Game Complexity Factor: A Collaborative Study of LeBlanc Taxonomy and Function Points Method

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***Abstract*—In 2015, the President of Indonesia established Bekraf—stands for Badan Ekonomi Kreatif (Creative Economy Association of Indonesia)—through Presidential Regulation (Perpres) number 6. The purpose of establishing Bekraf is to enable creative business actors to collaborate with government in developing this nation's entertainment industries. Nowadays, the game is accepted as an alternative form of education. Therefore, the researchers aim to assist the business of digital creative field to estimate computer game development effort. This research is based on Function Points (FP) method, which is better known as cost calculation of software application development project. The result of this study shows the need to modify the definition of computer games' parameters, including input, output, inquiry, internal file logic, and external file logic. Besides that, the complexity factors should be redefined and synchronized with 8 items of LeBlanc Taxonomy. Then, its collaboration is named Game Complexity Factors (GCF), consists of 22 items of complexity factors—8 items from LeBlanc Taxonomy and the rest from technical complexity..**

Keywords—function points, game complexity, complexity factor, game development, game estimation

I. INTRODUCTION

Since 2015, Indonesian creative industries have been officially managed by Badan Ekonomi Kreatif (Bekraf)—Creative Economy Association of Indonesia—as a result of a presidential regulation made that year. Among all the industries listed in Bekraf, the government is paying special attention to the development of a game industry. Digital games seem to be well-accepted by the society. According to the report released by Newzoo in 2017, the number of Indonesian gamers was as big as 43.7 million (ranked 16th worldwide in terms of game revenues). Meanwhile, Newzoo also noted that globally, game market revenues reached US$ 108.9 billion. Forty-two percent (42%) of it was dominated by mobile platform [1].

The growth of a digital game market inspired us—the researchers—to discover scientific method used to estimate game effort. There have been studies about that, but still not so many, especially in Indonesia. This research is based on Function Points Analysis (FP), a method developed by Allan Albrecht in 1979 [2] [3] [4]. That method was significantly modified and improved. In 1987, a method named International Function Points User Group (IFPUG) was known as a result of it [5].

FP method has been proven effective to estimate an effort in small, middle, or even big scale of software development project [6] [7]. Moreover, FP is considered better than the other methods, such as Use Case Points (UCP), Cost Constructive Models (Cocomo) [8] [9], and Activity-Based Costing [10].

Based on usability proofs discovered in earlier studies, we assume that the FP method can also be adopted for applications like digital games used for educational purposes. Here are a few reasons why we wanted to do research on that topic.

- There are similarities between input and output parameters measured by software applications and digital games.
- Parameters of the technical and environmental complexity of digital games are almost similar to those of software applications.
- Time needed to develop digital games is relatively shorter than to develop software applications. And so, the FP method can be applied in this case.
- Funds to develop digital games can be gotten from Business-to-Business (B2B) model.

Because of those four reasons, developers of digital games need tools to simplify the process of estimating the effort. We discovered that there were not many researches conducted on digital games due to the following factors.

- Digital games developers have not discovered the standard components needed to estimate effort. Meanwhile, we believe that the development process of digital games is similar to that of software projects. That is why there are a few parameters that can be used to measure how big or small a digital game is.
- Methods used to estimate the effort of software development have not been tested to digital games. That might possibly be caused by art or entertainment factors involved in the process of making digital games.

II. RELATED RESEARCH

A. Function Points for Estimating Software Effort

Allan Albrects introduced a method called Function Points (FP) in 1979 [4]. Fig.1 shows the steps needed to get the estimated score of effort.

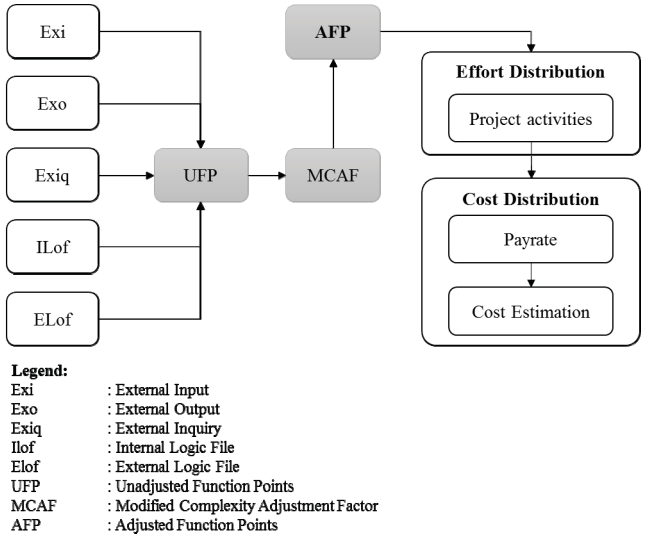

Fig. 1. Function Points Method in Software Cost Estimation [7]

FP method has been used for researches in estimating the effort of software development projects. Here are a few reasons why.

- FP is recommended because it can be applied not only in small software development projects but also in bigger ones [3][11].
- FP can be used in projects based on Geographic Information System (GIS) [13].
- FP scores can be improved by modifying technical complexity level. In a case study, they can go down from 27.5% to 10.45% (approximately 17%) compared to the actual effort of four public service applications [7] [6].

B. *Qualitative Approach for Studying Game*

Different from software applications, the concept of effort estimation is not used in digital game projects, particularly in Indonesia. According to our observations, some digital game industries are using raw estimation based on pay rate (man-hour or man-day) to get estimated cost without considering their effort. Some results of qualitative researches about the development of the digital game as below.

- Sabahat [14] stated that FP has been tested to 67 digital games written in various programming languages (Java, C#, C++, VB, and Pascal). There are 8 complexity factors identified: Number of Rules, Number of Players, Animation, 3D Visualization, Computer Opponent, Multi Skills, Number of Type of Variants, and Miscellaneous Game Options.
- LeBlanc [15] stated that there are 3 main elements in game researches: mechanic, design, and aesthetic. The latter is something that makes every digital game has "fun" factor. There is 8 taxonomy (see Table I) that need to be implemented so that digital games can be entertaining [16].

TABLE I. LEBLANC TAXONOMY OF GAME PLEASURES

Taxonomy	Description
Sensation	A game as sense-pleasure.
Fantasy	A game as make-believe.
Narrative	A game—specifically, flow of it—as drama.
Challenge	A game as an obstacle course, since there are things like time pressure and opponent play.
Fellowship	A game as a social framework, in which users can be encouraged by sharing information across certain members of a session (a team) or supplying winning conditions that are more difficult to be achieved alone.
Discovery	A game as uncharted territory, since there are things about rising tension and denouement.
Expression	A game as self-discovery, encourage an individual user to leave their mark.
Submission	A game as a pastime, in which there are milestones to continue the game.

Sabahat's research [14] did not accommodate 8 kinds of fun defined by LeBlanc yet. Therefore, we try to synchronize the complexity factors of FP with LeBlanc Taxonomy through this research.

III. RESEARCH METHODS

Systematically, this research is divided into two main phases. The first phase is redefining the main parameters of the FP method, which can be divided into three substeps. The second one is mapping and synchronizing the complexity factors, focusing on the justification of FP by Alan Albrecht and effort estimation scores (see Fig. 2).

Challenges we faced existed within those two phases. They can potentially change the formula or weighting of each parameter and complexity factors.

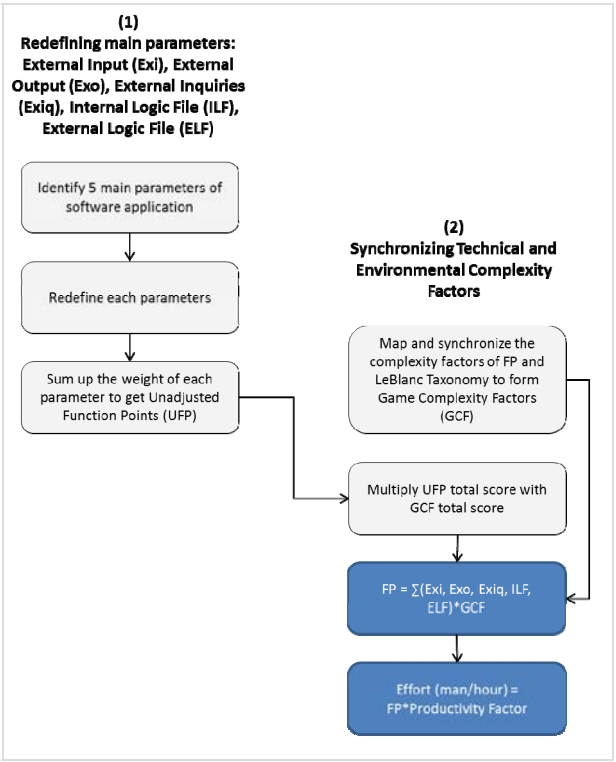

Fig. 2. Research Phases in Function Points Method on Computer Game

Primary data collection is obtained by interviewing a number of stakeholders related to mobile education games. Some informants needed include 3 project managers, 2 game designers, and 3 game players.

Data and information collected during interviews with project managers and game designers are how to set up funding allocations to develop a mobile education game. Justification of what complexity factors are used whether a mobile game is said to be large or small. Whereas in-game players, the data needed is an opinion about how entertaining a mobile education game is.

A. Redefining Main Parameters

According to Sabahat [14], digital games have a few components that need to be considered. In the FP method, five main components are needed to justify a software application. Unfortunately, his case study of digital games did not include those operated in a mobile platform. It is interesting for us to review the complexity factors related to difficulty level, be it in the technical side or environmental side of users.

B. Synchronizing Complexity Factors

Taxonomy formulated by LeBlanc [15] is significantly different from complexity factors of FP method. We assume that both can be mapped and synchronized so that LeBlanc taxonomy can be used as users' environmental complexity factor. In digital games, optimization should not be done to the technical side only. There are also nontechnical factors that should be optimized to create the "fun".

IV. Result and Discussion

Interviews were conducted with 3 stakeholders in game development, including project managers, game designers, and game players. The project manager was interviewed 3 times, while the game designer was interviewed 2 times and the game player was interviewed once after successfully playing the game according to the level provided.

According to the interviews done previously, we summarize the case study of digital game in Table II. There are 8 educational games in the casual genre used to test by 5 main parameters and complexity factors (technical and environmental).

TABLE II. Overview of Digital Games Used as Case Study

Game	Explanation		
	Description	Segmentation	Genre
Boci Trace Alphabet	A mobile game in which the user is asked to follow icons of plane, ship, and car to form a letter (alphabet).	2-4 years	Education-Casual
Boci Theme Park: Carnival	A mobile game in which user is asked to play with carnival such as Ferris wheel, roller coaster, and many more.	2-6 years	Education-Casual
Boci Play Counting	A mobile game in which user is asked to count something (such fruits)	4-6 years	Education-Casual
Boci Zoo	A mobile game in which the user is asked to imitate animal sounds in the zoo	2-6 years	Education-Casual
Boci Play Hide and Seek	A mobile game in which the user is asked to find his friend who's hiding somewhere	1-3 years	Education-Casual
The Expedition Man	A mobile game in which user pretends to be courier who should adhere to traffic regulations while sending package within the given time.	>12 years	Education-Casual
Soccer Tactic Simulation	A serious PC game in which the user simulates tactics and strategies in a soccer game.	Training center members	Education-Serious
Jermania	A mobile game in which the user can learn the culture and conversations used in Germany.	>8 years	Education-Casual
Abata	A serious mobile game in which the user can learn to recite Quran according to its rules of pronounciation (tajwid).	>3 years	Education-Serious

Basically, platforms or programming languages used in digital games are variations. But according to the report released by Newzoo, 42% of users prefer mobile games to PC or console games. From all those users of mobile games, most of them choose games with the casual genre.

A. Redefining Main Parameters

As mentioned before, the first phase of the FP method is redefining five main parameters (see Table III). Here, we are comparing casual games to software applications.

TABLE III. Comparison Between Digital Game and Software Application

Parameter	Frequence[a] in Software Application	Frequence in Digital Game
External Input	Always	Rare
External Output	Always	Rare
External Inquiries	Always	Rare
Logic File Internal	Often	Never
Logic File External	Often	Rare

[a]Notes on frequence:
- Always: a must use, frequence score >3
- Often: frequence score between 1-3
- Rare: relative, not a must use
- Never: not used at all

As shown in Table III, we can conclude that comparison between the usage of five main parameters in digital games tends to be "rare" or "never". Meanwhile, in software

applications, the usage of frequency is the opposite ('Often' and 'Always').

The purpose of redefining the main parameters in the FP method is for early investigation of the differences between software applications and mobile games. This certainly has an impact on the FP method formulation, especially in calculating the Unadjusted Function Point or UFP (see Figure 1). So, if the difference is very significant, the author then conducts an in-depth analysis related to the synchronization of game complexity factors (namely GCF).

B. *Synchronizing Complexity Factors*

After we know that there are significant differences in main parameters, the next step is mapping and synchronizing LeBlanc's taxonomy (Table I) and complexity factors used in the FP method. We name the result of that synchronization Game Complexity Factors (GCF), which consists of 22 items.

The summary of GCF and its scale(s) can be seen in Table IV.

TABLE IV. GAME COMPLEXITY FACTORS

No	Taxonomy	Scale Interval					
1	Sensation	0 ◄——► 10 Not attractive — Very attractive					
2	Fantasy	0 ◄——► 10 Non-pervasive — Persavive					
3	Narrative	0 ◄——► 10 Not dramatic — Very dramatic					
4	Challenge	0 ◄——► 10 Effortless — Very challenging					
5	Fellowship	0 ◄——► 10 Individual — Teamwork					
6	Discovery	0 ◄——► 10 Curiousless — Very curious					
7	Expression	0 ◄——► 10 Uninterest — Shareable					
8	Submission	0 ◄——► 10 Spare time — Anytime					
	FP's Complexity Factor	**0**	**1**	**2**	**3**	**4**	**5**
9	Level of reliability for recovery	No need recovery	High Score	In-App Purchase	Chat Message	Chat Voice	Multi-player
10	Level of data communications	Save Local			Online-only		Auto-Sync
11	Level of distributed data processing	Without Login			Login (optional)		Must Login
12	Level of performance needs	Casual	1 vs 1 player	5 vs 5 player	6-10 player	11-30 player	> 30 player
13	Level of environment configuration		Single platform	Dual platform	Triple platform	Quad platform	HTML5 multi platform
14	Level of transaction rate (pipe communication)		1 pipe comm	2 pipe comm	3 pipe comm	> 3 pipe comm	
15	Level of end-user efficiency		3 view/ class	4-10 view/ class	11-30 view/ class	31-50 view/ class	> 50 view/ class
16	Level of master file update	Without update	Update		Android game		Online game
17	Level of online real-time update	None			Delay ok		No delay
18	Level of reusability	Character reuse			Feature modified		Total modified
19	Level of installation ease	No install			Simple install		Hard install
20	Level of operational ease		Mouse/ touch	1-2 key press	2-5 key press	> 5 key press	
21	Level of customer variation		All age range	Selected age range			
22	Level of change possibility	No change			Game rule modified		Country policy

GCF is an important factor in weighting the difficulty level of a digital game. Based on GCF, we can measure how big or small the resource needed. In FP method, interval scale of complexity factors ranging from 0 to 5, different

from LeBlanc's taxonomy that is usually using interval scale 0 to 10. Therefore, both complexity variables in GCF should be weighted individually.

Table IV shows 22 items of complexity factors, 8 of them are based on LeBlanc's taxonomy and the rest 14 items are from technical complexity factors. Complexity factors based on LeBlanc's taxonomy can be explained below.

1) Sensation
   A digital game is said to have sensation when it can bring out attractiveness between its players. The more attractive it is, the higher the score is.
2) Fantasy
   A digital game can bring out a fantasy when the players unintentionally immersed in it and manage to follow the steps to reach the expected goal.
3) Narrative
   Narration plays an important role in bringing the game's flow. Digital games are expected to give a dramatic side when the players accomplish a certain task(s).
4) Challenge
   Digital game is expected to always provide different and new challenges in each scene. Digital games usually have a certain obstacle level to measure the players' effort. It should always make the users curious so that they will keep playing the game.
5) Fellowship
   There are social aspects contained in a digital game. They enable users to work or play together in accomplishing challenge(s) within the game.
6) Discovery
   One way to get the players engaged to the game is to dig their curiosity in the certain stage(s) or level(s). Players' curiosity will determine the score scaled between 0 to 10.
7) Expression
   Players show their enthusiasms through expression while playing. There are players who do not really interested in digital games because (maybe) they do not feel challenged. Otherwise, if a player thinks the game is fun, they will most likely share it with the other players.
8) Submission
   If players feel fun, they might be triggered to always play the game. They can spend their spare time, or even their day (anytime) to play the game.

For 14 items of FP method's technical complexity factors, score 0 to 5 refer to the explanation given Table IV, specifically on point 9 to 22. Technical complexity factors that used by FP method are: 1) Level of reliability for recovery, 2) Level of data communications, 3) Level of distributed data processing, 4) Level of performance needs, 5) Level of environment configuration, 6) Level of transaction rate, 7) Level of end-user efficiency, 8) Level of master file update, 9) Level of online real-time update, 10) Level of reusability, 11) Level of installation ease, 12) Level of operational ease, 13) Level of customer variation, and 14) Level of change possibility.

Since developing digital games differs from developing software applications, every developer team should measure the difficulties based on the involvement of infrastructure, regulations, and interactions between players.

V. Conclusion and Further Research

Here are a few conclusions we get from this research.

- In the Function Points (FP) method, there are 14 complexity factors focusing on the technical side of software development. Therefore, if our case study is digital games, the technical complexity factors should be redefined.
- LeBlanc's taxonomy should be a special consideration in measuring user's environmental complexity factors. LeBlanc formulated 8 kinds of "fun": sensation, fantasy, narrative, challenge, fellowship, discovery, expression, and submission.
- Technical complexity factors of FP can be synchronized with the user's environmental complexity factors of LeBlanc's taxonomy to form Game Complexity Factors (GCF). There are 22 items of GCF that can be customized for mobile digital games.

We plan to continue this research to estimate the hourly weight of each item of GCF (LeBlanc's taxonomy and technical complexity factors). Moreover, the calculation of effort estimation should also be determined based on the index of the programming language used in the digital game(s) chosen as the case study.

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