Metrics War: A Board Game Proposal for Teaching Software Metrics and Quality Attributes

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***Abstract*—Games are becoming popular for computing education, as they may increase learning effectiveness and engagement. Software Engineering (SE) courses are failing to demonstrate the relevance of using software measurement in practice, resulting in unaware SE professionals about key aspects of software measurement. This paper presents Metrics War, a board game proposal for teaching static software metrics to achieve quality attributes required in an indicated software product.**

***Keywords*-software engineering; software metrics; serious game; board game;**

I. Introduction

Software Engineering (SE) education has a persistent challenge to give sufficient hands-on experience to the students in building software [1]. Practical projects have been also highlighted as a possible solution [2], though some of the skills required by SE are not completely developed by using this method [3].

Games are becoming popular for computing education, as they may increase learning effectiveness and engagement [4]. They are considered as a powerful instructional constraints method to achieve an objective, resulting in a wide range of benefits, such as learning effectiveness, interest, motivation and persistence among the players [4].

Considering the teaching of software metrics, many courses fail to demonstrate the relevance of using software measurement in practice, reducing the students interest and leaving the impression that the subject is difficult and complex [5], as well as providing unaware SE professionals about key aspects of software measurement [6]. In this sense, this paper presents **Metrics War**, a board game proposal for teaching software metrics and software quality attributes in a practical, competitive and funny way.

II. Related Work

Several types of board games have been built to enhance the SE educational activity. As an example, *Risk Management Game* [7] is a board game whose players elaborate a risk planning to complete the delivery of a hypothetical project, passing through project phases with the allocated resources. In *SimulES* [8], the player objective is to be the first to complete a predefined software project. Each player performs different roles such as software engineer, technical coordinator, quality controller and project manager, performing common tasks and decisions in the context of software development. The game *XMED v1.0* focuses on the education of software measurement, simulating the definition and execution of a measurement program for project management in alignment with CMMI-DEV maturity level 2 [9]. Finally, *Problems and Programmers* [10] is an "educational card game that simulates the software engineering process from requirements specification to product delivery". It provides an "overall, high-level, practical experience of the software engineering process in a rapid enough manner to be used repeatedly in a limited amount of time".

III. Game Design

Metrics War was designed to be an educational board game for SE students. It is a game for 2 to 4 players that uses static software metrics to achieve quality attributes [11] required by a software product to be indicated to the player.

At the beginning of the match, the player receives an objective card (Figure 1), which indicates a hypothetical software system for the player. Each objective card demands a total of 50 points, and indicates how many points the player must conquer in certain attributes of software quality to win the game. Each player must hide their objective card from other opponents, hiding the player's proximity to winning the game.

Each player also receives a product quality board (Figure 2) with 9 software product quality attributes [11], which indicates the quality points obtained by the player during the match. This board is filled with scoring chips, which are won by the player through the combination of metric cards (Figure 3) obtained on the main deck of the game.

At the beginning of the game, each player receives 5 metric cards, which represent groups of static metrics chosen for the game, such as Size, Coupling, Complexity, Cohesion, Documentation, Error, Testing, Production and Extra (Figure 4). For each combination of two cards representing a group of metrics, the player can perform a trade for quality points,

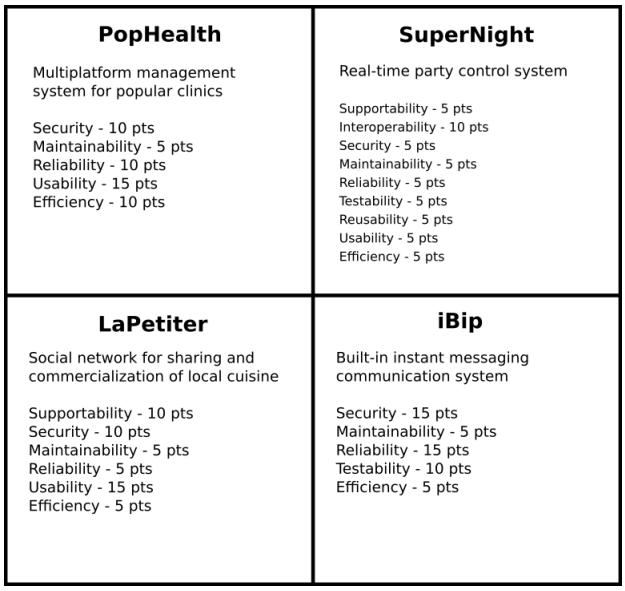

Figure 1. Objective cards of the game.

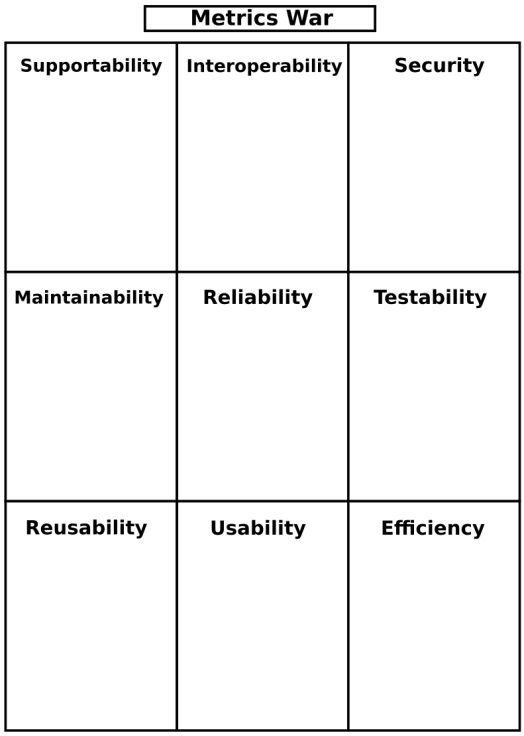

Figure 2. Product quality player board.

ranging from 1 to 3 points according to the defined metrics per quality attributes table (Figure 4).

Each player has the right to get a new metric card in your turn (from the deck or the opponent), and can accumulate as many cards as he or she deems necessary. However,

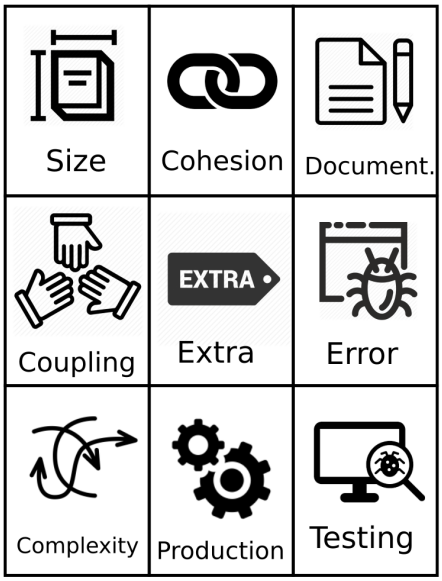

Figure 3. Metric cards of the game.

each player can only download a maximum of 3 card combinations in his turn. Each player can also steal quality points from the opponents (instead of earning points for themselves), by using the combination of metric cards to choose which quality attribute of the opponent to get the points in your turn.

The metrics per quality attributes table (Figure 4) indicates 3 possible metrics to be used according to the value obtained after the player roll the die (1 or 2, 1st metric; 3 or 4, 2nd metric; 5 or 6, 3rd metric), whose points can be used by the player according to the group of metrics obtained with the combination of metrics cards:

- **Size**: SLOC, Function Point, Nº of Modules;
- **Coupling**: Nº of Parameters, Nº of Methods, Inheritance Level;
- **Complexity**: Cyclomatic Complexity, Programming Practices, Nº of Transitions;
- **Cohesion**: Abstractness, Instability, Nº of Modules Called (Fan-in, Fan-out);
- **Documentation**: Source Code Organization, Manual Length, Total Design Documentation;
- **Error**: Bug Counting, Error Messages, Requirements Errors;
- **Testing**: Fault Detection, Unit Test Coverage, Change Request Frequency;
- **Production**: Nº of Man-Hours, Average Programmer Skill, Developed Artifacts/Month; and
- **Extra**: Secure Controls, Applied Algorithms, Dirty Programming Detected;

	Size			Coupling			Complexity			Cohesion			Documentation			Error			Testing			Production			Extra		
Attribute\Metric	*SLOC*	*FP*	*NM*	*NP*	*NM*	*IL*	*CC*	*PP*	*NT*	*Abs.*	*Inst.*	*NMC*	*Org.*	*ML*	*TDD*	*BC*	*EM*	*RE*	*FD*	*UTC*	*CRF*	*NMH*	*APS*	*DAPM*	*SC*	*AA*	*DPD*
Supportability	x	x	x				x	x	x		x		xxx	xxx	xxx	xx	xxx	xx	xxx	xxx	x		xxx			x	x
Interoperability	xx	xx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	x		x	x	x	xx	xx	xx	xx	x	xxx	x	x	xx	xx
Security		x	x				xxx	xxx	xxx	x	xx	xxx				xxx	xxx	xx	xxx	xxx	xxx		xxx	x	xxx	xxx	xxx
Maintainability	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xx	x	xx	xxx	xx	xxx	xx	xxx	xxx	xxx	xxx	xxx	x	xxx	xxx
Reliability	xx	xx	xx				xx	xx	xxx	x	xx	xx				x	x	x	xx	x	x	xxx		xx	x	x	x
Testability	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx	xx
Reusability	xx	xx	xxx	xxx	xxx	xxx	x	x	x	x	x	xx	xx	xx	xx	xx	xx					x	xx	x		x	x
Usability		x					xx	xx	xx				xxx	xxx	xxx	x	xxx	x	x				x		x		
Efficiency	xx	x	xx	x	x	x	xxx	xxx	xxx	x	x	x				x	xx	x							x	xxx	x

Figure 4. Points available for each product quality attribute according to selected metric to be used.

The game ends when a player achieves the necessary quality points indicated in the objective card. If all of the metric cards have been used in the match, the closest player to the total of the points indicated on the objective card wins.

IV. Results and Discussion

As a verification approach for the proposed mechanics and dynamics of the Metrics War game, a paper prototype of the game (Figure 5) was used by master degree and undergraduate students in SE courses (Figures 6 and 7). In this activity, groups of students were formed to participate in a game match with 3 players each one, which was performed after the conclusion of the Software Quality class. The initial objective of this activity is to evaluate the game usage, determining how balanced are the rules with the player actions during the game play, as well as their interactions with proposed elements defined for the game.

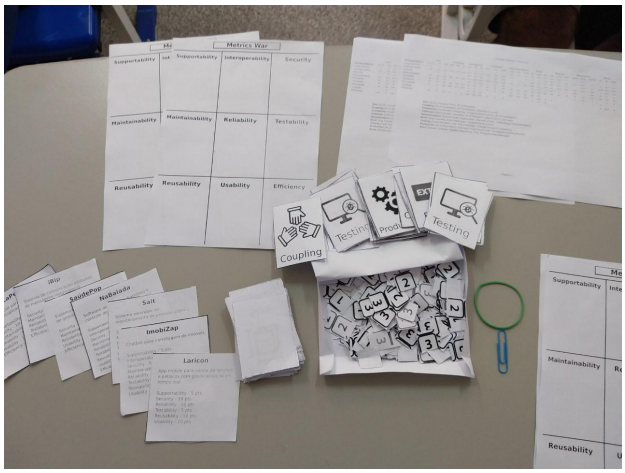

Figure 5. Metrics War paper-based prototype.

In addition, for validation purposes, a usability questionnaire [12] was also applied in each class, collecting positive points, negative points and general suggestions about the game to guarantee a qualitative analysis of the proposed board game. Among the positives are: “fast”, “easy to use”, “easy to learn”, “fun”, “adds knowledge”, “facilitates understanding of the subject”, “brings the class together for fun”, and “shows how to analyze software quality”. Among the negative points are: “theft of chips can slow the game”, “difficulty in finding the value of the metric in the table”, and “little explanation about the metrics used”. As suggestions for improvements in the game, some of them are: “greater font for the metrics table”, “improve the distribution of metrics table points”, “improve feedback on the chosen software attributes”, “make available on digital media”, “add time per move”, and “add event cards such as view objective card or exchange cards with the adversary”.

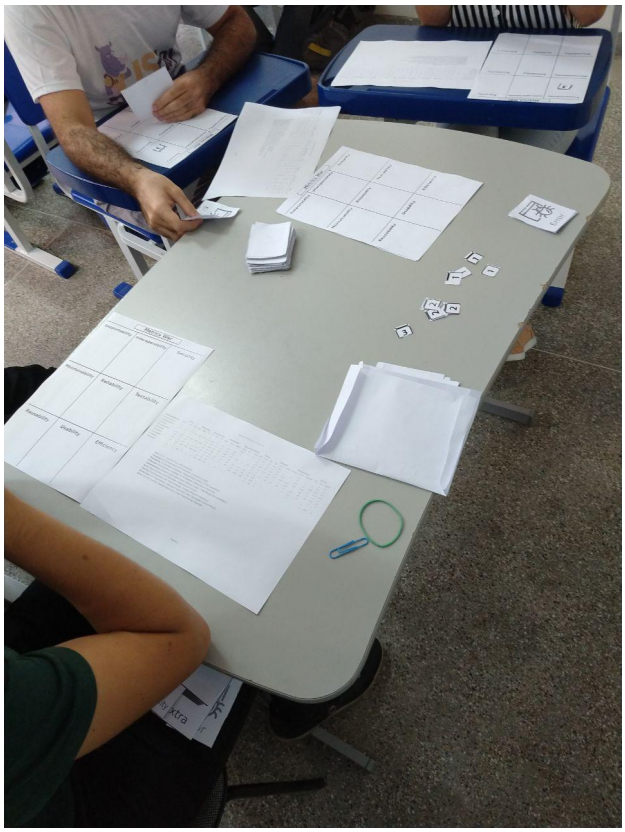

Figure 6. Metrics War game play with master degree students in a SE classroom.

As a result, it is possible to verify by the collected responses that the game mission to provide engagement

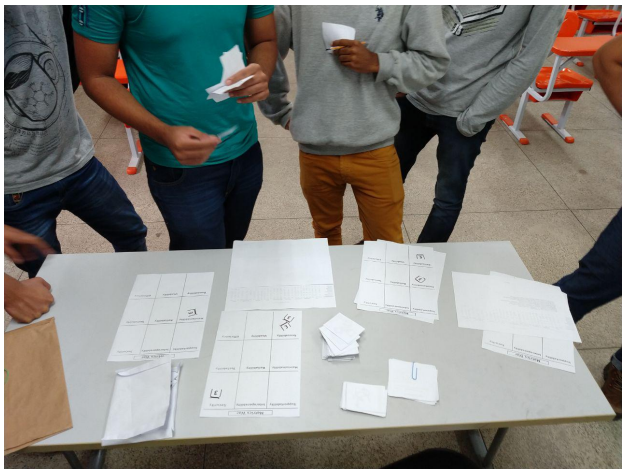

Figure 7. Metrics War game play with undergraduate students in a SE classroom.

and fun with SE knowledge has been achieved. However, it is also clear that it is necessary to improve some game aspects, such as the metrics table presentation, the inclusion of event cards in the metric cards, and the production of new interaction approaches for the player through digital resources.

V. Conclusions and Future Work

This paper introduced Metrics War, a board game proposal that presents in a funny and engaging way the relationship among static software metrics and software quality attributes for proposed software products. It is as an important game, due to the current lack of guidelines and time to teach the practical application of software measurement in the classroom [13]. Moreover, based on the current demand to devise new teaching methods of gamification in software measurement [13], Metric Wars can be defined as a new approach to introduce software metrics concepts in a gamified way for SE students.

Regarding the game verification, some usability criteria (satisfaction, usefulness, ease of learning and ease of use) were positively evaluated by the students, confirming that the proposed game can combine fun with SE concepts. However, it is also clear that there is a need to expand the proposed game mechanics, including event cards for example together with a review about the points distribution in the metrics per quality attribute table.

As future work, it is intended to produce a digital version of the proposed board game, to apply the use of augmented reality in the cards of the game, to seek an integration of the game with social networks for a viralization purpose, and to introduce the use of digital devices to improve the paper-based version support. The application and evaluation of the game in different SE classes, as well as the implementation of the improvements suggestions identified by the evaluated students, will also be carried out in the near future.

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