International Journal on Advanced Science Engineering Information Technology

Vol.13 (2023) No. 5
ISSN: 2088-5334

Critical Success Factors (CSFs) Model for Military Training Mobile Gaming Apps (MG apps)

Amalina Farhi Ahmad Fadzlah [a,*], Norshahriah Abdul Wahab [a], Suresh Thanakodi [a], Muhammad Lazim Talib [a], Mohd Norsyarizad Razali [a], Mohd Sidek Fadhil Mohd Yunus [a], Muhammad 'Afif Mohd Asri [a]

[a] *Faculty of Science and Defense Technology, National Defence University of Malaysia, Kem Perdana Sg Besi, Kuala Lumpur, Malaysia*
*Corresponding author: *amalina.farhi@upnm.edu.my*

Abstract*— Mobile gaming is a part of worldwide Information and Communication Technology (ICT) characterized by new paradigms and rapid growth (ICT). Integrating mobile games into military training equips trainee officers with the requisite effectiveness, efficiency, and enjoyment to accomplish training assignments. To ensure the optimization and quality of mobile gaming, it is vital to study key success factors (CSFs) to design app user interfaces. This study aims to develop a CSFs model of mobile gaming apps (MG apps) and assess the applicability of the model in military training. This research intends to examine the CSFs of MG apps, build a structure of CSFs of MG apps, and develop a CSFs model of MG apps for the purpose of military training. In the study, a sample of hundreds of cadet officers from the Malaysian Military Training Academy was utilized. The research was conducted in three phases: theoretical analysis, empirical study, and development of the proposed CSFs model of MG apps in military training. This paradigm is helpful to sectors of ICT and Defence Technology as an alternative way to ensure the success of the development of MG apps for military and armed forces education and training. This strategy also provides a new successful mechanism and assurance for using MG apps in military and armed forces education and training, as well as ICT-savvy cadet officers from Malaysia.

***Keywords*— Mobile gaming apps; military education and training; user interface; critical success factor.**

Manuscript received 3 Sep. 2022; revised 7 Nov. 2022; accepted 25 Aug. 2023. Date of publication 31 Oct. 2023.

I. INTRODUCTION

The most often used concept in software engineering that outlines the user and demand of an app is useful and usable components [1]. In addition, success describes the main success elements for building a user interface that is easy to comprehend, learn, operate, and aesthetically pleasing [2]. The primary objective of developing success factors is to effectively, efficiently, and satisfactorily fulfill the predetermined objectives in the stated circumstances [3]. In addition to correlating with designing and developing user interfaces, success criteria contribute to the overall acceptance of apps [4].

Due to the widespread significance of this rule of thumb, numerous experts and researchers [5]–[8] have proposed various generic criteria. Developers and assessors are tasked with attributing the term "generic" to the development of a variety of system kinds. Several studies considered only one aspect of user interfaces; however, these criteria were initially established for desktop programs [9]–[15].

Several issues and difficulties related to existing factors must be considered while developing user interfaces for mobile apps [16]–[20]. According to some researchers, designing a full set of elements for mobile apps is necessary. [21][22]. Consequently, many elements have been proposed to overcome physical constraints and enhance the user interface design of mobile apps [23]–[27]. These aspects are not only significant from the standpoint of research, but they are also the outcome of recent discussions among mobile UI designers and developers.

However, these characteristics do not include studies on the design of user interfaces for MG apps. According to Gerling et al. [28]-[29], mobile games may contain visual modification options that provide feedback across many modes (multi-modal) rather than a single communication channel [30]. In addition, the characteristics of developing user interfaces for MG apps differ from those of designing user interfaces for other mobile apps, therefore contradicting these considerations. Few studies were anticipated to investigate mobile game elements [31]–[36].

The rise in the number of mobile users in the military has increased the significance and relevance of designing and developing mobile game apps that can also be used for military training [37]. The creation of an interface appropriate for military training and the mode of interaction and skills while using touch technology has been addressed in previous attempts to develop MG applications for the military [38]-[40], [32]. There are also numerous works on developing user interface design factors for military MG apps. These aspects centered on building games for interaction paradigms ideal for rehabilitation therapy, cognitive and entertainment, interface design, and visual adaptation [41]–[45].

However, none of the researchers focused on building models to design user interfaces of MG apps for military training [46]. Hence, there is a major need for this study to be conducted to build a new model for creating user interfaces for mobile games for military training. The proposed model is helpful to the fields of ICT and Defense Technology, which serves as an alternate way to ensure the success of mobile apps in the context of military training. In addition to providing a new mechanism and assurance for MG apps in military training, this model also aims to equip expert ICT Malaysian military cadet officers with a deeper understanding of how mobile game apps function in their context.

"Serious games" are frequently used in contexts other than entertainment [47]. There are numerous examples of successful apps of games for military training [48]. The US, UK, Australian and Dutch armies employ Virtual Battlespace 2 [49]-[50], based on the commercial game Armed Assault, to train soldiers in fundamental infantry tactics. Steel Beasts [51]-[52] is a simulation game for training tactical vehicle movement and warfare that has been used for years. Tactical Iraqi [53]-[54] is a game that teaches soldiers how to communicate with Iraqi people using their language and cultural norms. Although America's Army [55]-[56] is more of a recruitment tool than a pure training game, it is one of the classic instances of serious games.

Due to improvements in realism and immersion, mobile games have a greater potential to be used in military training [57]. The military now uses mobile games to educate people because they give a visually accurate, immersive training environment and are inexpensive. Military training instructors increasingly utilize mobile games to instruct soldiers in various abilities and tactics [58]. While employing mobile games as a training tool, teachers confront obstacles. However, the user interface design is one of the most important aspects to consider. As a practical consequence, training effectiveness is frequently compromised by using predetermined models [59]–[62].

Previous authors highlighted features of user interfaces as user involvement, experience, and emotion in design [63]–[72]. Hallnas and Redstrom [73] viewed aesthetics as the logic of expression and a basis for designing presence, defining an expression as an object that is intended to carry a particular expression [74]-[75]. Petersen et al. [76] proposed a framework to differentiate between the aesthetics of use and appearance based on Shusterman's idea of Pragmatist Aesthetics [75].

Djajadiningrat et al. [77] discussed the role of affordances in aesthetic design and Norman's propositions for affective design with feedback dimensions. Lavie and Tractinsky [78] stated that aesthetics has two dimensions. Classical aesthetics emphasizes orderly and clear design and is also related to design rules such as principles [79]-[81]. To aid in the design of emotionally evocative interfaces, Kim et al. [82] tied design features and aesthetic responses to feelings that users typically experience when observing relationships. Park et al. [83] studied key aspects that affect the degree to which users feel and discovered that the diversity of user perception was directly related to the aesthetic quality of interfaces.

Researchers have studied a variety of success metrics for MG apps, including download volume, revenue and average user star rating [84]–[86]. Existing research has considered these variables as dependent and/or independent variables [87]-[90]. These studies demonstrated a positive relationship between user ratings and a number of ratings and download volume, a negative effect of price and a positive effect of ranking list position on download volume, and a positive effect of regular updates, placement in less popular categories, and a high volume of user reviews on sustaining the position of an app on top grossing ranking lists [91]–[93]. The success metrics and ongoing use were used in past mobile game research.

Considering that research has proven a favorable correlation between continuous use and enjoyment with hedonic systems, enjoyment-affecting aspects are vital to a game's success [94]. Identified characteristics include game design qualities (e.g., aesthetics, content, ease of use, and novelty) [95]-[99], social attributes (e.g., social norms, connecting to peers, and reputation) [100]-[103], and use context (e.g., location and mobility) [104]–[110]. Therefore, the researchers proposed that the download and continuous use of a mobile game (i.e., user engagement) are heavily influenced by its visibility and quality as well as social qualities that are provided by the presence of other players [111]-[112].

This demonstrates that important success elements for developing acceptable and valuable user interfaces are increasing. For these reasons, there is a compelling need for this study to investigate important success elements and create a new model in developing user interfaces of MG apps for military training.

II. Materials and Methods

Measurement, which can help to determine the degree of success or failure quantitatively, plays an important role in the empirical approach. Based on the above statements, this research was conducted based on the empirical approach, which followed the basic flow of a linear cycle through three main phases of the research method.

A. Theoretical Analysis

A thorough review of secondary data that yielded current state-of-the-art in developing the CSFs model was conducted. Based on these findings, an initial conceptual model was developed, and a list of research hypotheses was delivered to further probe for questionnaire construction. Papers published from the core forum of HCI research were scanned to identify current practices in assessing the successfulness of the developed MG apps. Studies presented in the journals were selected as the presentations were more carefully conducted and thoroughly reviewed.

A conceptual framework was developed as a guideline to propose a CSFs model. The procedure for constructing this logic-based graphical framework provided a conceptual model for analyzing and understanding the relationships between each success component. In order to confirm which success components were related to its consecutive hierarchy, hypothesized relationships were developed and needed to be tested. The hypotheses were divided based on two main relationships: critical factors that contributed to the attribute and attributes that contributed to the success of the MG apps as the goal.

B. Empirical Study

A questionnaire survey was conducted to test the research hypotheses outlined previously. Findings from this empirical study phase were then used to develop and construct a CSFs model. A questionnaire survey was developed to elicit responses from target respondents of mobile gamers. This instrument, Identifying Critical Success Factors (CSFs) of MG apps: From the Perspectives of User Interface, was used to guide whether to accept or reject the hypotheses outlined.

Before using the instrument, data was collected among students from Universiti Pertahanan Nasional Malaysia (UPNM). Data from these target respondents included various categories of demographic profiles, mobile usage experience and MG apps usage. Statistical Package for the Social Sciences (SPSS) program for analysis of Descriptive Statistics, Pearson's Chi-square, and Spearman's Rho were used to analyses the data. These approaches revealed the links involved in constructing a model of CSFs.

C. Model Development

This phase involved constructing an appropriate CSFs model for assessing the success of the developed MG apps. This was firstly done by identifying the appropriate weight value for each critical component towards its consecutive hierarchy. Codes were constructed for each critical component based on their hierarchical levels. By concentrating and focusing on the critical components to assess success, the relationships of each practice towards their consecutive hierarchies were viewed. In order to develop a hierarchical model, a conceptual framework, Critical Success Factors Framework (CSFs Framework) was introduced. This framework brings together different critical components and hierarchical levels, as discussed below:

1) Goal: At the highest hierarchy, the main objective of a goal is to satisfy certain successful requirements by identifying attributes that belong to a class of components that is related to assessing the overall success of MG apps.

2) Attributes: At the medium-level hierarchy, the main objective of attributes is to satisfy certain successful requirements by identifying factors that belong to a class of components that is related to accessing the success of the MG apps.

3) Factors: The main objective of factors is to satisfy certain success requirements by identifying critical components that belong to a class of practices related to accessing external values of user interfaces that depend on the context of use of users, tasks, equipment, and environment.

Each layer reflects interaction with other levels and has an effect on others. This can be explained as none, one or multiple elements may constitute a single attribute, and a collection of these attributes may represent the target. Components of the CSF were categorized according to their hierarchical levels, as illustrated in Table 1.

TABLE I
CSFs COMPONENTS

Factor	Attribute	Goal
Errors detected	Accuracy	Successfulness
Inputs entered		
Words written		
Buttons clicked		
Controls tapped		
Icon illustrated	Attractive	
Image appeared		
Text highlighted		
Color used	Behavior	
Layout presented		
Icon used		
Menu used		
Bar scrolled		
Practice needed	Cognitive Load	
Strategies employed		
Approach adopted		
Knowledge applied		
Skill adapted		
Task completed	Effectiveness	
Unintended actions		
Goal achieved		
Task completion rate	Efficiency	
Time to complete tasks		
Physical demand	Effortless	
Mental demand		
Temporal demand		
Performance demand		
Support demand		
Frustration demand		
Slip error	Error	
Input error		
Scenario error		
Interface error		
Task repetition	Learnability	
Usage familiarity		
Interface simplicity		
Design consistency	Memorability	
Re-establish proficiency		
Easy to remember		
User attitude	Satisfaction	
Comfort level		
Apps relevancy		
Usage acceptance		
Angle located	Steadiness	
Position arranged		
Data-entry rate		
Movement performed		
Time of interaction	Timeliness	
Time of learning		
Time of usage		
Time to start a task		
Time to end task		
Instruction delivered	Understand-ability	
Command retrieved		
Information conveyed		

A. Instrumentation

Questionnaires were developed to elicit responses from the target respondents. The instrument, Identifying Critical Success Factors (CSFs) of MG apps: From the Perspectives of User Interface, was also used to guide whether to accept or reject the hypotheses discussed previously. The results of the hypotheses tests were further used to develop a CSFs model for assessing the success of MG apps. Each part of the questionnaire was described below, and the discussions were segmented based on four parts.

The first part consisted of a section that comprised five questions that asked for respondents' gender, category, educational background, year of study, and experience in military practices. The second part consisted of a section that comprised four questions that asked for respondents' expertise, years of experience, usage frequency and duration in playing military-based MG apps. The third part consisted of a section that comprised six questions that asked for respondents' experience and likeliness in playing three different categories of military-based MG apps such as strategy, tactical, and operational games. Meanwhile, the last part consisted of fifty-five plus fourteen questions which required respondents to rate on a 5-point scale with the options of extremely important, slightly important, undecided, slightly unimportant and extremely unimportant in assessing the success of MG apps.

B. Pilot Study

In order to address the research survey, the pilot questionnaire was read by a panel of experts. The panels suggested some extra practices that should be included and excluded from the questionnaires. All positive opinions given by the experts were incorporated in the final questionnaires, whereas negative comments were eliminated from the instrument. Finally, the same panels reviewed an enhanced pilot survey, and the results confirmed that the questionnaire was appropriate and valid to be distributed to the pilot respondents.

In order to test the reliability of the pilot questionnaire, a survey was conducted among sixteen mobile game volunteers. The responses were then tested using Cronbach Alpha to determine whether the survey instrument was reliable or unreliable to be distributed as a final questionnaire. The Cronbach Alpha procedure (Cronbach 1951), used on the instrument's non-demographic items to determine internal consistency, produced a score of 0.913. The composite scale reliability indices indicated that all questions in the instrument met the minimum cut-off requirement of 0.85. Thus, this pilot study confirmed that the survey instrument was appropriate, and the overall instrument was proven reliable and consistent for distribution.

C. Data Collection

To gain the number of portable computer users among students in Universiti Pertahanan Nasional Malaysia, invitation emails that asked for participation were sent to all students in each faculty. Only 217 of the total students responded (9%) indicated their willingness to participate in the survey. A total of ninety-nine usable survey forms were returned, representing the sample of the study.

D. Data Analysis

Statistical analysis was used to ensure that quantitative variables were precisely measured, and confidence level was attained, which substantiated the findings. The data analysis followed a non-parametric statistical design since the data was in ordinal form. The statistical test results will be discussed as major findings to answer the research questions. The Descriptive Statistics test was used to determine the frequency and percentage of demographic profiles, mobile game background, and specific military-based mobile game experience. The Descriptive Statistics test was also used to analyze each critical component in assessing the success of MG apps.

Pearson's Chi-square test was done to determine statistical relationships between factors and attributes as well as attributes and goals. Spearman's Rho statistical analysis measured directions and the strength of linear relationships between two hierarchies. A positive coefficient implies a positive direction, while a negative coefficient implies inverse relationships. Results of this procedure that indicated the nearest coefficient value implied the relationships that contributed the most towards assessing the success of MG apps.

III. Results and Discussion

An exploratory study was conducted to present a specific analysis that supported the development of a model for assessing the success of MG apps. In order to discuss the surveyed analysis, the results of the relationship strength between each critical component towards its consecutive hierarchy were discussed. The outcomes concluded the overall critical components and hierarchies as the requirement for developing a model for assessing the success of MG apps.

Results of the relationship test showed that four factors were found to have no significant relationship towards its consecutive hierarchy in assessing the success of MG apps, which indicated negative relationship strengths. The remaining factors were found to be directly contributed to their consecutive hierarchy, which indicated a positive correlation level of significance at the p-value < 0.05 with various relationship strengths (Refer to Table 2).

TABLE II
RELATIONSHIP STRENGTH OF FACTORS AND ATTRIBUTES

Factors and Attributes	S-Rho	Relation
Accuracy		
Errors detected	.252**	Positive
Inputs entered	.196**	Positive
Words written	.211**	Positive
Buttons clicked	.215**	Positive
Controls tapped	.332*	Positive
Attractive		
Icon illustrated	.249**	Positive
Image appeared	.199**	Positive
Text highlighted	.244**	Positive
Behavior		
Color used	.158**	Positive
Layout presented	.519*	Positive
Icon used	.257*	Positive

Factors and Attributes	S-Rho	Relation
Menu used	.151**	Positive
Bar scrolled	.224**	Positive
Cognitive Load		
Practice needed	.258**	Positive
Strategies employed	.339*	Positive
Approach adopted	.216**	Positive
Knowledge applied	.389*	Positive
Skill adapted	.438*	Positive
Effectiveness		
Task completed	.219**	Positive
Unintended actions	.215**	Positive
Goal achieved	.260*	Positive
Efficiency		
Task completion rate	.196**	Positive
Time to complete tasks	.243**	Positive
Effortless		
Physical demand	.237**	Positive
Mental demand	.111**	Positive
Temporal demand	.242**	Positive
Performance demand	.265*	Positive
Support demand	.075**	Positive
Frustration demand	.146**	Positive
Error		
Slip error	.347*	Positive
Input error	.179**	Positive
Scenario error	-.092	Negative
Interface error	-.094	Negative
Learnability		
Task repetition	.194**	Positive
Usage familiarity	.211**	Positive
Interface simplicity	.449**	Positive
Memorability		
Design consistency	.213**	Positive
Re-establish proficiency	.133**	Positive
Easy to remember	.018	Positive
Satisfaction		
User attitude	.184**	Positive
Comfort level	.205**	Positive
Apps relevancy	.144**	Positive
Usage acceptance	.251**	Positive
Steadiness		
Angle located	-.045	Negative
Position arranged	.455*	Positive
Data-entry rate	.182**	Positive
Movement performed	.139**	Positive
Timeliness		
Time of interaction	.219**	Positive
Time of learning	.147**	Positive
Time of usage	-.088	Negative
Time to start task	.094**	Positive
Time to end task	.388**	Positive
Understand-ability		
Instruction delivered	.483**	Positive
Command retrieved	.270*	Positive
Information conveyed	.354*	Positive

[1] *Legend of the table: ** Correlation is significant at the level of 0.05 (2-tailed) and range in the value of +1 to –1. * Correlation is significant at the level of 0.01 (2-tailed) and range in the value of +1 to –1.*
[2] *Legend of the table: Grayed entries denote that the components listed have no significant relationship towards its upper hierarchical level.*

Results of the relationship test showed that all attributes were directly contributed towards their consecutive hierarchy in assessing the success of MG apps, which indicated positive correlation level of significance at the p-value < 0.05 with various relationship strengths (Refer to Table 3).

TABLE III
RELATIONSHIP STRENGTH OF ATTRIBUTES AND GOAL

Attributes and Goal	S-Rho	Relation
Successfulness		
Accuracy	.739**	Positive
Attractive	.624**	Positive
Behavior	.871**	Positive
Cognitive Load	.522**	Positive
Effectiveness	.675**	Positive
Efficiency	.739**	Positive
Effortless	.795**	Positive
Error	.317**	Positive
Learnability	.615**	Positive
Memorability	.400**	Positive
Satisfaction	.706**	Positive
Steadiness	.717**	Positive
Timeliness	.706**	Positive
Understand-ability	.498**	Positive

In order to assess the success of MG apps, a model, which was Critical Success Factors Model (CSFs Model), was introduced. As a result, a total number of fifty-one critical factors and fourteen attributes were found to be significantly contributed towards assessing the success of MG apps. These critical components, factors, and attributes were first ranked based on weights.

A. Weightage Values

The details of weightage values were obtained from the normalized relationship strength value results. Scores for each weightage could be introduced as the product of the un-normalized relationship strength value which was divided by the total corresponding relationship strength value as presented in the following equation.

$$\text{Weightage} = \frac{\text{The un-normalized relationship strength value}}{\text{Total corresponding relationship strength}} \quad (1)$$

The weightage values for each critical factor towards its consecutive attributes and weightage values for each attribute towards the goal are outlined in Table 4 and Table 5.

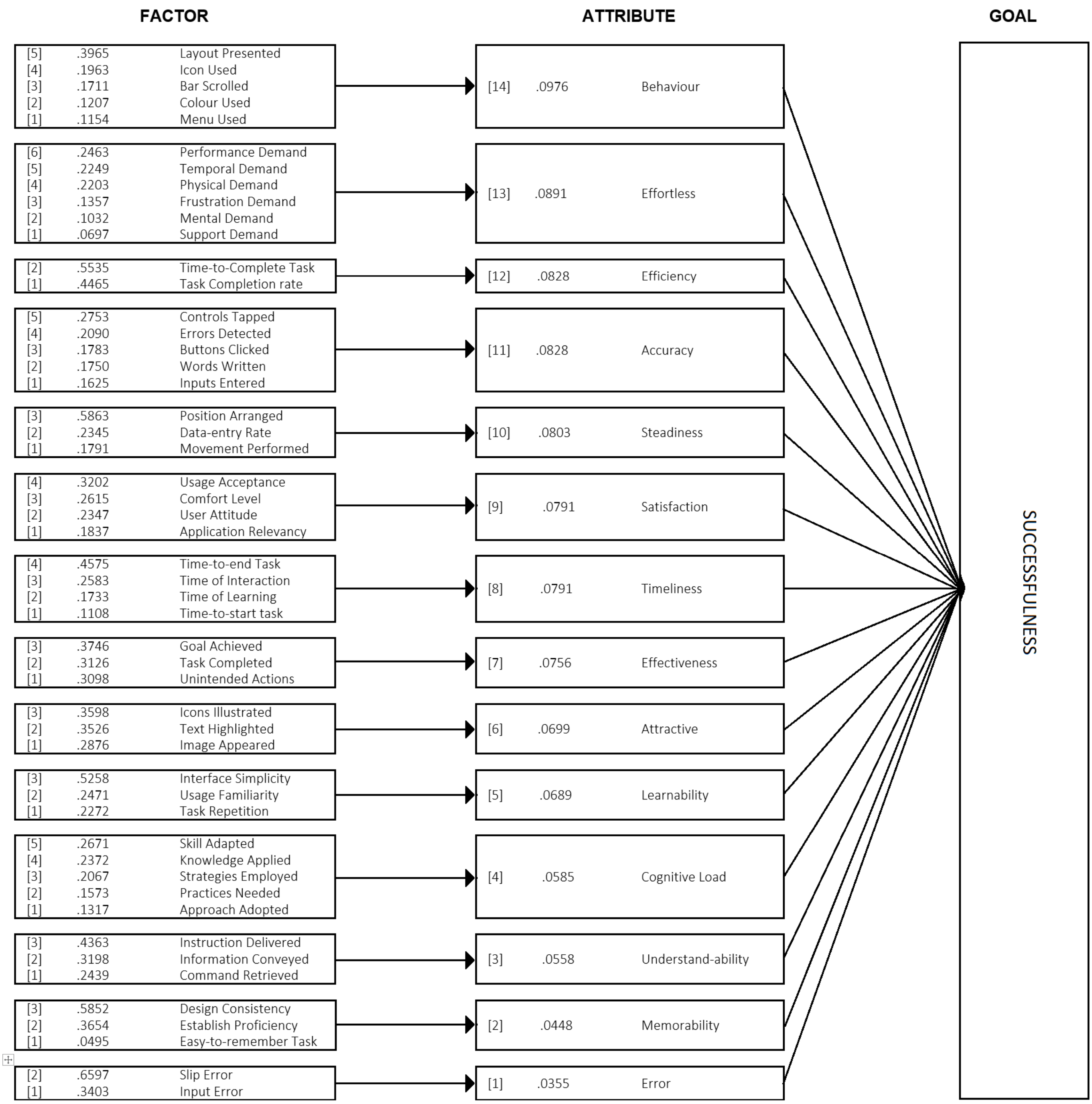

Fig. 1 The Critical Success Factors Model (CSFs Model)

TABLE IV
WEIGHTAGE VALUE OF FACTORS AND ATTRIBUTES

Factors and Attributes	Weightage	Rank
Accuracy		
Errors detected	0.2090	4
Inputs entered	0.1625	1
Words written	0.1750	2
Buttons clicked	0.1783	3
Controls tapped	0.2753	5
Attractive		
Icon illustrated	0.3598	3
Image appeared	0.2876	1
Text highlighted	0.3526	2
Behavior		
Color used	0.1207	2
Layout presented	0.3965	5
Icon used	0.1963	4
Menu used	0.1154	1
Bar scrolled	0.1711	3
Cognitive Load		
Practice needed	0.1573	2
Strategies employed	0.2067	3
Approach adopted	0.1317	1
Knowledge applied	0.2372	4
Skill adapted	0.2671	5
Effectiveness		
Task completed	0.3156	2
Unintended actions	0.3098	1

Factors and Attributes	Weightage	Rank
Goal achieved	0.3746	3
Efficiency		
Task completion rate	0.4465	1
Time to complete tasks	0.5535	2
Effortless		
Physical demand	0.2203	4
Mental demand	0.1032	2
Temporal demand	0.2249	5
Performance demand	0.2463	6
Support demand	0.0697	1
Frustration demand	0.1357	3
Error		
Slip error	0.6597	2
Input error	0.3403	1
Learnability		
Task repetition	0.2272	1
Usage familiarity	0.2471	2
Interface simplicity	0.5258	3
Memorability		
Design consistency	0.5852	3
Re-establish proficiency	0.3654	2
Easy to remember	0.0495	1
Satisfaction		
User attitude	0.2347	2
Comfort level	0.2615	3
Apps relevancy	0.1837	1
Usage acceptance	0.3202	4
Steadiness		
Position arranged	0.5863	3
Data-entry rate	0.2345	2
Movement performed	0.1791	1
Timeliness		
Time of interaction	0.2583	3
Time of learning	0.1733	2
Time to start task	0.1108	1
Time to end task	0.4575	4
Understand-ability		
Instruction delivered	0.4363	3
Command retrieved	0.2439	1
Information conveyed	0.3198	2

TABLE V

WEIGHTAGE VALUE OF ATTRIBUTES AND GOAL

Attributes and Goal	Weightage	Rank
Successfulness		
Accuracy	0.828	11
Attractive	0.699	6
Behavior	0.976	14
Cognitive Load	0.585	4
Effectiveness	0.756	7
Efficiency	0.828	12
Effortless	0.891	13
Error	0.355	1
Learnability	0.689	5
Memorability	0.448	2
Satisfaction	0.791	9
Steadiness	0.803	10
Timeliness	0.791	8
Understand-ability	0.558	3

B. Model Construction

In order to construct a CSFs model, the critical components, which were factors and attributes, were firstly ranked based on the weightage value. The greater the weightage value, the higher the rank of the components. The rank for each attribute towards success as the goal for assessing MG apps also contributed to the construction of the model (Refer to Fig. 1).

This study was mainly conducted to build a CSFs model for evaluating the success of MG applications based on empirical findings. Major results were framed to achieve the specific research questions objectives as discussed below.

- *What critical components can be associated with assessing the success of MG apps?* Fifty-five plus fourteen critical components were found to be associated with assessing the success of MG apps. These critical components ranged from the lowest measurement to the highest measurement of success as the aim of the process.
- *What hierarchies can be associated with assessing the success of MG apps?* The fifty-five plus fourteen critical success components were categorized into three different hierarchy levels which contained critical factors as the basic measure. This was followed by upper hierarchy levels of critical attributes as well as success as the goal.
- *What is the* ***importance*** *of each critical component towards its consecutive hierarchy in assessing the success of MG apps?* Only four out of fifty-five critical success factors were found to be important and had an association with their consecutive hierarchy. Meanwhile, all fourteen attributes were found to be strongly associated towards assessing the success of MG apps.
- *What is the* ***relationship*** *for each critical component towards its consecutive hierarchy in assessing the success of MG apps?* Among fifty-one critical success factors, fourteen attributes were found to be positively correlated towards their consecutive hierarchical level in assessing the success of MG apps.
- *What is the* ***strength*** *for each critical component towards its consecutive hierarchy in assessing the success of MG apps?* By establishing a relationship test, the strength of the linear association between two critical success components in different consecutive hierarchy was obtained and observed. Thirteen critical factors were found to be highly significant and had large strength to their corresponding attributes. However, majority of the factors were moderately involved and had medium strength. The remaining four factors were analyzed as having low significant and had small relationship strength towards their corresponding attributes. The four remaining critical factors were then excluded from the study. Results also reported that fourteen critical attributes had large relationship strength and were strongly correlated towards success as the goal. None of the critical attributes were observed as having medium and low relationship strength toward measuring the overall usability of portable apps.
- *What is the* ***rank*** *for each critical component towards its consecutive hierarchy in assessing the success of MG apps?* According to the analysis, a higher coefficient value indicated the top-rank critical success components, which would be the most deserving measures for quantifying the overall success of MG apps.

- What are the **weights** for each critical component towards its consecutive hierarchy in assessing the success of MG apps? A set of weights used for assessing the success of MG apps was defined based on the findings from the relationship strength test conducted. Two critical factors were observed as having weight values of less than .100, fifteen with values between .100 and .200, sixteen critical factors between .200 and .300, ten critical factors between .300 and .400, three critical factors between .400 and .500, four critical factors between .500 and .600 and only one critical factor with more than .600. One critical attribute was indicated as having weight values of less than .400 as well as between .400 and .500. Meanwhile, two critical attributes were identified as having higher weights which ranged from .500 to .600, two critical factors between .600 and .700, and three critical factors between .700 and .800. Finally, four critical attributes were indicated as having weight values between .800 and .900, and only one was stated as having a weight value of higher than .900.

By examining current practices and proposing a new approach to develop a CSFs Model, the lists of research contributions along with their explanations were provided below.

- *Comprehensive list of critical success components for assessing MG apps*: These critical components were expressed as a set of requirements in which the system used depending on its intended context. These components were used as the basic foundation to develop a model for assessing the success of MG apps.
- *Hierarchical model for assessing MG apps*: The hierarchical level of the CSFs Model was developed based on three different stages of factors, attributes, and goal, to assess the success of MG apps.
- *Alternative technique in analyzing and developing successful MG apps*: By concentrating on raising issues of success, this technique provides a common basis for comparing systems and helping in selecting a suitable product based on their needs. By producing a quantifiable rating of critical success factors, the overall success of the mobile game products can be assessed.

Suggestions that could be used for further improvement and enhancement of the model were provided, which could give a frame of reference in assessing the success of MG apps.

- *Review literature on recent usability components:* The literature review, which involves investigating critical components for assessing MG apps, generally lags several years behind. It would be helpful if future research could present more up-to-date critical components toward quantifying the success of MG apps.
- *Conduct survey on different respondent backgrounds:* A questionnaire survey was conducted based on specific category of respondents. However, it would be more challenging to investigate with developers, designers, and analysts. This could present more accurate outcomes towards other effects that are actually involved in the design and development of mobile game apps.
- *Integrate model to qualitative research approach:* An empirical study exploring the quantitative importance of critical success factors was conducted in this study. By combining qualitative approaches, this model might be more appreciated under a real context of use within different human potential, technical strategies or knowledge backgrounds.
- *Evaluate cases against actual mobile game environments*: With extensive apps experiences, critical success factors for assessing MG apps might change. Future work might incorporate more brand-new crucial elements. As a result, the developed model needs to be practically improved using numerous apps in the actual workplace.

IV. Conclusion

Due to the lack of a rigorous statistically based technique for determining important factors, both theory and practice of developing good user interfaces for MG apps have been constrained. The research offered a preliminary statistically based specification and method designed to generate a crucial success model for MG apps from the perspective of designing and building successful user interfaces. The primary advantage of using a statistically oriented strategy is that it provides a systematic means of doing evaluation research on the topic of designing user interfaces for MG apps.

A detailed analysis should focus on mathematical standards for measuring the level of success of MG apps, especially from the perspective of user interfaces, as research is an ongoing process. In turn, the adaptation of future mathematical equations has provided greater direction for establishing the best way to evaluate the overall effectiveness of the design and development of MG apps. By incorporating crucial success elements, user interface principles, and mathematical formulation, this future work is projected to be effectively implemented into the development methodologies of general mobile gaming apps.

Acknowledgment

The researchers express their gratitude to the Faculty of Science and Defence Technology, National Defence University of Malaysia, Centre of Research and Innovation, National Defence University of Malaysia, and Ministry of Higher Education, Malaysia.

References

[1] H.-J. Hoffmann, “Software Engineering in User Interface Design with Guidelines — from Traditional Applications to the Web Sphere — ,”*Springer eBooks*, 2001, pp. 263–272. doi: 10.1007/978-1-4471-0279-3_25.

[2] B. Shneiderman and C. Plaisant, *Designing the User Interface: Strategies for Effective Human-Computer Interaction (4th Edition)*. 2004. [Online]. Available: https://dl.acm.org/citation.cfm?id=983803

[3] A. Dix, J. Finlay, G. D. Abowd, and R. Beale, “Human-Computer interaction,” *Springer eBooks*, 2013, p. 869. doi: 10.1007/978-1-4614-3858-8_100431.

[4] S. Cronholm, "The usability of usability guidelines: a proposal for meta-guidelines." *Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design*. doi:10.1145/1738826.1738864.

[5] B. Shneiderman, "Shneiderman's" Eight Golden Rules of Interface Design". https://www.interaction-design.org/literature/article/shneid-erman-s-eight-golden-rules-will-help-you-design-better-interfaces (accessed 28-Jul-2019).

[6] B. Barker, *Basic principles of human Computer interface Design*. 1989.

[7] B. Shneiderman, “Designing for fun,” *Interactions*, vol. 11, no. 5, pp. 48–50, Sep. 2004, doi: 10.1145/1015530.1015552.

[8] T. Mandel, *The elements of user interface design*. 1997.

[9] B. Shneiderman, “Designing the user interface: Strategies for effective human-computer interaction,” *Applied Ergonomics*, vol. 24, no. 4, p. 295, Aug. 1993, doi: 10.1016/0003-6870(93)90471-k.

[10] A. Dix, J. Finlay, G. D. Abowd, and R. Beale, “Human-Computer interaction,” in *Springer eBooks*, 2013, p. 869. doi: 10.1007/978-1-4614-3858-8_100431.

[11] B. S. Institution, *Ergonomic Requirements for Office Work with Visual Display Terminals (VDTs): Dialogue principles*. 1996.

[12] D. L. Scapin and J. M. C. Bastien, “Ergonomic criteria for evaluating the ergonomic quality of interactive systems,” *Behaviour & Information Technology*, vol. 16, no. 4–5, pp. 220–231, Jan. 1997, doi: 10.1080/014492997119806.

[13] S. L. Smith and J. N. Mosier, “Guidelines for designing user interface software,” MITRE. Aug. 1986. doi: 10.21236/ada177198.

[14] K. Mullet and D. Sano, *Designing Visual Interfaces: communication oriented techniques*. 1995. http://ci.nii.ac.jp/ncid/BA25828473 (accessed Jul. 15, 2022)

[15] S. L. Smith and J. N. Mosier, “Guidelines for designing user interface software,” Aug. 1986. doi: 10.21236/ada177198.

[16] N. Z. Ayob, A. R. C. Hussin, and H. M. Dahlan, “Three layers design guideline for mobile apps”. *IEEE*, pp. 427-431, Apr. 2009.

[17] N. Ahmad, A. Rextin, and U. E. Kulsoom, “Perspectives on usability guidelines for smartphone applications: An empirical investigation and systematic literature review,” *Information & Software Technology*, vol. 94, pp. 130–149, Feb. 2018, doi: 10.1016/j.infsof.2017.10.005.

[18] H. Feng, T. Hoegler, and W. Stucky, “Exploring the Critical Success Factors for Mobile Commerce,” *IEEE*, Jun. 2006, doi: 10.1109/icmb.2006.15.

[19] A.S. Hashim, W. F. W. Ahmad, and A. Rohiza, “A study of design principles and requirements for the m-learning apps development”. *IEEE*, pp. 226-231, Dec, 2010.

[20] S. Amershi *et al.*, “Guidelines for Human-AI Interaction,” *Proceedings of the 2019 Chi Conference on Human Factors in Computing Systems*, May 2019, doi: 10.1145/3290605.3300233.

[21] S. Burigat, L. Chittaro, and S. Gabrielli, “Navigation techniques for small-screen devices: An evaluation on maps and web pages,” *International Journal of Human-computer Studies*, vol. 66, no. 2, pp. 78–97, Feb. 2008, doi: 10.1016/j.ijhcs.2007.08.006.

[22] M. Milne-Ives, C. S. Lam, C. De Cock, M. H. Van Velthoven, and E. Meinert, “Mobile apps for Health Behavior change in physical activity, diet, drug and alcohol use, and Mental Health: Systematic review,” *Jmir Mhealth and Uhealth*, vol. 8, no. 3, p. e17046, 2020, doi: 10.2196/17046.

[23] K.-C. Wu, Y.-M. Tang, and C.-Y. Tsai, “Graphical interface design for children seeking information in a digital library,” *Visualization in Engineering*, vol. 2, no. 1, May 2014, doi: 10.1186/2213-7459-2-5.

[24] L. F. M. Ibharim, N. Borhan, and M. H. M. Yatim, “A field study of understanding child’s knowledge, skills and interaction towards capacitive touch technology (iPad),” *IEEE*, Jul. 2013, doi: 10.1109/cita.2013.6637571.

[25] A.N. Antle, “Analyzing children’s hand actions using tangible user interfaces”. *Children and Tangibles*, pp. 3-9, 2009.

[26] T. Zhou, “Examining the critical success factors of mobile website adoption,” *Online Information Review*, vol. 35, no. 4, pp. 636–652, Aug. 2011, doi: 10.1108/14684521111161972.

[27] B. Kye, N. Han, E. Kim, Y. Park, and S. Jo, “Educational applications of metaverse: possibilities and limitations,” *Journal of Educational Evaluation for Health Professions*, vol. 18, p. 32, Dec. 2021, doi: 10.3352/jeehp.2021.18.32.

[28] D. L. Kappen, P. Mirza-Babaei, and L. E. Nacke, “Older Adults’ Physical activity and exergames: A systematic review,” *International Journal of Human-computer Interaction*, vol. 35, no. 2, pp. 140–167, Feb. 2018, doi: 10.1080/10447318.2018.1441253.

[29] A. Miroshnichenko, *On the Intersection of Theory and Practice: Hybrid Multi-Modal Game Design as A Medium of Affective Digital Communication*. 2020.

[30] Ç. Aker, Y. Inal, and K. Rızvanoğlu, “A multi-modal approach for evaluating player experience on different gaming platforms,” *International Journal of Mobile Communications*, vol. 18, no. 2, p. 175, Jan. 2020, doi: 10.1504/ijmc.2020.105845.

[31] P. Cairns, J. Li, K. Wang, and A. I. Nordin, “The influence of controllers on immersion in mobile games,” *ACM*, Apr. 2014, doi: 10.1145/2556288.2557345.

[32] K. Salen and E. Zimmerman, *Rules of Play: Game Design Fundamentals*. 2003. http://ci.nii.ac.jp/ncid/BA63865022 (accessed Jul. 15, 2022)

[33] J. C. Huizenga, W. Admiraal, S. Akkerman, and G. T. M. T. Dam, “Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game,” *Journal of Computer Assisted Learning*, vol. 25, no. 4, pp. 332–344, Jul. 2009, doi: 10.1111/j.1365-2729.2009.00316.x.

[34] S. Aleem, L. F. Capretz, and F. Ahmed, “Critical Success Factors to Improve the Game Development Process from a Developer’s Perspective,” *Journal of Computer Science and Technology*, vol. 31, no. 5, pp. 925–950, Sep. 2016, doi: 10.1007/s11390-016-1673-z.

[35] K. Browne and C. K. Anand, “An empirical evaluation of user interfaces for a mobile video game,” *Entertainment Computing*, vol. 3, no. 1, pp. 1–10, Jan. 2012, doi: 10.1016/j.entcom.2011.06.001.

[36] J. L. Wang, J. R. Sheng, and H. Z. Wang, “The association between mobile game addiction and depression, social anxiety, and loneliness,” *Frontiers in Public Health*, vol. 7, Sep. 2019, doi: 10.3389/fpubh.2019.00247.

[37] M. Voth, S. Chisholm, H. Sollid, C. Jones, L. Smith-MacDonald, and S. Brémault-Phillips, “Efficacy, Effectiveness, and Quality of Resilience-Building Mobile Health Apps for military, veteran, and public safety personnel populations: Scoping literature review and app evaluation,” *Jmir Mhealth and Uhealth*, vol. 10, no. 1, p. e26453, Jan. 2022, doi: 10.2196/26453.

[38] B. R. Sostak, “Applying Serious Game Principles to US Military Training”, *Journal of Applied Learning Technology*, vol. 2, no. 1, 2012.

[39] R. Hill *et al.*, “Pedagogically Structured Game-Based Training: Development of the Elect BiLAT Simulation,” *Proceedings of the 25th Army Science Conference*, Jan. 2006. https://apps.dtic.mil/sti/citations/ADA461575 (accessed Jul. 15, 2022)

[40] C. E. Gould *et al.*, “Development and refinement of educational materials to help older veterans use VA mental health mobile apps.,” *Professional Psychology: Research and Practice*, vol. 51, no. 4, pp. 414–423, Aug. 2020, doi: 10.1037/pro0000354.

[41] C. J. Bonk and V. P. Dennen, “Massive Multiplayer Online Gaming: a research framework for military training and education,” *PsycEXTRA Dataset*. Jan. 01, 2005. doi: 10.1037/e448112006-001.

[42] M. Jackson, “Making visible: using simulation and game environments across disciplines,” *On The Horizon*, vol. 12, no. 1, pp. 22–25, Mar. 2004, doi: 10.1108/10748120410540463.

[43] M. Kankaanranta and P. Neittaanmki, *Design and use of serious games*. 2009. doi: 10.1007/978-1-4020-9496-5.

[44] F. Laamarti, M. Eid, and A. E. Saddik, “An overview of serious games,” *International Journal of Computer Games Technology*, vol. 2014, pp. 1–15, Jan. 2014, doi: 10.1155/2014/358152.

[45] A. T. Bayrak, “Compassionate game design: A holistic perspective for a player-centric game design paradigm for games4health”, *International Journal on Advances in Intelligent Systems*, vo. 13, no. 1, pp. 1-18 2020.

[46] M. Silic and P. B. Lowry, “Using Design-Science based gamification to improve organizational security training and compliance,” *Journal of Management Information Systems*, vol. 37, no. 1, pp. 129–161, Jan. 2020, doi: 10.1080/07421222.2019.1705512.

[47] H. Marín-Vega, G. Alor-Hernández, R. Zatarain-Cabada, M. L. Barrón-Estrada, and J. L. G. Alcaraz, “A brief review of game engines for educational and serious games development,” *Journal of Information Technology Research*, Oct. 2017, doi: 10.4018/jitr.2017100101.

[48] J. Curry, “Professional Wargaming: A flawed but Useful tool,” *Simulation & Gaming*, vol. 51, no. 5, pp. 612–631, Apr. 2020, doi: 10.1177/1046878120901852.

[49] “Virtual Battlespace 2”, Bohemia Interactive Simulations, 2009. http://www.vbs2.com/ (accessed May 11, 2022).

[50] S. Driessen, M. Grever, and S. Reijnders, “Lessons of war. The significance of battlefield tours for the Dutch military,” *Critical Military Studies*, vol. 8, no. 2, pp. 214–232, Aug. 2019, doi: 10.1080/23337486.2019.1651044.

[51] “Steel Beasts”, *eSim Games,* 2009. http://www.steelbeasts.com/ (accessed May 11, 2022).

[52] D. Noh, *The Gamification Framework of Military Flight Simulator for Effective Learning and Training Environment*. 2020.

[53] "Tactical Iraqi Language & Culture", *Alelo Inc.,* 2009. http://www.tacticallanguage.com/ (accessed May 11, 2022).

[54] P. V. R. Carvalho, D. O. Ranauro, A. C. Abreu Mol, A. Jatoba and A. P. L. Siqueira, "Using serious games in public schools for training fire evacuation procedures", *International Journal of Serious Games*, vol. 9, no. 3, pp. 125-139, 2022.

[55] "America's Army", *US Army,* 2009. http://www.americasarmy.com/ (accessed May 11, 2022).

[56] S. B. Godfrey, S. P. Caamaño, and A. Tremori, *Micro-games for Quick Learning of Declarative Knowledge: Preliminary Application and Usability Testing*. Springer International Publishing, 2021.

[57] B. Fischer, A. Peine, and B. Östlund, "The Importance of User involvement: A systematic review of involving older users in technology design," *Gerontologist*, vol. 60, no. 7, pp. e513–e523, Nov. 2019, doi: 10.1093/geront/gnz163.

[58] R. Costello, *Gamification Strategies for Retention, Motivation, and Engagement in Higher Education : Emerging research and opportunities*. 2020. http://dx.doi.org/10.4018/978-1-7998-2079-6 (accessed Jul. 15, 2022)

[59] J. Blom and A. Monk, "Theory of Personalization of appearance: Why users personalize their PCs and mobile phones," *Human-Computer Interaction*, vol. 18, no. 3, pp. 193–228, Sep. 2003, doi: 10.1207/s15327051hci1803_1.

[60] M. Hassenzahl, "The interplay of beauty, goodness, and usability in interactive products," *Human-Computer Interaction*, vol. 19, no. 4, pp. 319–349, Dec. 2004, doi: 10.1207/s15327051hci1904_2.

[61] M. Hassenzahl, A. Platz, M. Burmester and K. Lehner, "Hedonic and ergonomic quality aspects determine a software's appeal". ACM Press, pp. 201-208, 2000.

[62] A. J. Keith, D. K. Ahner, and N. Curtis, "Evaluation theory and its application to military assessments," *The Journal of Defense Modeling and Simulation*, Mar. 2019, doi: 10.1177/1548512919834670.

[63] P. Dourish, *Where the action is: the foundations of embodied interaction*. 2001. https://www.researchgate.net/profile/Paul_Dourish/publication/200026266_Where_the_Action_Is_The_Foundations_of_Embodied_Interaction/links/09e4150afd29965764000000.pdf (accessed Aug. 30, 2022)

[64] J. McCarthy and P. Wright, "Technology as experience," in *The MIT Press eBooks*, 2007. doi: 10.7551/mitpress/6687.003.0011.

[65] D. A. Norman, "Emotional design: why we love (or hate) everyday things," *Choice Reviews Online*, vol. 41, no. 11, pp. 41–6846, Jul. 2004, doi: 10.5860/choice.41-6846.

[66] J. Johnson, *Designing with The Mind in Mind: Simple Guide to Understanding User Interface Design Guidelines*. Morgan Kaufmann, 2020.

[67] J. Redström and H. Wiltse, *Changing Things: Innovation Through Design Philosophy*. Loughborough University Press, 2019.

[68] L. C. Kruse, S. Purao, and S. Seidel, "How designers use design principles: design behaviors and application modes," *Journal of the Association for Information Systems*, vol. 23, no. 5, pp. 1235–1270, Jan. 2022, doi: 10.17705/1jais.00759.

[69] J. Ruiz, E. Serral, and M. Snoeck, "Unifying functional user interface design principles," *International Journal of Human-computer Interaction*, vol. 37, no. 1, pp. 47–67, Aug. 2020, doi: 10.1080/10447318.2020.1805876.

[70] J. A. Marvel, S. Bagchi, M. Zimmerman, and B. Antonishek, "Towards effective interface designs for collaborative HRI in manufacturing," *ACM Transactions on Human-robot Interaction*, vol. 9, no. 4, pp. 1–55, Oct. 2020, doi: 10.1145/3385009.

[71] T. Alves, J. Natálio, J. Henriques-Calado, and S. Gama, "Incorporating personality in user interface design: A review," *Personality and Individual Differences*, vol. 155, p. 109709, Mar. 2020, doi: 10.1016/j.paid.2019.109709.

[72] L. Wilcox et al., "Design in the HCI classroom: Setting a research agenda." *Proceedings of the 2019 on Designing Interactive Systems Conference*. 2019.

[73] L. Hallnäs and J. Redström, "From use to presence," *ACM Transactions on Computer-Human Interaction*, vol. 9, no. 2, pp. 106–124, Jun. 2002, doi: 10.1145/513665.513668.

[74] J. Redström, "From use to presence: on the expressions and aesthetics of everyday computational things," *Interactions*, vol. 9, no. 4, pp. 11–12, Jul. 2002, doi: 10.1145/543434.543441.

[75] R. Shusterman, "Pragmatist aesthetics: living beauty, rethinking art," *Choice Reviews Online*, vol. 30, no. 05, pp. 30–2615, Jan. 1993, doi: 10.5860/choice.30-2615.

[76] M. G. Petersen, O. S. Iversen, P. G. Krogh, and M. Ludvigsen, "*Aesthetic interaction: A pragmatist's aesthetics of interactive systems"*. Cambridge MA, 2004.

[77] J. P. Djajadiningrat, C. J. Overbeeke, and S. Wensveen, "Augmenting fun and beauty," *CHI 2007 Proceedings Empirical Studies of Web Interaction*, May 2007, doi: 10.1145/354666.354680.

[78] T. Lavie and N. Tractinsky, "Assessing dimensions of perceived visual aesthetics of web sites," *International Journal of Human-computer Studies*, vol. 60, no. 3, pp. 269–298, Mar. 2004, doi: 10.1016/j.ijhcs.2003.09.002.

[79] C. Simone and L. Howles, "*Designing the online learning experience: Evidence-based principles and strategies"*. Taylor & Francis, 2023.

[80] X. Ye, X. Peng, X. Wang, and H.-H. Teo, "Developing and testing a theoretical path model of web page impression formation and its consequence," *Information Systems Research*, vol. 31, no. 3, pp. 929–949, Sep. 2020, doi: 10.1287/isre.2020.0924.

[81] G. Marmat, "Influence of aesthetics attributes of brand Web pages on customer brand engagement," *Global Knowledge, Memory and Communication*, vol. ahead-of-print, no. ahead-of-print, Jan. 2022, doi: 10.1108/gkmc-07-2021-0126.

[82] J. Kim, J. Lee, and D. Choi, "Designing emotionally evocative home pages: An empirical study of the quantitative relations between design factors and emotional dimensions," *International Journal of Human Computer Studies,* vol. 59, no. 6, pp. 899-940, 2003.

[83] S. E. Park, D. Choi, and J. Kim, "Critical factors for the aesthetic fidelity of web pages: empirical studies with professional web designers and users," *Interacting With Computers*, vol. 16, no. 2, pp. 351–376, Apr. 2004, doi: 10.1016/j.intcom.2003.07.001.

[84] C. Z. Liu, Y. A. Au, and H. Choi, "Effects of freemium strategy in the mobile app market: An Empirical study of Google Play," *Journal of Management Information Systems*, vol. 31, no. 3, pp. 326–354, Jul. 2014, doi: 10.1080/07421222.2014.995564.

[85] J. P. Davis, Y. Chhabra, and P.-L. Yin, "Experimentation Strategies and entrepreneurial Innovation: Inherited market Differences in the iPhone ecosystem," *Social Science Research Network*, Jan. 2014, doi: 10.2139/ssrn.2408310.

[86] L. Yong and H. Li, "Exploring the impact of use context on mobile hedonic services adoption: An empirical study on mobile gaming in China," *Computers in Human Behavior*, vol. 27, no. 2, pp. 890–898, Mar. 2011, doi: 10.1016/j.chb.2010.11.014.

[87] H, F. O'Neil et al., "*Using cognitive and affective metrics in educational simulations and games: Applications in school and workplace contexts"*. Routledge, 2021.

[88] T. Chadwick et al., "Characterizing Novelty in the Military Domain." *arXiv:2302.12314*, 2023.

[89] K. Davis et al., "Thriving at the US Air Force Academy," *Journal of Character and Leadership Development,* vol. 6, no. 2, 2019.

[90] K. Schenke et al., "Measuring and increasing interest in a game," *Using Cognitive and Affective Metrics in Educational Simulations and Games,* pp. 159-189, 2021.

[91] C.-H. Song, K.-D. Park, and B. C. Kim, "Impact of online reviews on mobile app sales: Open versus closed platform comparison," *Pacific Asia Conference on Information Systems*, p. 12, Jan. 2013. https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1011&context=pacis2013 (accessed Jul. 15, 2022).

[92] R. Garg and R. Telang, "Inferring App Demand from Publicly Available Data," *Management Information Systems Quarterly*, vol. 37, no. 4, pp. 1253–1264, Apr. 2013, doi: 10.25300/misq/2013/37.4.12.

[93] G. Lee and T. S. Raghu, "Determinants of Mobile Apps' Success: Evidence from the App Store Market," *Journal of Management Information Systems*, vol. 31, no. 2, pp. 133–170, Oct. 2014, doi: 10.2753/mis0742-1222310206.

[94] H. Van Der Heijden, "User Acceptance of Hedonic Information Systems," *Management Information Systems Quarterly*, vol. 28, no. 4, p. 695, Jan. 2004, doi: 10.2307/25148660.

[95] Z. Yu, G. Ming-Le, and L. Wang, "The effect of educational games on learning outcomes, student motivation, engagement and satisfaction," *Journal of Educational Computing Research*, vol. 59, no. 3, pp. 522–546, Nov. 2020, doi: 10.1177/0735633120969214.

[96] S. Mustonen et al., "*Historical Character Design for a Mobile Game"*. Springer Nature Singapore, 2021.

[97] J. Zeng, S. E. Parks, and J. Shang, "To learn scientifically, effectively, and enjoyably: A review of educational games," *Human Behavior and Emerging Technologies*, vol. 2, no. 2, pp. 186–195, Apr. 2020, doi: 10.1002/hbe2.188.

[98] R. Handican, and S. Wahyu, "Developing a mobile game using scientific approach to support Mathematics learning." *Edumatika: Jurnal Riset Pendidikan Matematika*, vol. 4, no. 1, pp. 47-58, 2021.

[99] L. F. Rodrigues, A. Oliveira, and H. Rodrigues, “Main gamification concepts: A systematic mapping study,” *Heliyon*, vol. 5, no. 7, pp. e01993, Jul. 2019, doi: 10.1016/j.heliyon.2019.e01993.

[100] L. Chen, N. Liu, C. Li, and J. Wang, “Peer-to-Peer Energy Sharing with social Attributes: a stochastic Leader–Follower game approach,” *IEEE Transactions on Industrial Informatics*, vol. 17, no. 4, pp. 2545–2556, Apr. 2021, doi: 10.1109/tii.2020.2999328.

[101] O. Lopez-Fernandez, A. J. Williams, and D. J. Kuss, “Measuring female gaming: gamer profile, predictors, prevalence, and characteristics from psychological and gender perspectives,” *Frontiers in Psychology*, vol. 10, Apr. 2019, doi: 10.3389/fpsyg.2019.00898.

[102] O. López-Fernández, A. J. Williams, M. D. Griffiths, and D. J. Kuss, “Female Gaming, Gaming Addiction, and The Role of Women within Gaming Culture: A Narrative Literature review,” *Frontiers in Psychiatry*, vol. 10, Jul. 2019, doi: 10.3389/fpsyt.2019.00454.

[103] B. Joleen, “*The dynamic game character: Definition, construction, and challenges in character ecology”*. IT-Universitetet i København, 2020.

[104] J. Merikivi, V. K. Tuunainen, and D. T. Nguyen, “What makes continued mobile gaming enjoyable?,” *Computers in Human Behavior*, vol. 68, pp. 411–421, Mar. 2017, doi: 10.1016/j.chb.2016.11.070.

[105] C.-L. Hsu and H.-P. Lu, “Why do people play on-line games? An extended TAM with social influences and flow experience,” *Information & Management*, vol. 41, no. 7, pp. 853–868, Sep. 2004, doi: 10.1016/j.im.2003.08.014.

[106] J. Hamari, N. Hanner, and J. Koivisto, “Service quality explains why people use freemium services but not if they go premium: An empirical study in free-to-play games,” *International Journal of Information Management*, vol. 37, no. 1, pp. 1449–1459, Feb. 2017, doi: 10.1016/j.ijinfomgt.2016.09.004.

[107] L. S. Ferro, “The Game Element and Mechanic (GEM) framework: A structural approach for implementing game elements and mechanics into game experiences,” *Entertainment Computing*, vol. 36, p. 100375, Jan. 2021, doi: 10.1016/j.entcom.2020.100375.

[108] L. L. Pereira, R. Craveirinha, and L. Roque, “A Canvas for Participation-Centered Game Design,” *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, vol. 11, Oct. 2019, doi: 10.1145/3311350.3347154.

[109] S. B. Dias *et al.*, “Assistive HCI-Serious Games Co-design Insights: The case study of i-PROGNOSIS Personalized Game Suite for Parkinson’s Disease,” *Frontiers in Psychology*, vol. 11, Jan. 2021, doi: 10.3389/fpsyg.2020.612835.

[110] Z. Yu, “A Meta-Analysis of Use of Serious Games in Education over a Decade,” *International Journal of Computer Games Technology*, vol. 2019, pp. 1–8, Feb. 2019, doi: 10.1155/2019/4797032.

[111] A. K. Y. Tang, “Key factors in the triumph of Pokémon GO,” *Business Horizons*, vol. 60, no. 5, pp. 725–728, Sep. 2017, doi: 10.1016/j.bushor.2017.05.016.

[112] C. Standing and J. Mattsson, “‘Fake it until you make it’: business model conceptualization in digital entrepreneurship,” *Journal of Strategic Marketing*, vol. 26, no. 5, pp. 385–399, Oct. 2016, doi: 10.1080/0965254x.2016.1240218.