

# Optimizing the Blood Donation App with Gamification Using User-Centered Design

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**Abstract:** In today's digital era, motivating the younger generation to participate in routine voluntary blood donations is a significant challenge in the health sector. This research aimed to develop a gamified application called Gamified Blood Donation (G-Blood), designed using the User Centered Design methodology. This application integrates gamification into the blood donation process, with features including donor location information, available blood stock data, and individual donation history. Using gamification elements such as challenges, ranking boards, and emblems enhanced user interactivity and motivation. Evaluation of G-Blood demonstrated its effectiveness in achieving this goal; it scored 75 (Grade B) on the System Usability Scale (SUS), indicating good usability, while an average total index calculation from all responses on the Likert scale of 84.125% underscored its success in motivating younger generations towards regular blood donations. These results suggest combining digital technology with gamification can encourage recurring voluntary blood donation among younger generations. This research opens avenues for further exploration into leveraging digital technology to address other public health concerns.

**Keywords:** G-Blood; User Centered Design; System Usability Scale; Blood Donation; Motivation

## INTRODUCTION

Increasing a sufficient and sustainable blood supply is a challenge in health, especially with the ever-increasing demand for blood transfusions, while blood donation participation still needs to be higher. Factors such as lack of awareness and motivation, fear or hesitation about the donation process and risks, and practical constraints like time limits and physical discomfort often become obstacles. To increase participation in blood donations, effective strategies need to be directed to overcome these barriers through better public education, improved medical service standards, and the provision of more comfortable donation facilities (Shama et al., 2022; Ashipala & Joel, 2023; Yosef et al., 2020).

The Indonesian Red Cross (PMI) is focused on community welfare and blood donation services (Sartika Sari & Hamidah Nasution, 2020). With a high demand for blood bags, about 5.1 million bags per year, various factors inhibiting blood donation participation were identified through preliminary surveys on 17-25-year-old students at Amikom University Purwokerto. These factors include a need for more facilities and information about blood donation procedures, questions about the competence of medical staff, minimal motivation among teenagers to donate blood (Nugraheni, 2019), and a lack of dissemination of information about positive experiences in donating blood. Even though teenagers dominate the donor population demographic, their retention rate is low (Foth et al., 2013). Therefore, increasing awareness and education about blood donations and improving medical service standards could be essential strategies to encourage more teenagers to become active and loyal donors.

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PMI has implemented various strategies, including seeking out blood donors in multiple locations, giving certificates of appreciation, and utilizing digital media to increase participation in donating. These strategies are relevant considering that approximately 75.59% of individuals aged 17-25 are active mobile device users, and many are gamers. However, PMI Banyumas Regency has yet to reach the ideal target of 4% of the total population as voluntary blood donors; the current participation rate is only around 2-3% (UDD Kabupaten Banyumas, n.d.). Innovative strategies targeting young people's needs are needed to increase their participation in voluntary donations and become regular donors.

Blood donor applications have emerged as a potential solution for increasing participation in donating (de Oliveira et al., 2015; Takanagane et al., 2017). These applications facilitate donation processes by providing real-time information about transfusion needs and offering easy access to nearby donation locations. However, existing applications must fully exploit their potential for raising awareness about the importance of donating. This heightened awareness is crucial for ensuring a sustainable supply chain while encouraging more individuals to become donors (Sayedahmed et al., 2020).

According to Wangi et al. (2022), Gamification is a strategy that integrates game design elements into non-game contexts to enhance motivation, engagement, and learning outcomes. Combining elements such as badges or leaderboards into mobile-based donation apps could create a more engaging experience that motivates its users (Fallis, 2013). Gamification has been successfully applied across fields like education, where it effectively changes behavior while enhancing individual motivation (Riduan et al., 2019; Molina-Torres et al., 2021; Struik et al., 2018). Therefore, its implementation within a context related to donations could represent an innovative step toward increasing tech-savvy young donors' regular voluntary activities.

The design application for Gamified Blood Donation (G-Blood) becomes necessary for motivating young generations towards volunteering regularly at donation centers. User Interface (UI) design and User Experience (UX) are essential in this case. UI refers to visual aspects like color uniformity, element consistency, images, icon layout other visual elements that can enhance user comfort during interaction with the application (Putri Aprilia, 2022; Dwinawan, 2016). Meanwhile, UX refers to responses impressions someone might have when interacting product or service Navigation structure important part of application design because it influences user evaluation regarding design quality and provides a memorable experience when participating in donations (W. Kusuma et al., 2019). Therefore layout arrangement and navigation structure within the donor app must be carefully designed to create an attractive appearance and easy operational understanding used by users

The young generation's closeness technology demands optimal UI UX development gamified-based donor apps designed to motivate and increase their participation during donations The user-centered design method becomes essential in this context where the user needs a preferences-centered design process (Kujala & Kauppinen, 2004). UCD proved effective in various fields like website design (Khasanah et al., 2019), medical devices (Aquino Shluzas & Leifer, 2014), architecture user interfaces (UI) (Wu et al., 2022), and decision support systems (Sari et al., 2021), (Defriani et al., 2022). Therefore, the UCD approach can be used to create functional, attractive blood donor applications that motivate young people to donate blood regularly.

## LITERATURE REVIEW

### Gamification

Gamification involves using various game elements such as points, badges, leaderboards, and prizes to create a more interactive and enjoyable learning experience (Inchamnan & Chomsuan, 2021). Gamification aims to enhance participant involvement with interventions and improve compliance and effectiveness of their learning process (Kelders et al., 2018). Gamification, including blood donors, is also recognized as a potential strategy to change behavior. By integrating the elements and techniques of game design into the blood donation process, gamification aims to improve motivation, engagement, and participation in donation activities (Sardi et al., 2019; Mugi Karanja & Njoroge, 2021). In addition, gamification can also deal with psychological factors that influence behavioral change. Gamification aims to move the player's motives from seeking logical gain toward himself, leading to intrinsically motivated behavior (Behl et al., 2023). By combining the elements of pleasure, challenge, and

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achievement, gamification can leverage the individual's intrinsic motivation and make the blood donor experience more enjoyable and beneficial. It can help overcome barriers and increase the likelihood of sustainable behavioral change. In conclusion, gamification has the potential to have a positive impact on blood donor behavior by increasing motivation, involvement, and knowledge among donors. By combining elements and game design techniques, gamification can make the blood donor experience more enjoyable (Lister et al., 2014).

### User Center Design

According to Yasmine & Atmojo (2022), the user-centered design (UCD) is a method that prioritizes users' needs in the design process. It involves gathering feedback, expectations, goals, suggestions, experiences, and evaluations from potential users to create UI/UX designs that are more satisfying to use. This approach ensures the design is based on user requirements and preferences, ultimately leading to a better user experience (Zhang & Liu, 2022). Effective UI design is crucial as it serves as the bridge between users and the programming language. A well-designed UI helps users meet their needs when using an application most effectively. It should be neat, organized, and by user requirements. Additionally, UI design elements such as color, typography, navigation, and input controls play a significant role in creating a user-friendly interface (Doni et al., 2021). In the context of digital solutions, user interface design involves defining interface elements that are easy to understand and interact with (Diehl et al., 2022). It should consider the specific characteristics of the users and the context in which the digital solution will be used. Designers should also know broad and complex issues such as context-oriented design, user requirements, and adaptable and adaptive interactive behaviors. Following established heuristics and principles in UI design can guide designers in creating accessible and universally usable interfaces (Hasani et al., 2022).

### System Usability Scale

According to (Ramadhani et al., 2022), the System Usability Scale (SUS) is a widely used questionnaire that measures the usability of a computer system from the user's subjective perspective. It was developed by John Brooke in 1986 and has since been utilized in various domains to assess usability. The SUS questionnaire consists of 10 items that evaluate aspects such as ease of use, learnability, efficiency, and satisfaction. The SUS has several advantages that contribute to its popularity. Firstly, it is easy to administer and understand by respondents, making it suitable for a wide range of users. Additionally, the SUS can provide valuable insights even with a small sample size, allowing for efficient usability evaluation. It can also distinguish between usable applications and those that are not (A. S. Kusuma et al., 2022).

The SUS has been applied in different research studies to evaluate the usability of various systems. For example, it has been used to assess the usability of mobile application user interfaces (Ramadhani et al., 2022), exergaming platforms for senior fitness testing (Tsai et al., 2020), news applications (A. S. Kusuma et al., 2022), and user interfaces for GMS service companies (Suratno & Shafira, 2022). In these studies, the SUS provided subjective perceptions of usability and helped researchers understand the user experience (Ramadhani et al., 2022; A. S. Kusuma et al., 2022; Tsai et al., 2020; Suratno & Shafira, 2022).

According to Soboczenski et al. (2019), The SUS is considered a standard usability measure and applies across different domains and technologies. It allows researchers to place systems on a scale ranging from dire to excellent usability. By collecting qualitative feedback alongside the SUS scores, researchers can comprehensively understand the user experience and subjective perception of system usability.

In summary, the System Usability Scale (SUS) is a widely used questionnaire that measures the usability of computer systems from the user's subjective perspective. It has advantages such as ease of administration, suitability for small sample sizes, and the ability to distinguish between usable and non-usable applications. The SUS has been applied in various research studies to evaluate the usability of different systems and provides valuable insights into the user experience and subjective perception of system usability.

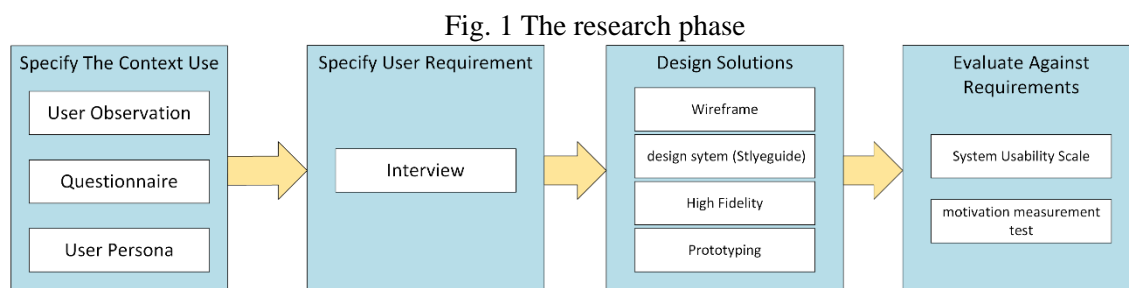
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## METHOD

The research phase describes the research workflow, from the initial research stage to the final step. This research phase can be seen in Fig. 1.



In User-Centered Design (UCD), the "context of use" pertains to the specific circumstances, tasks, and users that a system or application is intended for (Soboczenski et al., 2019). This requires a thorough understanding of user needs, objectives, attributes, and any organizational or environmental factors that could influence the design. For instance, interviews and questionnaires are distributed to potential users when designing a gamified blood donation application. This process aims to ensure that the final design meets the needs and preferences of its intended users so its target audience can effectively use it in the future. In this study's context, 42 students from Amikom University in Purwokerto were involved in interviews and questionnaires. These respondents are young adults with blood donation experience but do not do so consistently.

The second stage in the User-Centered Design (UCD) methodology is "Specify User Requirements," where the main focus is to identify the needs, preferences, and goals of potential users (A. S. Kusuma et al., 2022; Kim et al., 2020). In the context of a gamified blood donation application, techniques such as surveys and interviews are used to gather data directly from potential users. Questionnaires can provide a general picture of what users expect from the application, including which features they consider necessary or valuable.

The Design Solution stage in the design methodology is about crafting a solution based on the previously identified user needs, using the Figma application to assist in the design process and visualization of concepts. This process begins with creating a wireframe, a rough sketch of the appearance and structure of the G-Blood application, which provides an initial idea of how each page or feature will look and function. After completing the wireframe, the next step is developing a design system or style guide for G-Blood, a collection of guidelines dictating design elements such as typography, colors, icons, and other components used consistently throughout the application. The goal here is to ensure visual consistency and enhance user experience. The following step involves High Fidelity Design using Figma, where this design more closely approximates the final version of how the app looks with full-color elements and other graphic details added to it. The final stage is creating a working prototype of the application using Figma. This prototype allows potential users to see how their interaction with features within the app unfolds in real time so they can assess its overall functionality and comfort.

This research employs an evaluation tool known as the System Usability Scale (SUS) to measure the level of satisfaction and ease of use of the application from a user's perspective. This tool provides insight into how well the application design meets user needs and expectations and indicates areas that may require improvement. As a crucial part of this assessment, the study also involves motivation testing. The Likert scale technique is used in this process, which consists of distributing questionnaires to users to gauge their responses to various aspects of the application, including gamification features and how game elements are implemented in app design. Motivation testing is vital because it helps determine whether gamification elements genuinely add value for users or merely serve as aesthetic decoration. In other words, evaluation tools like SUS and the Likert scale ensure that gamification elements genuinely enhance user motivation to become regular voluntary blood donors - the primary goal of creating the gamified blood donation application.

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## RESULT

### Understand the context of use.

The results of identifying potential users to gather precise information from prospective users of the gamified blood donation application are displayed in Table 1 and Table 2.

Table 1 Specifications of Potential Users

Demography	Blood donors, both new and experienced
Geography	Community scope within Banyumas Regency
Psychography	Smartphone users who actively use the internet
Behavior	Regular smartphone usage, need for comprehensive blood donation information.

Table 2 User Needs and Interactions with the Application

Viewing procedural information about blood donation	Participating in existing challenges (Challenge)
Checking available bloodstock	Inviting friends to participate
Locating places for blood donation	Earning badges through participation or achievements
Accessing and downloading personal history of blood donations	Accumulating G-points from completed challenges that can be redeemed during a blood donation event
Setting reminders for upcoming scheduled blood donations	Viewing a leaderboard based on G-points accumulated and challenges completed

The identification results of potential users for the gamified blood donation application have been outlined in two tables. Table 1 presents the prospective users' demographic, geographic, psychographic, and behavioral profiles. Demographically, this application targets both new and seasoned blood donors. Geographically, it is designed to cater to the needs of the Banyumas Regency community. The ideal user is an individual who actively uses a smartphone and the internet (psychographics), frequently uses a smartphone, and requires comprehensive information about blood donation (behavior). Table 2 then provides further details about specific features these potential users expect. These features include the ability to view procedural information on blood donation, participate in challenges, check bloodstock, invite friends to donate, locate nearby donation sites, earn badges as a form of appreciation for their participation in blood donations, download their donation history, see total G-Points accumulated from completing challenges (which can be redeemed during a blood donation event); set reminders for upcoming donations schedules; and view leaderboards based on G-Points and completed challenges. These features are designed to meet users' informational needs about donating blood and enhance their engagement with this activity by adding interactive elements such as challenges and point systems.

### Specify user requirements

The specific needs of the users identified are displayed in Table 3.

Table 3 User Needs

Potential and existing blood donors:	
Ability to view information related to blood donation, such as the procedures.	Ability to check available bloodstock
Access to personal history of blood donations	View upcoming blood donation schedules
Locate and register for blood donations at nearby locations	Guidance on how donors can maintain their blood quality and avoid conditions that could prevent them from donating, such as high or low blood pressure

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Table 3 details the specific needs of prospective and current blood donors. First, they require access to information related to the procedures and requirements for blood donation. Second, a feature to view the availability of bloodstock at nearby donation locations has been identified as a crucial need. Third, users also need to track their donation history to understand their frequency and dates of donations. Fourth, having a feature to view upcoming blood donation schedules greatly aids users in planning their programs. Fifth, locating nearby blood donation sites and registering to donate there is one of the primary needs. Lastly, information or guidance on maintaining blood quality is crucial for donors to ensure that they are in optimal condition for donating blood and avoid situations that could cancel it, such as high or low blood pressure. Thus, this identification indicates various aspects that must be considered in designing the G-Blood application to meet its users' needs.

## Design solution

### Wireframe

A wireframe is designed to provide an initial idea of how a page or feature will look and function. An example of a wireframe design for the G-Blood blood donation application is shown in Fig. 2.

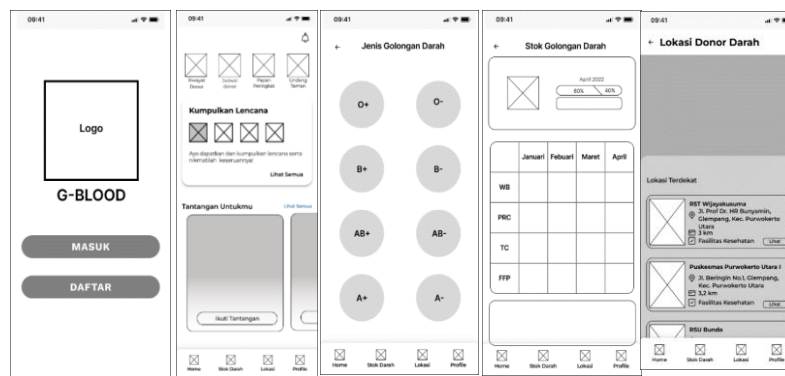


Fig. 2 Wireframe for Login, Main Page, Blood Stock, and Donor Location.

## Design System and Style Guide

After the wireframe is designed, all design systems and style guides are planned for the design needs of the blood donation application. The aim is to determine the basic materials for creating a blood donation application. The Design System and style guide used are shown in Fig. 3.



Fig. 3 Style guide for the blood donation application.

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Fig. 3 displays the style guide, including the font type and primary color palette. The chosen font is Montserrat, a sans-serif font. This choice is based on the visual qualities of Montserrat that give a firm yet elegant impression, a characteristic expected to influence user perception of the application. The primary colors in this style guide were chosen considering the basic color of the Indonesian Red Cross logo, which was used as a reference for primary and secondary colors in application design. However, color selection is not solely based on the visual identity of the Indonesian Red Cross; it is also a result of in-depth research through questionnaires and interviews with young people who have and have not donated blood before. This research resulted in an understanding that the young generation's aesthetic preferences tend towards a color palette that is relatively quiet but also isn't boring. Therefore, the color choices in this style guide reflect a balance between wanting to maintain visual relevance with the identity of the Indonesian Red Cross and the aesthetic aspirations of the target demographic for G-Blood blood donor application.

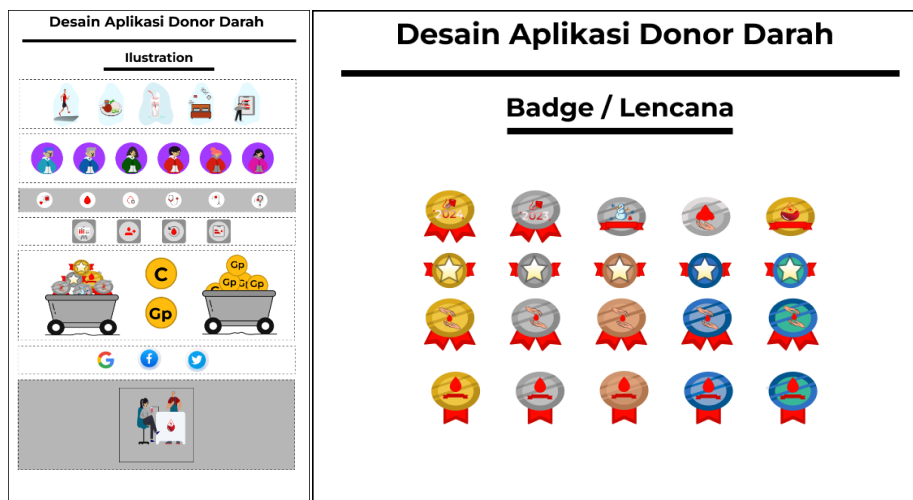


Fig. 4 G-Blood System Design

Fig. 4 shows the design system of the blood donation application, which includes emblem illustrations, information icon illustrations, profiles, challenges, total G-points, coins, icons, and others.

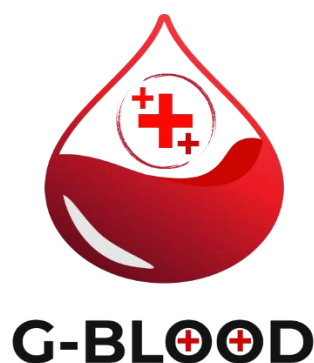


Fig. 5 G-Blood Design Logo

Fig. 5 displays the G-Blood logo. This logo has several symbolic elements, each with a specific meaning. First, the red blood icon serves as a direct representation of the blood donation theme. Red was chosen because it is traditionally associated with courage, passion, and strength - values expected to motivate users to donate blood. Second, the circle in the logo symbolizes one of the blood types. This reflects the G-Blood application's aim to connect donors and recipients from various blood groups.

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Lastly, the positive (+) symbol in the logo directly references the Indonesian Red Cross emblem. This symbol was first used in the Geneva Conference in 1863 and has since become a universal emblem for the International Red Cross and Red Crescent Movement. Overall, G-Blood's logo design reflects this application's mission of facilitating blood donation while respecting the historical heritage and values embodied in Indonesian Red Cross symbols.

### Prototype

Designing an application usually involves several stages, from creating a wireframe to developing a prototype. A wireframe is a basic sketch of the application design that shows the arrangement of the main elements in the user interface. After completing the wireframe, the next step is to create a high-fidelity design. High Fidelity design is a more detailed and complete wireframe version that includes colors, typography, images, and other visual elements. This design provides a clear picture of how the final appearance of the application will look and function. Once the fidelity design is completed, the prototype is built. This prototype is an interactive version of the high-fidelity design that allows users to navigate through various pages and features of the application as in an actual usage environment. In this research, an example of High Fidelity design for a gamification-based blood donation app is shown in Figure 6. In this process, these designs are prototyped so that each page and its features can function and be simulated directly to potential users of such blood donation applications. The aim is to get initial feedback on usability and feasibility before further development or official launch.

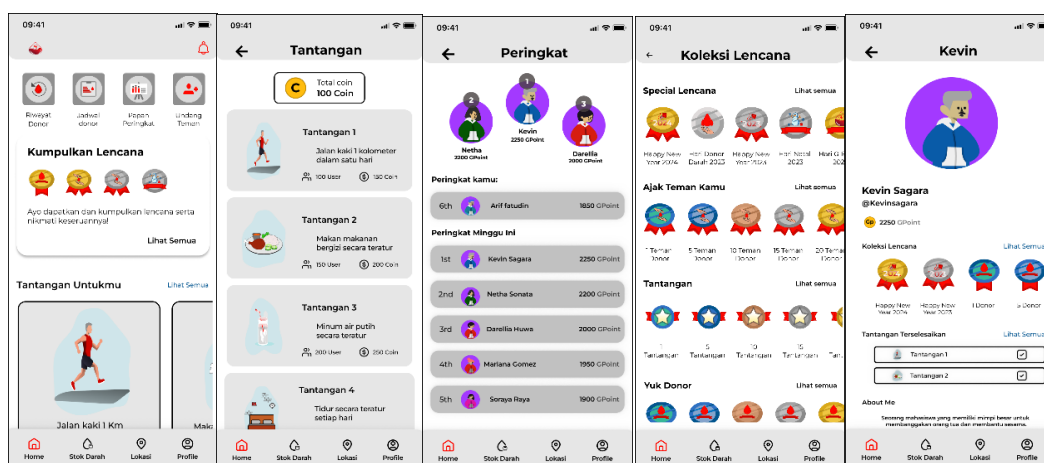


Fig. 6 Gamification design prototype

### Evaluate against requirements

#### System Usability Scale

The System Usability Scale is conducted to measure the level of ease of use (efficiency), success rate (effectiveness), and user satisfaction from the blood donation application prototype (Suyanto & Ependi, 2019). The questionnaire was distributed to respondents who are students of Amikom Purwokerto University who have made voluntary blood donations, which was taken as a sample. Table 4 displays the results of the questionnaire responses.

Table 4. SUS questionnaire results

Questions	Answers				
	SD	D	N	A	SA
Q1 I will use this application.	-	-	6	1	20
Q2 I find the system complicated to use	8	2	1	-	-
		1	2		

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<b>Q3</b>	I think the system is easy to use	-	1	5	2	16
					0	
<b>Q4</b>	I need help from others or developers in using this system.	-	2	9	7	1
			4			
<b>Q5</b>	The system and its features run well.	-	-	2	2	16
					4	
<b>Q6</b>	I feel there are many inconsistencies in design-related matters	4	2	1	2	1
			4	1		
<b>Q7</b>	Others will understand how to use this system quickly.	-	1	6	2	12
					3	
<b>Q8</b>	I need clarification on the system.	9	2	8	-	-
			4			
<b>Q9</b>	I didn't encounter any obstacles in using this system.	-	1	5	1	19
					7	
<b>Q10</b>	I need to familiarize myself first before using this system	1	1	1	1	3
			2	1	4	

Table 4 shows answers from the responses of all respondents regarding their experience with G-Blood blood donation application usage. These responses were then scored based on their feedback using a Likert scale: Strongly Disagree got a score of '1', Disagree got a score of '2', Neutral got a score of '3', Agree got a score of '4', and Strongly Agree got a score of '5'. After all test data was obtained and arranged in tables, the scoring process was carried out next, performed by the System Usability Scale (SUS) testing method, an evaluation tool for measuring user satisfaction level and ease-of-use for any product or service from a user perspective point-of-view. The results from these scores were then categorized into the SUS Score categories list as shown in Fig. 7; these categories provide an overview of how far respondents rated ease-of-use for the app and their satisfaction level. Through such evaluation methods, researchers can better understand user responses toward the G-Blood blood donation app and how gamification elements affect their motivation to donate blood regularly.

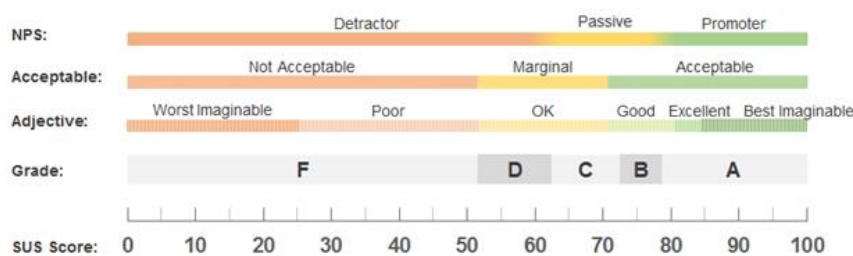


Fig. 7 System Usability Scale (SUS) testing categories

Based on Fig. 7, this study shows the evaluation results of the G-Blood blood donation application using the System Usability Scale (SUS) method. The average score obtained in this evaluation is 75, included in Grade B. In the Adjective Rating category, this value falls into the 'Good' category, meaning that most users are satisfied with the usefulness and operational ease of the application. Furthermore, in the Acceptable category, this value falls into 'Acceptable'. This means that users rate that application as acceptable according to their expectations. Next, on the Net Promoter Score (NPS), that score falls into the 'Passive' category. NPS measures customer willingness to recommend a product or service to others. The 'Passive' type indicates that although users are generally satisfied with the application, they may not actively recommend it to others. Based on these SUS evaluation results, it can be concluded that the G-Blood blood donation application prototype is rated well by respondents. The usability value and user satisfaction level are high, so it's likely to facilitate the blood donation process for the younger generation. This evaluation also serves as an essential basis for further improvements and enhancements on certain features to improve overall user experience.

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Motivation measurement testing

The next test measures user experience improvement and motivation to donate blood regularly. This test also distributed a questionnaire to 42 respondents who had donated blood before. The scores obtained from the questionnaire results will be calculated using the Likert scale formula with the weight value of the answers as follows: Strongly Disagree score 1, Disagree 2, Neutral 3, Agree 4, and Strongly Agree 5. The results of the distributed questionnaire are displayed in Table 5.

Table 5. The questionnaire results

Questions	Answers				
	SD	D	N	A	SA
<b>Q1</b> The applied gamification elements are exciting and can increase motivation to volunteer for blood donation regularly.	-	-	7	18	17
<b>Q2</b> Gamification elements can enhance user experience and meet user needs.	-	-	6	18	18
<b>Q3</b> Gamification elements are very appropriate for a blood donation application.	-	-	5	19	18
<b>Q4</b> Gamification challenge elements can help maintain blood quality and body health.	-	1	6	13	21
<b>Q5</b> The applied gamification challenge elements are easy to follow and can increase motivation for regular voluntary blood donation.	-	-	6	20	16
<b>Q6</b> The presence of gamification challenge elements can increase motivation to maintain more blood quality.	-	2	5	21	14
<b>Q7</b> Having a blood donor application by applying a gamification element helps in donating blood.	-	-	4	20	18
<b>Q8</b> I felt that having a Blood donor application implementing the Gamification element could improve my motivation for regular voluntary donations.	-	-	9	14	19

Based on the results of the Likert scale calculation, it is evident that most respondents strongly agree with implementing gamification elements in blood donation applications. This is indicated by a high average index, which is 84.125%. For each question, the index ranges from 82% to 86%, meaning that there are no significant differences in responses to various aspects of gamification proposed in the questions. Furthermore, no respondents answered below "Neutral" for all questions, demonstrating a solid general acceptance of this idea. The high index indicates that respondents received gamification elements well and see it as a positive enhancement for motivation in regularly volunteering for blood donations. Specifically, they feel that gamification can improve user experience and meet their needs.

**DISCUSSIONS**

The discussion section of this study is centered around the implementation and impact of gamification elements in the G-Blood blood donation application. The results obtained from the System Usability Scale (SUS) evaluation and Likert scale questionnaire indicate a positive response from users towards the integration of gamification. With an average SUS score of 75, which falls under Grade B and is considered 'Good' or 'Acceptable,' it can be inferred that users find the application easy to use and satisfying. Furthermore, with an agreement index of 84.125% based on the Likert scale questionnaire, it's clear that most respondents strongly agree that gamification elements increase their motivation to donate blood regularly. This high agreement among respondents suggests successfully implementing

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gamification strategies within the app. Comparing these results with traditional methods or apps without integrated gamification could highlight its effectiveness even more distinctly. The introduction of game-like elements has fostered a more engaging user experience, motivating regular voluntary blood donations. However, it's important to note that while these findings are promising, they represent initial user responses. Long-term engagement and sustainability remain crucial for maintaining regular blood donations – aspects that require further research. Overall, these findings provide strong evidence supporting the integration of gamification into public health initiatives such as blood donation applications. They demonstrate how effectively designed digital solutions can motivate positive health behaviors among younger generations – critical insights for future development in public health technology (Sardi et al., 2019; Mugi Karanja & Njoroge, 2021).

### CONCLUSION

This study examined the impact of gamification in the G-Blood blood donation app using a User-Centered Design (UCD) approach. The System Usability Scale (SUS) and Likert scale questionnaire results showed that user-focused gamification positively affected user experience and motivation. The SUS score was satisfactory, suggesting an easy-to-use application, while most respondents agreed that gamification elements enhanced their incentive to donate blood regularly. Despite these positive initial responses, further research is needed to assess long-term engagement and donor sustainability. In conclusion, this study strongly supports using UCD-based gamification in public health initiatives to encourage positive health behaviors among younger generations, offering important insights for future public health technology development.

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