



Interaction Design on Basic Hand Movement Training Game in Taekwondo Using User-Centered Design

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Abstract: This research will develop an interaction design for basic hand movement games in taekwondo with the hope that it can become an alternative physical exercise for hand stretching. UCD is one of the methods in interaction design that focuses on the user. By designing interactions in hand movement training games using the UCD method and present technology, it is hoped that this can be a stretch in the dense student activities. The results of the interaction design evaluation using UCD obtained an average of 90.24% for the 6th heuristic based on ten evaluation heuristics. Combining the UCD method at the design stage and utilizing present technology is an innovation in designing easy-to-use game-based interaction designs. The study results show that the UCD method for interaction design is suitable for use in the game design process.

Keywords: Interaction Design; Game; UCD; Interaction.

1. Introduction

The interaction between humans and technology is closely related to the human-computer interaction (HCI) field, which consists of designing and implementing interfaces easily used by humans [1]. Interaction design is the design of an action focusing on the relationships between people [2]. Interaction is a process of action and reaction between different media, such as humans and computers, also known as Human-Computer Interaction (HCI). Interaction design differs from traditional HCI in that its goal is to balance humans and computers for usability and user experience [3]. Interaction design built into games can help achieve the game's goals [4]. Interaction design is formed by four main approaches, one of which is User-Centered Design. User-centered design involves creating a design or concept involving direct user input from the beginning of the design process until it becomes a system or application that meets user needs. Taekwondo is the art of using empty hands and feet [5]. Some basic movements can be practiced independently in this martial art, but they still need to be directed and understood theoretically. For example, through interactive games offering information and learning about taekwondo, users can practice basic techniques more engagingly [6]. Interactive games do not require the physical presence of the user [7], thereby increasing interactivity with the theoretical content of taekwondo in the game. Therefore, interaction design will focus on developing this movement training game, which teaches the theory of fundamental movements in taekwondo as a learning tool for junior high school students participating in taekwondo activities or interested in the sport.

There are four main approaches to interaction design: user-centered design, activity-centered design, system-centered design, and genre-centered design. In this research, the approach being used is user-centered design. The research focuses on interaction design in developing a serious game with content related to problem-solving quizzes [4]. The study uses the User-Centered Design (UCD) method in the design phase and concludes that the design meets the requirements of effectiveness, ease of learning, and enjoyment of the game [8]. The UCD method consists of components covered in several stages: needs identification, design, building an interactive version of the design, evaluation, and the final product. Each stage is interconnected, and in the evaluation stage, it can be looped back to the design stage to improve the previous design before moving on to the next stage, resulting in iterations. The UCD method is also used in other research on interactive games for therapy for children with autism [9]. However, this study found failures due to a lack of significant functions and features needed for children with autism. Interface modeling supports the interaction design for the game being developed [10], thus used in research to create a first-aid game using the UCD method [11]. In addition to games, there is research on using UCD in HCI applications [12].

Another study focused on evaluating a web user interface using the UCD method. This evaluation involved stages such as understanding the context, collecting user needs, designing solutions, and evaluating. The research concluded that it excelled in visual aspects, with an evaluation score of 89.7% [13]. Hazard Studio developed a taekwondo-themed game application called "Latihan Taekwondo Di Rumah" (Taekwondo Practice at Home), which was published on the Play Store and received a rating of 4.2 out of 5. However, some negative comments were made regarding the app's interface. One feature not utilized in the game was the lack of music and real-time interaction [4], making the learning process effective but unbalanced in terms of usability. The effectiveness score reached 97.4%, while the usability score using the System Usability Scale (SUS) was 70.5/100. Therefore, usability could be improved by obtaining feedback from previous usability tests [4].

Another serious game research on simulation games encountered difficulties connecting to the internet and servers, requiring preparation time. However, in the third iteration, positive feedback was received from users, although there was a lack of understanding of tasks and settings within the game [7]. In another severe game study focusing on educational games, in the first iteration, the completion rate was 83.33%, with an SEQ score of 5.93 out of 7, which is average. However, the application still had shortcomings. The average SEQ score improved to 6.37 out of 7 in the second iteration. The lowest score was 6 for completing missions, indicating issues such as time constraints affecting enjoyment and effort needed to access game features [8].

Other research on interaction games focuses on technology, such as developing an action-reflection game using GTA5 with PoseNet technology [14]. Another study used the UCD method to establish a Yoga Pose interaction game, utilizing PoseNet technology [15]. Considering the current interaction design, games, and technology usage, this research aims to build an interaction design for a hand movement training game using user-centered design, leveraging PoseNet technology in its development. This game is expected to serve as a medium for practicing basic hand movements in taekwondo, providing an engaging activity for students.

2. Research Method

Research methodology is a systematic approach to gathering steps, providing an overview for designing the final project by identifying problems. This research goes through five stages: data collection, game design, final game development, game testing, and documentation. In the Data Collection stage, the aim is to gather information for the game's needs. This stage is also part of the game design process with a User-Centered Design (UCD) approach. Observation is conducted directly at the training location, observing every taekwondo student's activities to obtain detailed data. Interviews involve users, including coaches and some students in SMP Negeri 2 Ngamprah training. The target of the interviews is coaches and students with expertise in taekwondo to gather information about the game to be built from inception to completion. Surveys involve creating forms/questionnaires so that users, specifically middle school-aged children, can make selections to ensure the game can be played effectively. Literature Review consists of gathering information from various literature sources to support the results of interviews and surveys.

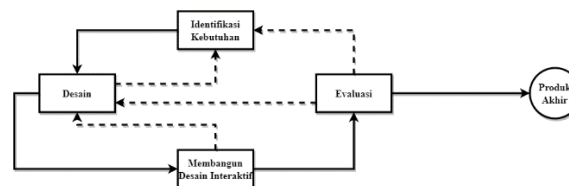


Figure 1. UCD Flowchart

In the Game Design stage, User-Centered Design (UCD) is an iterative design process based on user input. The flow of this game design is depicted in Figure 1. Needs Identification (Interview). Needs Identification is the process of identifying needs to build a game. Initial identification is designed through steps like interviews, focus groups, and questionnaires. Further needs identification occurs after evaluation. Design is the process of creating initial drafts. The design stage occurs after needs identification and adapts the initial identifications through various stages. The design stage can be iterative, receiving evaluations from the identification or after designing additional elements or from direct user feedback during development. This process repeats until users achieve their needs and goals. Building Interactive Design is a development process involving several iterations. After the design draft stage, the design is built based on the design. The development can be updated with new needs or evaluations. This stage falls under the category of design process with a UCD approach until the final product stage. Development in UCD is built until the final stage, which refers to the finishing process of the final product in UCD. Evaluation occurs when the game is built. This stage is repeated until user needs and goals are met, producing a final product. Game testing is also conducted in this stage to identify bugs and technical shortcomings after the development stage. The Final Product is the outcome of the development up to the design that will be implemented when user needs and goals have been met from the initial design needs, system design, and game development. However, design and development evaluations will be conducted if user needs are still unmet. Once all requirements are met, the product/application will be used according to user desires and needs. The report written following national standard writing guidelines is the documentation stage in this research. The report covers all stages and processes, from data collection to design, development, and testing, and it includes results and conclusions.

3. Result and Discussion

3.1 Results

Needs identification is a fundamental aspect of User-Centered Design (UCD), focusing on understanding user requirements from the inception of design until the application's final form. System developers must grasp users' needs and ensure acceptance, providing solutions to overcome difficulties and achieve desired outcomes. Additionally, the design process emphasizes aligning the system with user skills and desired targets. Various steps are involved, including conducting interviews, utilizing questionnaires for data collection, and more. This research employs qualitative and quantitative methods, incorporating interviews, focus groups, and questionnaires. The interview findings, detailed in point 1, along with data from focus groups and questionnaires outlined in points 2 and 3, are derived from responses from taekwondo coaches and students selected based on their expertise and fundamental knowledge of taekwondo. In interviews, six informants, including the Taekwondo club coach and students, shed light on essential pre-training stages, such as

ceremonies, warm-ups, and core training, influencing the game flow's foundation. Focus groups involving 5 participants representing the club's student body provided diverse perspectives crucial for interface and feature design considerations. Questionnaires aimed to gauge game needs from the respondents' standpoint, serving as the target users. Questions encompassed respondents' familiarity with game interaction, taekwondo knowledge, and preferences for game features. A cohort of 40 taekwondo students with varying skill levels responded, utilizing a 5-level Likert scale for measurement. The design process integrates initial design outcomes based on Hierarchical Task Analysis (HTA) from the needs identification phase, derived primarily from interview findings. These interviews' structured steps facilitate system design within the created game.



Figure 2. HTA Taekwondo Training



Figure 3. Initial Display Design

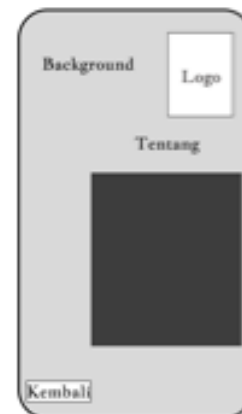


Figure 4. About Display Design

The initial display design of the game interface includes several essential elements aimed at providing a user-friendly and intuitive experience. At the forefront, the logo is prominently displayed to ensure brand recognition and establish the game's identity. Below the logo, a series of functional buttons are strategically placed for easy access. These buttons include the start button, which serves as the gateway for users to begin their gaming experience, directing players to the main gameplay area and initiating the taekwondo training activities. The settings button allows users to customize their gaming experience by providing options to adjust various settings such as sound, difficulty levels, and other preferences to enhance usability and accessibility. The about button offers users information about the game, including its development, objectives, and credits, providing transparency and context to help users understand the purpose and background of the game. Additionally, the exit button provides a straightforward way for users to exit the game, ensuring that they have control over their gaming session and can easily close the application when desired. The about display further enriches the user experience by presenting detailed personal data about the developers and contributors, often including biographies, roles, and contributions of the team members involved in the game's creation. This section also contains a return button, enabling users to navigate back to the initial display seamlessly. This design choice ensures that users can easily return to the main menu without any confusion.

or interruption in their experience. The inclusion of these elements in the initial display design is integral to creating an engaging and user-friendly interface, setting the stage for a positive interaction with the game.



Figure 5. Settings Display Design



Figure 6. Level Display Design

In the settings section, there is a feature to turn the music on and off by selecting the sound button. For the level selection display, there are three levels that are part of the game. Each level contains basic taekwondo hand movements from the most basic to intermediate. Then there is a return button.

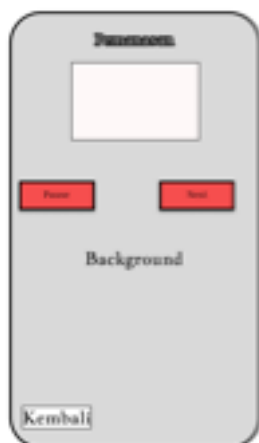


Figure 7. Warm-up Display Design



Figure 8. Play Area Display Design

After selecting the level, the user does not immediately enter the core game but first navigates to the warm-up section. This design choice mirrors real-life training routines, where participants engage in warm-up exercises before beginning the main workout to prevent injuries and prepare their bodies for more intensive activities. The warm-up section in the game includes a series of guided exercises that help users stretch and get ready for the taekwondo training, emphasizing the importance of preparation and safety. In the final display, the portrait position is maintained to ensure consistency and ease of use. The core game area is designed to detect user movements accurately by positioning points at specific locations. If the user's movements align with these points, they earn points, promoting correct technique and encouraging practice until perfection is achieved. This interactive approach not only makes the training more engaging but also provides immediate feedback, helping users to improve their skills effectively. The design implementation phase, as outlined in the previous sections, employs C++ and Java programming languages. This phase involves creating and integrating various interfaces, beginning with the Main Menu Interface. Each interface is meticulously developed to ensure smooth navigation and an intuitive user experience. The main menu provides access to different sections of the game, including the warm-up and core training areas, and is designed to be visually appealing and easy to use. This comprehensive design and development process highlights the game's commitment to providing a realistic and beneficial training experience for users,

combining the principles of User-Centered Design with advanced programming techniques to create a seamless and effective educational tool.



Figure 9. Main Menu Interface Implementation



Figure 10. About Interface Implementation

The Main Menu page has several components. These components include start, about, settings, and exit buttons. On the About display, there is data from the system maker, the application logo, and Taekwondo animation Figures.



Figure 11. Settings Interface Implementation



Figure 12. Level Interface Implementation

In the settings interface implementation, users are provided with several essential options to customize their gaming experience. This view includes on and off buttons, which serve different functionalities to enhance the user's interaction with the game. The on button activates the background music, creating an engaging and immersive environment that can enhance the overall experience. Conversely, the off button allows users to turn off the light, providing a more focused and distraction-free setting, which can be particularly useful in various lighting conditions or user preferences. Additionally, the settings interface prominently features the application logo, reinforcing brand identity and consistency across different sections of the game. Taekwondo animation figures are also included, adding a dynamic visual element that aligns with the game's theme and makes the settings interface more visually appealing and contextually relevant. The level selection page is designed to guide users through choosing their desired difficulty level for the training game. This page features several key components to facilitate easy navigation and selection. The central element is the level figure, which is represented as a silhouette of taekwondo animation. This visual representation not only enhances the thematic consistency but also provides a clear and intuitive indication of the game's focus on taekwondo movements. Three distinct levels are displayed on the level screen, each representing a different difficulty or progression stage in the training. These levels allow users to select an appropriate challenge based on their skill level and training needs. Additionally, a back button is included on this page, enabling users to return to the main menu seamlessly. This feature ensures that users have the flexibility to navigate the game efficiently.

and make adjustments to their settings or level selection without any hassle. The thoughtful implementation of these interfaces highlights the game's commitment to user-centered design, providing an intuitive and customizable experience that caters to individual preferences and enhances the overall usability of the game. By incorporating user feedback and focusing on essential functionalities, the settings and level selection interfaces contribute significantly to creating a user-friendly and engaging training tool for taekwondo enthusiasts.



Figure 13. How to Play Interface Implementation



Figure 14. Prayer Interface Implementation

The How to Play page has several components. The narration on this display is a narration before entering the level selection. Choose one level to proceed to the next stage, and the back button to return to the level selection page. Before entering the Level display, there is a prayer narration before practicing the movements. There is a Next button to continue to the level display.



Figure 15. Warm-up Interface Implementation



Figure 16. Movement Tutorial Interface Implementation

The Warm-up page has several components. These components include back, play, and next buttons. The back button functions if the user chooses to return to the level display, the play button functions if the user wants to pause during the warm-up, and the next button functions if the user has completed the warm-up while the video is playing. Before entering the Play Area page, there is a display that will show movement tutorials that will later become part of the game.



Figure 17. Play Area Interface Implementation

The play area has several components. Components within the play area are a camera switch to change the camera direction, then there are movement names to be implemented up to 10 points. Finally, there are points that serve as a reference if the user has performed the movement correctly up to 10 points.

3.2 Discussion

In the research evaluation stage, data collection was conducted again through questionnaires for success measurement. Testing was conducted on 41 respondents with various respondent characteristics. Respondent characteristics were used to determine the variety of respondents based on gender, age, and also active or inactive in taekwondo activities. This is expected to provide a fairly clear picture of the respondent's condition and its relation to the problems and objectives of the research. Respondents were asked questions about several aspects present in the game using 10 heuristic evaluation criteria aimed at testing the success of the interaction design.

Table 1. Questionnaire Response Calculation Results

No	10 Heuristic Evaluation	Questions	Average Component (%)
1.	Visibility of System	Are there features in the game that allow users to know the correct/appropriate movements Are you provided with tutorials on Taekwondo movements	84,88%
2.	Match Between System and the World	Are there words in the application that have unusual meanings Are there languages that you cannot understand Do you know the language used in the application	80,33%
3.	User Control and Freedom	Does each stage have a cancel feature to repeat the game Are there features in the game that can be cancelled/undone	80,09%
4.	Consistency and Standard	Are the words used in the game commonly used in games in general Is this game consistent with what you do during training Are the movements in the game appropriate with the practice	85,53%
5	Error Prevention	Are the movements in this game based on Taekwondo knowledge in general	88,54%

		Are there movement detection features in the game if the movements are wrong	
6.	Recognition rather than Recal	Are there videos and descriptions of the correct movements in the game Are there tutorials in the game that help you remember those movements	90,24%
7.	Flexibility and Efficiency of Use	Is this game easy to use Is this game suitable for all age groups	89,51%
8.	Aesthetic and Minimalist Design	Does this game have an attractive design to play Does this game have a lightweight size	81,22%
9.	Help Users Recognize, Diagnose and Recover from Errors	Are there error detection features in the game if the movements are incorrect Are there warnings if the game encounters an error	81,71%
10.	Help and Documentation	Are there save features in the game if you exit the game Are there restart features in the game to repeat the previous level	85,85%

This evaluation refers to the ten evaluation heuristics. The first point regarding the Visibility of the System resulted in a score of 84.88%. Then, the following point concerning the Match Between the System and the World yielded a percentage of 80.33%. The evaluation for User Control and Freedom produced a rate of 80.09%. Moving on to Consistency and Standard, it scored 85.53%. The percentage for Error Prevention was 88.54% for the fifth point. The highest average score was achieved for the sixth heuristic, Recognition rather than Recall, which resulted in an average of 90.24%. The average percentage for the seventh heuristic, Flexibility, and Efficiency of Use, was 89.51%. The average score for the eighth heuristic, Aesthetic, and Minimalist Design was 81%. The ninth heuristic, Help Users Recognize, Diagnose, and Recover from Errors, and finally, for Help and Documentation, scored 85.85%. The positive feedback and high evaluation scores across multiple criteria demonstrate that the interaction design effectively meets user needs and enhances the taekwondo training experience. The implementation of User-Centered Design principles has proven successful in creating an engaging, intuitive, and educational game. These results underscore the importance of involving users throughout the design process to achieve a high-quality, user-friendly product.

4. Related Work

Several studies have explored the application of User-Centered Design (UCD) in developing interactive educational tools, particularly in severe games and health applications. Chen (2022) developed a breath-control audio game to support sound sleep, illustrating how UCD can enhance user engagement and the overall efficacy of health-related applications by focusing on user needs and feedback throughout the design process [1]. In education, Ramadhani, Mulyanto, and Niwanputri (2020) employed UCD to design a digital game to teach children computational thinking [4]. Their study highlighted the importance of involving users from the initial stages to ensure the game meets educational goals effectively and is enjoyable for the target audience. Similarly, Aslina, Mulyanto, and Niwanputri (2020) created serious games for Indonesian upper elementary school students, emphasizing the role of UCD in refining game interactions based on continuous user feedback [8]. Taekwondo and physical training, Ashari, Idham, and Fendryan (2019) utilized Kinect camera sensors to recognize and assess taekwondo moves [5]. Their research is particularly relevant to the current study, underscoring the potential of integrating technology with martial arts training to improve movement accuracy and assessment. Shapi'i *et al.* (2018) focused on developing interactive games for autistic children using hand-eye coordination methods. This study demonstrated how UCD can be adapted to create therapeutic tools tailored to the specific needs of children with autism, highlighting the versatility and effectiveness of UCD in addressing diverse user requirements [9]. Schulz *et al.* (2020) explored using UCD in developing scenario-based severe games for healthcare education [7]. Their findings support the notion that UCD can significantly improve serious games' usability and educational value by ensuring that the design process is informed by user input and real-world application scenarios. These studies collectively affirm the efficacy of UCD in creating interactive, user-friendly educational tools across various domains. By involving users throughout the design and development process, UCD helps ensure that the final product is effective and engaging, meeting the

specific needs of its target audience. This body of work provides a strong foundation for the current research on developing a taekwondo training game using UCD principles, leveraging technology to enhance the training experience and improve user outcomes.

While these studies provide substantial insights into the application of UCD in various interactive and educational, this research focuses on developing an interaction design for a basic hand movement training game in taekwondo. Unlike previous studies, this research leverages the UCD approach to create a game that engages users through interactive technology and provides a structured and theoretically grounded training experience for taekwondo practitioners. The novelty of this study lies in its integration of UCD principles with the practical requirements of martial arts training, aiming to enhance both the learning experience and the accuracy of physical movements through real-time feedback and advanced motion detection technologies. By addressing the unique needs of taekwondo training, this research contributes a specialized application of UCD that extends beyond general educational games, offering a targeted solution for sports training and physical education.

5. Conclusion

The game with an interaction design theme for a Taekwondo club using the UCD approach has been tested with 41 respondents who have tried playing the game. The ten heuristic evaluation calculations yielded satisfactory results for the respondents who tried the game. The results obtained in the sixth question regarding Recognition rather than Recall obtained the highest result at 90.24%. Users can easily recognize the movements because there are tutorials in the game. The game also successfully delivered what was expected by the Taekwondo club members with various desires, such as a new application design that met expectations, making this application usable during training and at home. Interviews and focus groups also aided this during training sessions, which made the design more tailored to the club's members. Therefore, it can be concluded that using UCD to create interaction designs yields good results and creates a game that meets their desires by designing it accordingly.

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