the 1950s, general purpose computing platforms have been used for the development and playing of computer games. The pre-existing input and output capabilities of the computing platforms were leveraged for game play purposes. For example, in 1961, the initial implementations of the "Spacewar!" game, running on the DEC PDP-1, used the test-word toggle switches for player input (Graetz 1981).

However, even in those early game environments the opportunities for specialized game controllers were recognized. The location of the toggle switches on the DEC PDP-1 (c. 1960), relative to the visual display, gave one of the players the advantage of being able to see the display more easily. To overcome this problem, a dedicated control box incorporating these switches was constructed. In addition to implementing the required switch functionality, the control box configuration also utilized more natural and intuitive mappings for the controls, e.g., the rotation switch was configured so that moving the switch to the right resulted in the craft being rotated to the right; a lever-style control could be moved to accelerate the craft. Graetz, one of the "Spacewar!" developers, stated that the new control mechanism "improved ones playing skills considerably, making the game even more fun" (Graetz 1981).

Over the past decades, the improvements in processor speeds and storage have been matched by developments in the field of input and output devices. During this time, the evolution of game software and game controllers has been inextricably linked. Games have influenced the design of game controllers, and game controllers have influenced the design of games (Cummings 2007). Many games, especially those played on general purpose computing platforms, have been designed to use the pre-existing control methods for the platform. However, the development of new generations of dedicated gaming platforms, and sometimes specific games, has often incorporated innovation in the area of game controllers.

12.2.1 Standard Game Controllers

The majority of games have been designed to operate with standardized (or de facto standardized) platform-specific controllers, e.g., each game console has an associated standardized first-party controller. Today, most games running on consoles support the standard console controller; most games running on personal computers support input via the keyboard and mouse; mobile phone games are played using the standard phone controls; and the recent proliferation of devices incorporating a touch screen have also supported that interaction method in games. Thus, the majority of games are designed to incorporate support for existing control methods.

Much of the innovation in the area of game controllers has been associated with dedicated gaming platforms. There are a number of popular-press books that document the development of the console games industry and technology (Sheff 1993, Kent 2001, Forster 2005). Throughout this almost 40-year development of game consoles, newer generations of consoles were typically accompanied by some degree of development and innovation in the associated game controller. In many cases, the level of controller innovation for a new console was relatively minor, and in some cases there was significant change and innovation, e.g., Nintendo Wii Remote, Nintendo Entertainment, and System gamepad.

Controllers for dedicated gaming platforms have traditionally been very tightly integrated with the console system electronics, supporting firmware/software and games. Through the 1970s and early 1980s, players used a variety of controls (switches, dials, and sliders) that were an integral part of the console itself, e.g., Magnavox Odyssey 100–500 series, and Coleco Telstar series. From the early 1980s onward, it became increasingly common for the controllers to be distinct separate physical entities (usually gamepads or joysticks) that were connected to the game console through a cable, or in more recent systems, a wireless link.

Each of today's game consoles has a "standard" controller that was designed with the capabilities of its console in mind and is tightly coupled to that system. A "standard" controller, with support implemented in games in a uniform manner, can help ensure a consistent interface for the user while playing games on that platform. Most games take a conservative approach and adhere to the recommended controller guidelines for their target platforms. The widespread use of standard controllers, together with the use of common control mechanisms within many game genres, results in controls being one of the most difficult areas in which to innovate within a game (Rabin 2005).

12.2.2 Focus on Innovative Game Controllers

While uniformity of game controller support can be beneficial, it can also be very limiting for both the game designer and the player (Rabin 2005). Even in the early years of game console systems, when the console and game controls were part of the same mechanical enclosure, there were attempts to make controllers that were targeted toward a particular game or genre of game, e.g., Atari Stunt Cycle (Atari Inc. 1977) and steering wheel controller. These types of developments mirror what was also happening in the arcade machine arena, i.e., the use of dedicated controllers for flying games, racing games, etc.

In recent years, an increasing number of games have added support for new and innovative controllers in their games. Incorporating support for innovative controllers in games offers opportunities for a game to distinguish itself in the market place (Kane 2005, Marshall et al. 2006). Custom controllers, designed to operate with specific games, offer possibilities to enhance the user experience in games by enabling interaction styles that are not possible using standard controllers, as described above.

While designing and implementing a custom controller offers opportunities to greatly enhance a game, it also introduces significant additional work, more project schedule risk, and probably an increased retail price for the game-plus-controller bundle. However, apart from platform-specific checklists, the advice available to guide designers and developers considering new or innovative controllers is very limited. Support for innovative controllers must be carefully planned and designed, and their performance evaluated. Problems associated with developing and implementing support for custom controllers have been listed in the postmortem reports which are published on a monthly basis in Game Developer magazine (Game Developer Magazine 2008). For example, Guitar Hero in February 2006 edition, Metal Gear Solid in May 2006 edition, and Tony Hawk in January 2007 edition.

12.3 Evaluating Game Controllers: Experience, Usability, and Functionality

As with all technology, the interaction between humans and game controllers is multifaceted and complex. This section describes McNamara and Kirakowski's (2006) theoretical framework for understanding interactions with technology and discusses the implications of applying this model to game controllers.

12.3.1 Introduction to the Components of Human–Computer Interaction

Recent developments in HCI have highlighted the importance of focusing on user experience in the design of technology. This need for high-quality user experience is especially important for computer games, as their primary function is to entertain. This revelation has led to some theoretical difficulties, as the concept of user experience does not easily fit into the traditional HCI fields of usability and ergonomics. In order to fully understand interactions with technology, we must understand the various components of the interactions and how these components impact on each other.

McNamara and Kirakowski (2006) propose a three-factor model for understanding the interactions between humans and technology, represented in Fig. 12.1.

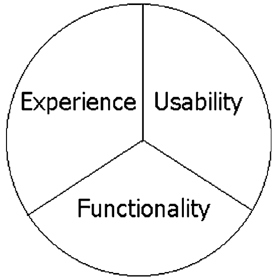

Fig. 12.1 Components of technology usage from McNamara and Kirakowski (2006)

This theoretical framework presents three separate but codependent components of human–computer interaction. "Functionality" describes the technology side of the interaction, focusing on the technological possibilities of the interaction. Conversely, "experience" describes the purely human side of the interaction. This factor looks at how the interaction impacts on the person involved by asking questions such as "Do they enjoy the interaction?" and "Does it make them happy?". Finally, "usability" looks at the dynamics of the interaction itself, is it efficient, effective, and satisfying? They propose that in order to fully understand an interaction we must study each of these three components.

12.3.2 Functionality and Game Controllers

This aspect describes the purely technology-based part of the interaction. Key questions in this area are "Does it work?" and "What does it do?" This is the one aspect of the interaction that is relatively independent of both environment and user.

Looking at game controllers, it becomes clear that the primary function is to facilitate user interaction with computer game software. Traditionally, controllers only supported a one-way interaction from the user to the game, with audio visual devices providing feedback from the game to the user. However, the recent development of in-controller feedback means that the interaction with game controllers is now bidirectional. For example, haptic gamepads, steering wheels, and speakers integrated in the WiiMote. These developments mean that when considering game controller functionality, we must consider the range of input and feedback that a given control method can provide.

In some cases, controllers may not have the required number of controls to allow the player to invoke all the game commands. For example, flight simulator games typically support a larger number of game commands (often more than 30) than there are physical controls on a low-end joystick. In this case, the player must select a subset of the game commands to be assigned to their joystick controls, and the remaining commands can be invoked via the keyboard (or perhaps not used at all by the player).

Another important issue of game controller functionality is the level of support for the controller in a given game. A controller with a wide range of possible inputs and outputs is of little benefit if game software does not support it. Assessing controller functionality in isolation from software is fairly straightforward, as the range and sensitivity of various inputs and outputs can be easily tested. However, relating this to in-game functionality is a more complex issue, as the range and sensitivity of a controller may not be supported or necessary for a given game.

12.3.3 Usability and Game Controllers

A classic description of usability is "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" (ISO 1998a). This definition highlights four core concepts central to interaction: effectiveness, efficiency, satisfaction, and context of use. Each of these concepts is important when discussing game controller design.

Effectiveness describes the ability of the user to complete specific tasks with the technology. This goes further than basic functionality, as not only must the technology have the potential to perform tasks, the user must also be able to operate the technology sufficiently to actually complete these tasks. The importance of effectiveness in game controller design is obvious: If users cannot use a controller to perform game tasks, they will be unable to interact with the game in any meaningful way.

The importance of efficiency in game controller design is a more complex issue. Efficiency considers the resources that must be expended by the user to complete tasks. These resources can be mental effort, physical effort, or time. In terms of computer games, this is closely linked to concept of difficulty: i.e., if a game requires a large amount of resources (time, skill, mental effort, etc.), then it is described as difficult and, conversely, if it requires few resources, it is described as easy. This might seem to be of limited importance when discussing game controllers, as the main focus of games is to enjoy playing them, not to effectively complete tasks. However, as Csikszentmihalyi (1975) reports, completing tasks that are easy can become boring and tasks that are difficult can become frustrating. This need for balance of effectiveness presents a dilemma in game controller design.

The concept of satisfaction deals with how the interaction impacts the user; are they free from discomfort and do they have a positive attitude toward the interactions? Once again the importance of this concept to game controller design is fairly obvious, as playing computer games is an entertainment-driven activity, and the interaction should be satisfying. Unlike efficiency, effectiveness, and context of use, satisfaction is purely subjective. While the other core concepts of usability can to some degree be directly observed, satisfaction must be assessed solely on the basis of user feedback. This can cause problems in game controller design, as variables such as context of use can influence user report and distort findings.

Context of use is unlike the other concepts discussed as it is not a vital part of usability, but is a factor that must be considered when studying efficiency, effectiveness, and satisfaction. Basically, context of use describes the situation in which an interaction is happening (Bevan and McLeod 1993). It is important to consider that this refers not only to the physical environment, but also to the individual differences and the social environment in which the interaction is taking place. While this concept is vital when studying all forms of technology, it is especially important when working with control devices because, as interaction facilitation devices, they introduce additional complexity that must be considered. The device a controller is being used to control has a huge influence on the usability of the interaction. In terms of game controllers, this means both the hardware (PC or console) and software (the specific game) must be considered in design.

12.3.4 Experience and Game Controllers

This final aspect of interaction design is perhaps the most recent to be explored. Experience refers to the psychological and social impact technology has on users. While this is related to the usability concept of satisfaction, it has a much wider scope, looking at interaction in a much broader sense than merely task completion. When studying experience, concepts external to the interaction must be considered, for example aesthetics, marketing, social impact, attachment, and mood can all affect users' experience of interacting with technology.

Once again, the nature of game controllers as intermediary devices can make studying this aspect of user interaction difficult. In addition to the social, psychological, and environment factors that must be considered when looking at experience of any technology, the hardware and software that is being controlled may also impact on user experience with game controllers. Little research or theory exists relating to user experience with game controllers, making it impossible to predict what factors are key to users' experiences in this area. However, the tools needed to explore this area do already exist; qualitative psychological methods such as critical incidents technique, semi-structured interview, grounded theory, content analysis, and ethnography have been used to evaluate experience in a wide range of fields (McCarthy and Wright 2004), and their flexible nature means they can be easily applied to the study of game controllers.

12.3.5 Evaluation and Design of Game Controllers

This section discusses the impact of the McNamara and Kirakowski's framework on research and design in this field. First, current literature is explored and then the implications for design are discussed.

Looking at recent research into controllers in general reveals that a significant number of research papers have explored the performance of pointing devices (including mice, touch pads, and trackballs), keyboards in traditional desktop/laptop computing scenarios, and keypads usage on handheld devices (Card et al. 1978, MacKenzie 1992, Silfverberg et al. 2000). In recent years, HCI researchers have also explored a variety of increasingly popular interaction methods including gesture, touch, haptics, and styluses (Dennerlein et al. 2000, Forlines et al. 2007, Albinsson and Zhai 2003). Most of this work has been concerned with the effectiveness and efficiency of the input methods, but user satisfaction has also been considered (Brewster et al. 2007, ISO 1998b).

Despite the fact that game control has been highlighted by many studies as an important aspect of game design (Federoff 2002, Johnson and Wiles 2003, Desurvivre et al. 2004, Adams 2005, Hoysniemi 2006, Pinelle et al. 2008, Falstein and Barwood 2008), little research has been conducted that focuses on game controllers. Some work has studied the development of input devices and how they affect user performance (Kavakli and Thone 2002, Pagulayan et al. 2003, Klochek and MacKenzie 2006); however, the effects of game controllers on user experience have yet to be explored in detail. According to McNamara and Kirakowski's (2006) model, we will not be able to fully understand the interaction involved with game controllers until it has been studied in terms of functionality, usability, and user experience.

Current game controller design practice continues this pattern, with an emphasis on the functionality aspects but little attention paid to usability, still less to user experience. For example, the game play and console compliance checking activities incorporate evaluation of controller support. The associated checklists typically contain very specific advice with respect to assignment of functionality to buttons. Apart from this very platform-specific advice, the guidelines and heuristics related to support of standard controllers are very limited.

The next question that must be answered is how adopting this model impacts game controller design? Currently, little research exists to help focus game controller evaluation on the aspects of game controllers that have the greatest effect on user interaction. This lack of focus leaves controller designers with two choices when it comes to evaluation: either perform a broad range of evaluations to ensure that all aspects of the controller are examined, or perform a few tests and hope that most of the important issues are found. Neither of these are ideal solutions, as the first is costly to perform and it may be even more costly to correct all the issues found, and the second is likely to miss key issues and produce a poor product. The McNamara and Kirakowski (2006) model highlights the distinct components of the interaction, allowing designers to perform fewer evaluations but still investigate each of the components of the interaction. Ensuring that controller functionality, usability, and user experience are all evaluated means that all the vital aspects of the controller can be assessed without performing a huge range of evaluations.

12.4 Case Study

In order to further explore this area, a case study was designed to evaluate both standard and innovative computer game controllers usages in a game. This study focused on control of racing games and evaluated keyboard and mouse, standard gamepad, and force feedback steering wheel control methods with respect to each aspect of user interaction, as described by McNamara and Kirakowski (2006). This study is designed in order to highlight the benefits of evaluating user experience, within the context of a multi-component game controller evaluation.

12.4.1 Justification

In order to fully explore the interaction between user and game controller, each controller was assessed in terms of functionality, usability, and user experience. Measuring each of these component measures brings with it unique challenges.

12.4.1.1 Functionality

Functionality describes the purely technology-based part of the interaction. Since this component is relatively independent of both environment and user, it can be measured by an inspection of the technical limitations of each game controller This inspection was done by comparison of the quantity and range of outputs produced by each controller relative to possible inputs recognized by the game. In addition to this, the use of inputs was measured with custom logging software.

12.4.1.2 Usability

This quality is dependent not only on the user, but also on the environment in which the interaction takes place. Each aspect of usability as described by the ISO (1998b) was measured independently. Efficiency was measured in terms of mental effort required to use the controllers: the lower the mental effort required, the more efficient the interaction with the controller. Mental effort was measured using the self-report Subjective Mental Effort Questionnaire (Arnold 1999). Effectiveness was measured via lap time. The faster users can complete a lap using a controller, the more effective the interaction, as fast lap completion is the primary task in racing games. Satisfaction was measured via the Consumer Product Questionnaire (CPQ) (McNamara 2006), a standardized measure for evaluating user satisfaction with electronic consumer products.

12.4.1.3 Experience

As this aspect is purely subjective in nature, it can be difficult to measure and is dependent on a huge range of psychological and social factors external to the interaction itself, including aesthetics, advertising, and social desirability (McCarthy and Wright 2004). Critical Incidents Technique (CIT) (Flanagan 1954) was used to collect qualitative data describing user experience. This method involves asking each user to report his/her three most positive and three most negative experiences with the controller in an open-ended questionnaire. This method was chosen for two key reasons. First, as a postgame play measure, it will not interfere with the game play experience itself. Many during-play methods such as talk out loud can alter the experience of game play and reduce the validity of any findings. Second, CIT is open-ended and does not require a knowledge base in the area being explored. This is important, as a lack of previous research in this area means that other researcher-lead methods are not appropriate. In addition to the CIT evaluation, each subject was asked to report his/her preference between the controllers on a set of three two-way controller preference scales (ranging from "much preferred controller A" to "much preferred controller B").

12.4.2 Methodology

A total of 12 subjects took part in this study. Gender balance was reasonably equal with five female and seven male subjects. The mean age of the participants was 24.6, with ages ranging from 19 to 30. Participants were also asked if they drive regularly as this may give them an advantage with the steering wheel controller; five responded that they did. They were also asked if he/she had any experience of racing games, all except subject 1 responded that he/she had little or none.

The test system was an HP Compaq dc7800p running Windows XP. The following three controllers were evaluated in the study:

Keyboard. Dell USB keyboard.

Gamepad. The Logitech Dual Action is a USB gamepad, with two mini-joysticks (similar to those commonly used on game consoles) and 12 digital buttons.

Steering wheel. The Logitech MOMO Racing is a USB force feedback device, with an analog steering wheel, analog accelerator and brake pedals, and 10 digital buttons.

A single game was used in the study, Colin McRae Rally DiRT (Codemasters 2007). In order to minimize the impact of game-specific artifacts on the evaluation, a number of the game settings were fixed. The same difficulty level (amateur), control assignment, view (behind the car), car (Subaru Impreza), and track (Avelsbachring) were used for all subjects.

This study used a repeated measures type design, with each subject taking part in every condition. The independent variable was the type of control method used and was operationalized in three conditions: Gamepad, Keyboard, and Force Feedback Steering wheel.

In order to reduce confounding variables between conditions, a number of controls were used. The order of conditions was counterbalanced in order to counteract any effects due to learning. Each condition used the same software and hardware, except for the control method, so reducing the effect these may have on the evaluation.

12.4.2.1 Procedure

After completing a short demographic questionnaire, the subjects were introduced to the game and the first control method they would use. They were then asked to play the game until they felt comfortable with the control method. How long this step took was left to the participants' discretion and varied from 5 to 20min. Then the participant performed two timed laps of the test track. Once they had done this the participant was asked to complete the CPQ, SMEQ, and CIT questionnaires. This procedure was repeated for each control method.

12.4.3 Results

12.4.3.1 Functionality

When comparing the controllers in terms of functionality, there are two issues to be considered. First, “Are all the game commands supported by the controller?” and second, the issue of exactly how the control is supported. The DiRT game has only a small set of commands. In addition to steer, accelerate, and brake, a small number of extra commands are also supported (change camera, handbrake, look left/right/back, and gear up/down). Even though the use of all the game commands was not examined in the study, the various controllers had sufficient controls for all of these game commands to be assigned, i.e., 100% of the game commands can be assigned to the controllers.

Both the gamepad and steering wheel support analog steering. However, as Table 12.1 highlights, their response characteristics are very different, with the wheel being several times more precise in terms of angular resolution. This data show that in terms of functionality in the context of this game, the steering wheel is the superior control method, with the widest range of motion and sensitivity. Conversely, the keyboard has the poorest functionality, only accommodating binary input for both steering and acceleration.

12.4.3.2 Usability

The usability of each game controller was measured in terms of effectiveness, efficiency, and user satisfaction.

Table 12.2 shows the results for each component of the usability analysis of the three controllers. It indicates poorer performance for the steering wheel compared to the other two control methods in terms of both completion time and SMEQ (low values of SMEQ indicate mental effort required). Gamepad and Keyboard results for these two measures appear to be much closer. In terms of CPQ results, the Keyboard reports an extremely low result for satisfaction, with the Gamepad and Steering Wheel performing slightly better (50% on the CPQ is an average device score, according to the CPQ database). A series of one-way repeated measure ANOVAs were used to determine the statistical significance of these results. ANOVA was used as it is a robust method of difference testing, and performing multiple t-tests would increase the likelihood of a type II error. For this exploratory study, an alpha level of 0.05 was used.

Table 12.1 Functional differences between gamepad and wheel controllers

Control parameter	Gamepad	Wheel
Physical range (approximately)	25	240
Analog counts	255	1024
Deadzone	Yes (center)	No
Angular resolution (approximately)	<10.2	4.3

Table 12.2 Means scores on usability measures

Controller type	Completion time	SMEQ score	CPQ score (%)
Steering wheel	04:39	72.92	20.83
Gamepad	02:59	34.42	15.08
Keyboard	03:13	42.58	6.25

Table 12.3 ANOVA results for usability measures

	Completion time	SMEQ score	CPQ score
F value	5.876	7.258	3.268
Degrees of freedom	10	10	10
P	0.021	0.011	0.081

Table 12.4 P-values for STEP analysis of completion time ANOVA

Completion time	Steering wheel	Gamepad	Keyboard
Steering wheel	–	0.014	0.027
Gamepad	–	–	0.4
Keyboard	–	–	–

Table 12.3 shows that the ANOVA results indicate significant results at an alpha level of 0.05 for completion time and SMEQ scores. Results for CPQ scores show the data approach significance, but fail to reject the null hypothesis at a 0.05 alpha level. In order to further investigate the differences, a post hoc STEP analysis was performed on each of the significant ANOVA results.

Table 12.4 shows the probability values for the STEP analysis of the completion time data and reveals significant differences between Gamepad and Wheel, and Keyboard and Wheel. This shows that the steering wheel performed significantly worse than the other two methods in terms of effectiveness.

Table 12.5 reveals similar results for the STEP analysis of the SMEQ data. Significances were found between Steering wheel and Gamepad and between steering wheel and keyboard. This shows that the steering wheel also performed significantly worse than the other control methods in terms of efficiency.

In summary, the usability data collected show an interesting trend in terms of the steering wheel. This controller scored significantly worse than both of the other control methods in terms of efficiency and effectiveness (as measured by Completion

Table 12.5 P-values for STEP analysis of SMEQ ANOVA

SMEQ results	Steering wheel	Gamepad	Keyboard
Steering wheel	–	0.014	0.027
Gamepad	–	–	0.4
Keyboard	–	–	–

Time and SMEQ), but scored the highest in the measure of user satisfaction. This set of results suggests that while the steering wheel was not an effective or efficient controller, the participants enjoyed using it. Keyboard data show the opposite trend, with good efficiency and effectiveness scores, but the poorest satisfaction results. Finally, the Gamepad performed the best of three controllers in terms of usability, producing the best lap times, the lowest SMEQ scores, and a reasonable score in the CPQ, compared to the other controllers. It is also worth noting that all three control systems performed poorly in terms of user satisfaction, with means scores ranging from 6.25 to 20.83%. The lack of statistical significance may be due to a "floor" effect, i.e., the CPQ scores could hardly get much worse.

12.4.3.3 User Experience

The data collected to measure user experience took two forms: First, user preference was gauged and second CIT was used to report user attitudes toward the devices.

Table 12.6 presents the mean user preference scores and shows a preference toward the gamepad compared to the other two controllers and a preference for the keyboard over the steering wheel. In order to test the significance of these results, one-way repeated measures ANOVA was performed at alpha level 0.05, producing an F value of 3.015 with 10 degrees of freedom. This falls outside the critical region and so does not show statistical significance.

As the CIT produces quantitative data, a more detailed analysis is required. The responses for each game controller were formed into categories using content analysis. This method involved grouping the comments collected into categories, based on the content of those categories, in order to identify the key areas of the users' experience with the game controllers.

Table 12.7 shows the results of the content analysis of the steering wheel comments. This table highlights *Sensitivity*, *Feedback*, *Easy to pick up*, and *Realism* as the most reported aspects of users experience with this device.

The *Sensitivity* comments highlight the high sensitivity of left/right steering using the wheel. For example:

"... impressive accuracy while playing." (Subject 1, positive)

"Controller is very sensitive to movement, it takes a while to judge accurately how much force is required." (Subject 7, negative)

"Hard to control. The steering was highly sensitive." (Subject 11, negative)

While the majority of these comments are negative, showing frustration at the highly sensitive controls, three of the subjects listed this as a positive feature that actually enhanced their game play experience.

Table 12.6 User preferences scores on a 1–5 scale

User preference	Keyboard – gamepad	Keyboard – steering wheel	Steering wheel – gamepad
Mean	4	2.5	3.92
Standard deviation	1.28	1.57	1.44

Table 12.7 Content analysis of steering wheel comments

Steering wheel categories	Positive comments	Negative comments	Total
Sensitivity	3	9	12
Feedback	7	4	11
Easy to pick up	7	4	11
Realism	9	2	11
Physical characteristics	4	3	7
Learning potential	1	3	4
Miscellaneous	0	1	1
Total	31	26	57

Comments in the *Feedback* category discuss the force feedback produced when using the steering wheel. For example:

> "The motion of the wheel when on rough terrain (vibration) added to the experience of crashing." (Subject 6, positive)
>
> "The vibrations of the wheel were a nice effect in making it seem like you were really on the terrain, like the grass." (Subject 12, positive)
>
> "The motion/vibration of the wheel often made turning the wheel very difficult – it moved a lot less smoothly" (Subject 6, negative).

Again, the comments in this category are both positive and negative. The positive comments show an appreciation of the fun and realism that force feedbacks add to the interaction, while the negative comments mention situations where it got in the way of playing the game. This shows the care with which innovative controller features should be applied so that they add to the game experience without getting in the way of the basic features of the game, in this example steering.

The *Easy to pick up* comments mention instances where this control system was or wasn't easy to pick up and use. Some subjects found the familiar steering wheel and pedals provided an intuitive control system, but for others the reproduction of driving conditions was not accurate enough to make it easy to pick up. For example:

> "Using a steering wheel is quite intuitive; it's obvious how it works." (Subject 6, positive)
>
> "The accelerator and brake pedals were awkward to use at first and I never really got comfortable with them." (Subject 3, negative)

The *Realism* category produced the most positive comments for the steering wheel, with only two negative comments from 11. These comments mainly praise the realism of this control method, and two of the comments call for even more realism. For example:

> "The wheel combined with the pedals made it seem like a very realistic driving system." (Subject 6, positive)
>
> "Steering wheel only had half turn each way rather than the 1.5 as I am used to when driving." (Subject 8, negative)

Table 12.8 Content analysis of keyboard comments

Keyboard/categories	Positive comments	Negative comments	Total
Ease of use	10	3	13
Sensitivity	3	8	11
Physical characteristics	5	6	11
Realism	0	3	3
Comfort	0	2	2
Feedback	0	2	2
Familiarity	2	0	2
Total	20	24	44

Table 12.8 shows the results of the content analysis of the keyboard comments. It is worth noting that this is the only control method that received more negative comments than positive ones. The categories that contain the most comments and are the focus of the evaluation are *Ease of use*, *Sensitivity*, and *Physical characteristics*.

The *Ease of use* category contains comments discussing how easy the keyboard was to use. Most of these are positive comments focusing on the simplicity of the interface, but some mention the limited control that is afforded by keyboard control. For example:

> "Actions didn't translate well to game. Even though controls are simple, car was difficult to control and judge." (Subject 7, negative).

The category containing the most negative remarks was *Sensitivity*, which contained comments relating to the binary nature of the keyboard input. A few comments praised this as easy to use, while most of them criticized the lack of sensitivity. For example:

> "Easier to make incremental adjustments during steering." (Subject 2, positive)
>
> "Breaking was instantaneous, I had no control over slowing down, it was stop or nothing." (Subject 3, negative)

Comments in the *Physical characteristics* category discuss the implication of the physical layout of the keyboard, either praising the localized controls or criticizing it for being cramped. For example:

> "Small choice space-i.e. arrow keys within easy range of fingers" (Subject 2, positive)
>
> "Spacing of input keys is a small bit cramped." (Subject 9, Negative)

Table 12.9 shows the results of the content analysis of the gamepad comments and reveals that the comments in this category are more evenly spread across the categories produced; this suggests that there were not any aspects of the interaction that were experienced by all the users. The categories that contain the most comments are *Comfort*, *Learnable*, *Sensitivity*, *Personal preference*, and *Ease of use*.

Table 12.9 Content analysis of gamepad comments

Gamepad – categories	Positive comments	Negative comments	Total
Comfort	8	2	10
Learnable	4	3	7
Sensitivity	3	4	7
Personal preference	2	5	7
Ease of use	6	1	7
Feedback	0	3	3
Realism	1	1	2
Misc	2	0	2
Total	26	19	45

Comfort is the largest category produced and contains the most positive comments. These comments simply talk about how comfortable the gamepad is. For example:

"Very comfortable. I could hold it all day long." (Subject 3, positive)
"Makes my thumb sore after playing for a while." (Subject 1, negative)

Comments in the *Learnable* category talk about how easy or difficult it is to get used to using the gamepad controller. For example:

"Very familiar. I knew exactly how it worked within very little time" (Subject 3, positive).
"Maybe if someone used this for the very first time it would be difficult to figure out" (Subject 7, negative).

It is interesting to note that while several users mention this method is easy to learn, none talk about how intuitive it is, as they did with both the steering wheel and the keyboard. This may suggest that it may be familiarity with this device rather than an intuitive interface that makes learning easier.

The *Sensitivity* comments highlight the positive and negative effects of steering, acceleration, and break sensitivity. For example:

"Natural feeling, right sensitivity" (Subject 1, Positive)
"The acceleration and brakes didn't seem to work well together. It was hard to brake slightly; you had to come to a complete stop." (Subject 11, negative)

Comments in the *Personal preference* category discuss issues relating to control assignment setting in the game. Most of these comments are negative, perhaps representing the fact that the participants were not allowed to alter these settings during the study. For example:

"Would have preferred to accelerate on the 'trigger' buttons" (Subject 2, negative)
"The button for the break should be to the right side, not above the accelerator." (Subject 8, negative)

The *Ease of use* category contains comments relating the simplicity (or lack of) using this control method. Most of these comments are positive, with only a single comment stating that this device is difficult to use. For example:

"Very easy to use. Actions were displayed accurately in the game. It was easy to judge how much movement/force was required." (Subject 7, positive)

"The joystick seems sometimes a little bit difficult to use." (Subject 5, negative)

In addition to highlighting some of the key issues in game controller user experience, these data have revealed an interesting trend, the mixture of positive and negative comments throughout the categories relating to all three control methods. The vast majority of categories discovered contain both positive and negative comments; this trend highlights the importance of individual differences when analyzing game controllers. What some users may see as a positive feature or aspect of a game controller, others may view in an extremely negative light. For example, when discussing the binary nature of the keyboard, one subject found it much easier to steer with, while another found the lack of sensitivity frustrating.

"Easier to make incremental adjustments during steering." (Subject 2, keyboard, positive)

"Very difficult to control the strength of the control/action by simply pressing one key." (Subject 4, keyboard, negative)

12.4.4 Combining the Results

While each of the evaluations produced interesting results, a more complete picture can be gained by looking at a combination of all three measures. While a complete analysis of all the data collected falls outside the scope of this chapter, this section highlights a single issue that was reported by several of the analysis methods and explores it in more detail.

The issue of controller sensitivity is one that seems to have an impact on all three components of the interaction. The user experience analysis highlighted controller sensitivity as an important aspect of experience for each of the control methods. Categories within each analysis revealed each control method's advantages and disadvantages in terms of sensitivity. The results suggest that this aspect of the interaction was the most influential when using the steering wheel, as nine comments mentioned sensitivity as a problem. However, in terms of functionality the steering wheel is clearly superior, being sensitive to small gradations in terms of steering, acceleration, and braking.

To examine this in more detail, an analysis of the data collected by the logging software for subject 1 (the subject with the best laps times using the wheel) and subject 5 (a subject with close to average lap times with the wheel) was conducted.

Figure 12.2 shows the reports captured by the logging software for subjects 1 and 5, while using the gamepad and steering wheel to control the steering axis while driving the two timed laps of the track. The chart is a frequency distribution of the range of controller reports. Both controllers report a different range of values in response to movement. In order to display them all on the same X-axis scale, the data from both controllers have been normalized; –1000 is the controller axis at the extreme left; +1000 is the controller axis at the extreme right; and 0 is the center position for the controller. The Y-axis represents the total number of reports of a given value.

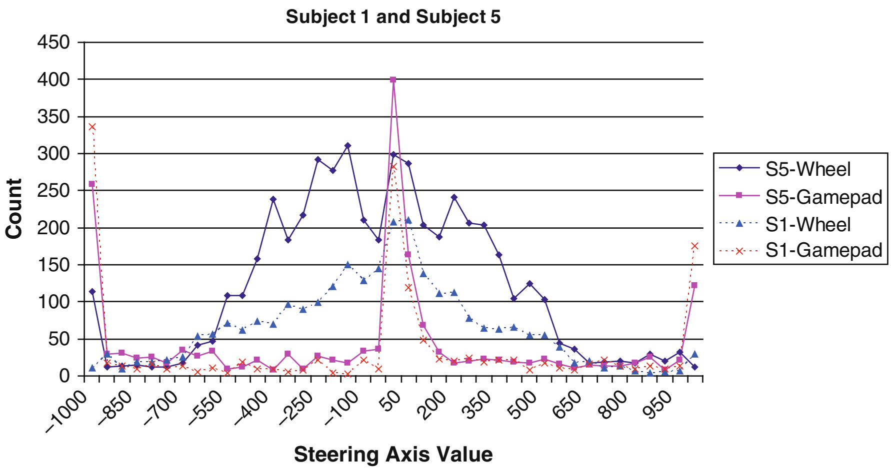

Fig. 12.2 Device steering reports for subjects 1 and 5

The bias of data toward the left-hand side of the chart is a result of the track being driven in an anticlockwise direction. As can be seen in Fig. 12.2, the profile of reports generated by both subject 1 and subject 5 while using the gamepad is very similar. The distribution of the data shows that little of the analog capability of the mini-joystick on the gamepad is being used. Most of the reports are either close to the axis center (mini-joystick is moved to the center "deadzone") or at the limit of the device range, i.e., the gamepad mini-joystick is essentially being used as a digital control in a manner similar to the keyboard.

The profiles of reports generated by both subjects while using the steering wheel are obviously different. The increased number of wheel reports for Player 5 vs. Player 1 is a reflection of the fact that Player 5 took more time to complete the two laps while using the wheel, and thus generated more reports. In contrast to the gamepad data, the analog capability of the wheel is being utilized. The graph for Player 1, who had the fastest drive time for the wheel, shows a concentration of reports about the center position of the wheel. In contrast, the graph for Player 5 shows a wider distribution of data, as he/she struggled to control the vehicle using the wheel, i.e., significant over steering.

This suggests that, although a more sensitive control method is a useful tool for a more skilled user, it is of little benefit to those of less skill. As few of the participants had much experience with steering wheels in games; this could explain the negative comments regarding the steering wheel, as they found it frustrating to use without the time to master. The distraction caused by this unfamiliar sensitivity could also go some way toward explaining the poor usability scores reported for the steering wheel. The analog nature of the brakes and pedals on the steering wheel controller allows the player to perform a variety of real-world rally driving techniques in a game, such as the "heel-and-toe" and "left foot braking". However, none of the subjects in the study used these techniques.

This example highlights the main advantage of using this multi-component analysis: the ability to fully explore an issue that has been highlighted by one of the methods and find its root cause. While a traditional usability or user experience evaluation would probably discover that sensitivity is a key issue for these control devices, they would not be able to explore this issue in its entirety, as this multi-component evaluation has.

12.4.5 Critique

When considering the results of this study, there are several possible short weaknesses that must be considered. The most obvious of these is the range of methods used. While this allows a great deal of data to be collected for each component of the interaction, it also means that compromises have to be made when assessing each component. For example, when exploring user experience, McCarthy and Wright (2004) suggest evaluations in the field, but the present study used a laboratory environment so that usability evaluations could be performed simultaneously. The lab was set up to closely resemble a home environment, but it is impossible to recreate the exact conditions of a field study.

Another factor that must be considered is the inexperienced participants. Only 1 of the 12 subjects reported having regularly played racing games, and none of them had more than a few hours of experience with steering wheel controllers. The results must be interpreted with this in mind, and may not be generalizable to more experienced gamers.

12.4.6 Conclusions

The steering wheel is an attractive device which supports all the functions needed by the game commands, and therefore may be a selling point for the game. In the hands of an inexperienced user, however, it will lead to poor game performance. Nonetheless, at least initially, users will feel satisfied with it.

Although the gamepad comes out above the steering wheel and the keyboard on usability performance measures, the keyboard has the advantage that it is regarded as very easy to learn. "Experience" and "usability" in this case seem to be telling different stories. Which should the game designer go for if there is a choice to be made? If there is a trade-off between the keyboard and the gamepad, the designer may well choose not to support the gamepad if user experience is the key issue.

The issue of controller sensitivity shows the complexity involved in understanding a small aspect of user experience with game controllers. It highlights not only the need for greater understanding of user experience with game controllers, but also the need for parallel research of both functionality and usability in order to understand the interaction as a whole.

Overall, all three of the devices studied were able to support the game command functions, and the steering wheel was also able to transmit extra output using haptic feedback. Thus, we may infer that for the game and devices studied, the game controller was working at 100%. However, the devices differed in the way the user interacted with them in the game. This study shows that the method of user interaction is actually an important aspect of game play, and how one may be able to assess its impact in a simple and direct laboratory evaluation. With experienced facilitators, a study such as this need not take more than two elapsed days.

In terms of game controller user experience, several issues were highlighted that appear to be important for all of the controllers evaluated. These include: Sensitivity, Ease of use, Realism, and Comfort. This information represents an initial baseline of game controller user experience, which can be further explored with future research.

12.5 Discussion

Much of on-going game play testing that is performed as a regular part of the development process is accomplished using informal techniques. Such informal evaluation could also be complemented by more a structured evaluation of controller support, as outlined in the user study. It is relatively quick and easy to perform and could be especially useful during the early stages of development to benchmark controller support.

12.5.1 Implications and Recommendations

Between discussion and the case study presented here, the advantages and disadvantages of a multi-method evaluation have been highlighted. The main advantage shown is the ability to identify the root cause of the issues discovered in any of the evaluations. The main disadvantage is that when performing a range of evaluations simultaneously, compromises such as the use of a laboratory setting must be made.

In terms of practical implications, these findings suggest that a multi-component model such as this could be useful within a game development process, where it is important not only to highlight issues, but also to discover their root causes and fix them. However, the compromises that must made in the evaluation process means that focused user experience evaluations may be more appropriate in academic setting, where understanding of the intricacies of an issue is more important.

12.5.2 Future Research

In terms of user experience, the case study presented has laid the ground work for exploring how game controller affects user experience. Having discovered some of the key issues in this area, the next step is to explore these issues in more detail with more in-depth data collection and analysis, such as interview and grounded theory.

This user study was deliberately constrained in that it only explored the initial stages of game play for each of the controllers in a single game. However, with extended game play, the players will become more familiar with both the game and the controllers. As a result, longitudinal studies would be required to explore the issues that arise in the context of longer game play durations over an extended period of time. The same techniques applied in this user study could also be applied in the context of longitudinal studies, and the data then analyzed to explore change over time.

The data collected in the study consist of both data collected during game play (with logging software) and data collected afterward as subjects complete questionnaires. The data collected during game play in the study were limited to the reports generated by the game controllers. It would be useful to complement this in-game data with biometric and video capture data (with emphasis on facial expressions and body movement). This could perhaps allow better interpretation of the in-game reports and complement the information collected postgame play in the questionnaires.

Future studies should seek to elaborate on the effects of functionality on usability and experience. For instance, where possible, to observe the effects on game players in setups where the game controls, controllers, and support devices offer different levels of functionality as defined in this chapter.

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