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A Framework for Game-based Soft Skills Development: A Case of Inventors of Future

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Abstract*--- *Purpose: *Sophisticated human-machine interface can be configured through game-based training programmes in the fourth industrial revolution (IR4.0), but its potential cannot be exploited without a proper framework that connects games to skills development. This paper proposed a game-based framework that focuses on critical thinking, problem-solving and creativity for educators who intent to develop soft skills through games.* ***Materials and Method:*** *To develop this framework, a series of semi-structured interviews were conducted with game technologists, grassroots innovators and practitioners of inventive problem-solving. A digital game was developed based on this framework.* ***Results:*** *A mobile game prototype named "Inventors of Future" was created as an instance of the framework, featuring three missions that afford learners to learn, invent and assess ideas and solutions for inventive problem-solving. These game features are constructively aligned to critical thinking, problem-solving and creativity skills which are parallel to IR4.0.* ***Conclusion:*** *This paper discusses the development of a game-based framework for learning soft skills. This framework aims to equip learners with soft skills by playing a bespoke digital game. The framework is grounded on three learning facets: (a) contents of soft skills selected for deploying strategies in learning activities; (b) technology for creating invention games, which maps structural game elements against intended learning outcomes; and (c) assessment rubrics which measure the attainment of learning outcomes. Upon the completion of these missions, learners should be able to visualize their inventions using a virtual pen and canvas in the game.*

***Keywords*---** *Invention Games, Soft Skills Development, Assessment Rubrics, Game-based Framework, Game-based Learning.*

I. INTRODUCTION

In the fourth industrial revolution (IR4.0), workers engage with rapid changing tasks, demands and environment which require multidisciplinary knowledge to support decision-making and problem-solving[1]. The support can be featured through smart interaction between human and Cyber-Physical System (CPS), that can be achieved through smart tutoring systems, virtual reality (VR) and augmented reality (AR) training programmes based on educational games or simulation[2]. In Malaysia, the government prepares the industry for the transformation in IR4.0 by addressing the issue of the lack of above-mentioned soft skills among Malaysian fresh graduates when joining the

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industry workforce[3]. Unlike hard skills, contemporary robots have not acquire soft skills to define a problem, visualize the solution and integrating information for decision-making[4,5].

The new generation grows up alongside with the rise of digital games, thus they should be able to acquire new skills efficiently through digital games[6,7]. Soft skills are important to most employers when recruiting workers, while game-based learning has been regarded as a productive means for developing soft skills. Hence the need of a framework that connects games to soft skill development, exploiting the potential of the human-machine interface[6]. This paper proposed a framework for educators who intent to develop soft skills through games. This framework focuses on three soft skills: critical thinking, problem-solving and creativity. These skills were captured from the future job report prepared by the World Economic Forum.

II. PROPOSED FRAMEWORK

There are several game-based frameworks developed for soft skills development but they are not dedicated for skills emphasized for IR4.0[7]. The dynamic nature of soft skills learning environment in these frameworks limits the assessment on participants' presence and responses within specific game mechanics[8-10].

A framework was proposed to develop and assess three specific soft skills—problem-solving, critical thinking and creativity among post-secondary Malaysian (see Figure 1). Scenarios of problems which prompt grassroots innovation are constructively aligned to three levels of game challenges, i.e. problem identification, solution creation and evaluation using the DUMBS (doable, usable, marketable, bankable & sustainable) model.

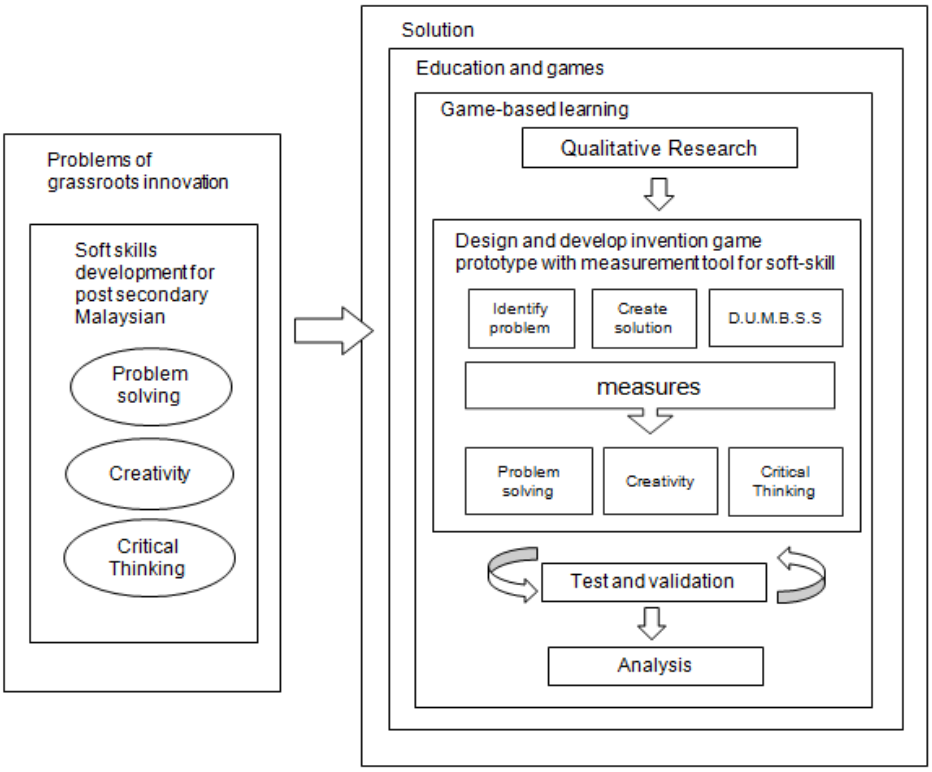

Figure 1: Proposed game-based framework for soft skills development

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(a) Soft skill development

Towards the digital transformation, big organization and small and medium enterprises (SMEs) embark on innovation[11]. A strong industry sector should expand the capacity of innovation to position Malaysia as a strong competitor hence attracts technologically advanced investment[11]. Soft skills are one of the key success factors of innovation[12]. Table 1 depicts differences between types of soft skills development in Malaysian higher education and top ten skills in 2020 suggested by World Economic Forum (WEF). This paper focuses on assessing specific soft skills demanded by employers, which are problem-solving, critical thinking and creativity.

Table 1: Soft skills development in Malaysia versus soft skills demands in year 2020

Soft skills in Malaysian Higher Education	**Top Ten Skills in 2020**
Communication skills	Complex Problem-solving
Critical Thinking and Problem-solving Skills	Critical Thinking
Continuous Learning and Information Management	Creativity
Teamwork Skills	People Management
Entrepreneurial Skills	Coordinating with Others
Leadership Skills	Emotional Intelligence
Professional Ethics and Moral	Judgement and Decision Making
	Service Orientation
	Negotiation
	Cognitive Flexibility

Without human capability to identify problems, solutions cannot be developed or made[14]. Basic problem-as discovered by Koehler, is a process of identifying a problem and approaching problems rationally and decisively[13,15]. This skill can be developed by exploring environment[16]. The exploration and assessment processes can be embedded in games as a form of problem-solving activity[17].

Critical thinking, also known as higher-order thinking by John Dewey, is a cognitive process where an individual gathers information and make a decision in the complex working environment[17,18]. In the context of IR4.0, critical thinking is referring to analysing the potential and limitation of solutions to the problem[5]. Socrates believed that critical thinking skill can be practised through exploring learning material, brainstorming alternative solutions[19].

Creativity is a cognitive process that cannot be replicated by artificial intelligence (AI) robots[5]. It is a process of developing new ideas or solutions, fostering innovation[20]. Creativity and innovation can be integrated into the education system to nurture inventors through digital games[20,21]. In conclusion, past research indicated that, soft skills can be developed through digital games with interactive learning and assessment.

(b) Invention game

Soft skill is essential for workplace innovation[22], as innovative use of soft skills contributes to the process of commercializing invention[23,24]. A digital game with such soft skills can be a learning stimulant to increase intrinsic and extrinsic motivation[17,25]. However, it is essential to included intended learning outcomes when integrating and delivering those skills through the game[17]. Hence, the invention process is taught through the game extrinsically; while soft skills are developed intrinsically throughout the process.

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Learning outcomes were broken down into the smaller sections for players to acquire three specific soft skills[17]. Semi-structured interviews were conducted with subject matter experts, including grassroots innovators and certified TRIZ (theory of invention problem-solving) practitioners to dissect generic invention processes. Figure 2 summarizes three sections of a generic invention process: identifying problem, creating solution, and assessing solution. These sections were aligned to three soft skill development: learning problem-solving skill when identifying problem[5]; developing creativity when sketching out ideas of solution[27]; and sharpening critical thinking skill by assessing solution[5,17]. Each alignment was gamified to engage players[9].

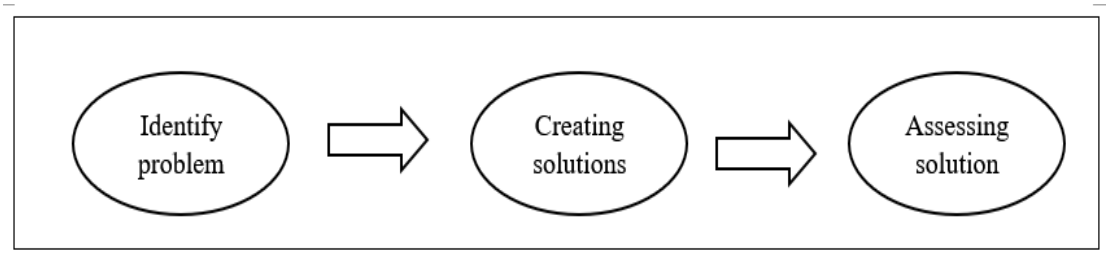

Figure 2: Generic invention process

(c) Assessment rubric

Assessment is the practice of using data to justify the achievement of the learning goal[29]. Without the assessment, the game is just a message broadcaster that has no training module and skill improvement[30]. The proposed framework includes a mechanism to afford self-assessment of invention.

A rubric was prepared for the self-assessment, consisting five criterias[31]. Many rubrics have proven effective for assessing invention and soft skills[13,27]. Compared to these rubrics, DUMBS as shown in Table 2.0 comes with metrics which assess product-oriented solution through probing questions[26]. The rubric divides the five-point Likert scale into three grades: excellent, average, and poor[32], allowing players to select from zero to five points.

Table 2: DUMBS assessment rubrics

Criteria	Excellent (4-5)	Average (2-3)	Poor (0-1)
Doable	Problem identified for the product is a major problem faced by everyone regardless of habits, experts, background and location.	The problem that was identified involves a group of people with similar habits, experts or background from the same village state.	Problem identified involves an individual or particular person only.
Usable	The product that is designed can be used everyday and by everyone.	This product can be used once or several times in a week or month.	This product is useful for certain occasion only.
Marketable	This product can be sold everywhere, whether in the night market, supermarket, shopping mall, online.	This product can be sold among friends, community.	This product cannot be sold, only as it is only a gift.
Bankable	Bank can provide a full loan to run business and sell the product in mass for long term.	Bank cannot provide full loan for selling this product.	No money can be borrowed to sell in mass.
Sustainable	This product can be produced in mass for the long term.	This product can be produced in a small amount for the long term, or a large amount for the short term.	This product cannot be sustained for the long term in the market because it is just a temporary requirement.

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III. DESIGNING LEARNING CONTENT

Constructivism is a learning theory that leads to 21st-century skill development followed by innovation.[33-34] Constructivist learners explore environments to solve problem based on knowledge from their field.[17] Through this theory, critical thinking, creativity, and problem-solving skills can be delivered to the learners.[34-35] The engagement of players to learn invention can be increased through game-based learning (GBL) approach.[36] The learning content will be gamified by adding game elements such as rules, aims, challenges, interaction, and feedback integrated with the learning.[36] By adopting Biggs' constructive alignment, the intended learning objectives of the invention game are aligned with observable behaviour, degree of attainment and conditions of attainment with game structures as shown in Figure 3.0.[28] After the alignment of the learning objective, game and assessment are integrated to discuss the outcomes of the learning activity.

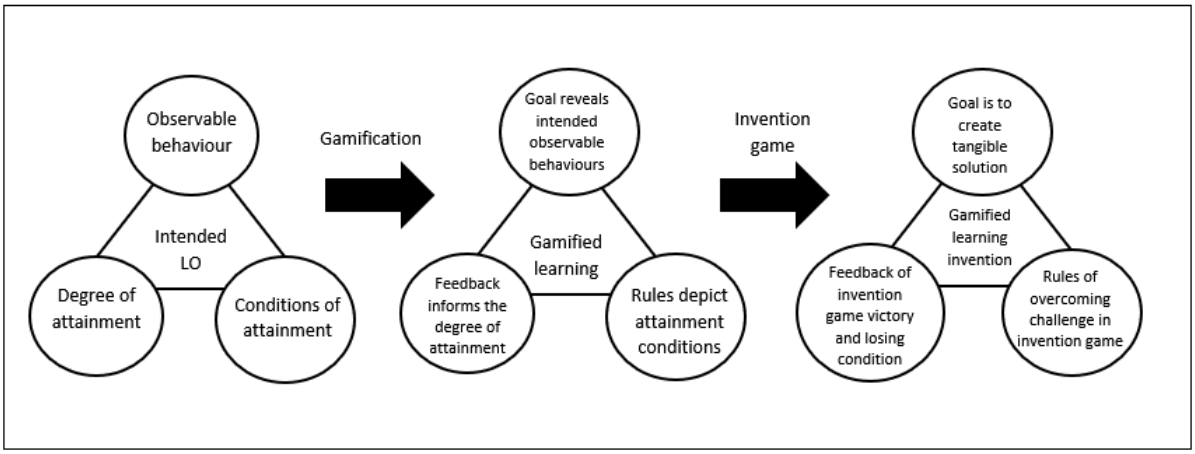

Figure 3: Gamification of learning content for the Invention Game. Data for the constructive alignment from[37]

IV. DESIGN AND DEVELOPMENT OF INVENTION GAME

The *IoF* is a proof-of-concept mobile game that aims to demonstrate how the learning of invention knowledge can encourage learners to generate tangible solutions at ideation level and at the same time develop soft skills. In this game, the role of the player is a grassroots innovator who joins an invention challenge in the virtual world to gain the title of "Inventors of Future" among friends. The process of the educational game is divided into three parts which are pre-production, preparation, and game-based learning adoption.[38].

In the preproduction stage, semi-structured interviews are conducted to discover the process of invention. Grassroots innovators, TRIZ practitioners, and game technology experts have been interviewed by the researcher through audio recording. Data that have been collected are transcribed into text and analysed per question. Next, in the preparation stage, based on the result of the interview and iterative discussion with the game designers, *IoF* is designed. There are three main modules in the game which are Learn, Invent and Assess. The learn module teaches knowledge of invention through factual knowledge of invention principles and mini-games for assessments, invent module challenges players to invent products by sketching solution on the virtual sketch board in the game, assess module is a virtual prototype market for players to assess each other invention through DUMBS. In the invention

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challenge, player will draw a solution based on the mission given in the game. The solution will be a screenshot according to Figure 4.0 and submit the researcher as proof of mission completion.

Figure 4: Screenshot of IoF in the invention challenge titled "classroom challenge".

After completion of the invention challenge, players can review the invention by following D.U.M.B.S rubrics which were created through 5 Likert rating scale as shown in Figure 5.0.

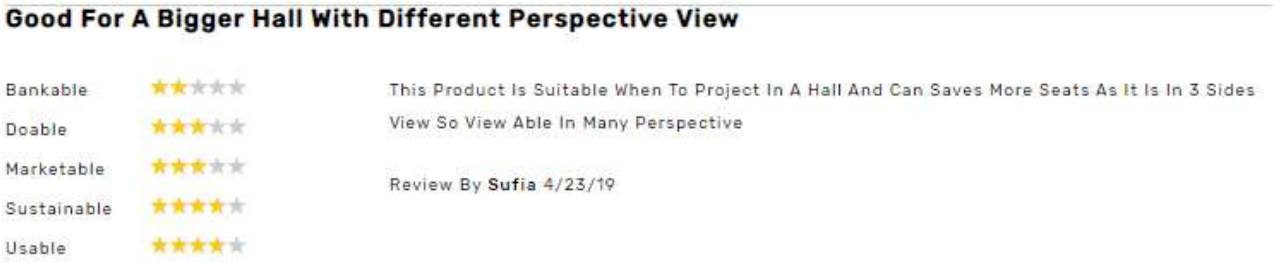

Figure 5: Game-based assessment by using the DUMBS approach

V. CONCLUSIONS

The framework was created successfully based on the information delivered by inventors, TRIZ practitioners, and content experts. The game prototype has demonstrated the use of the framework in the game. This framework should be tested further with the content expertise to validate the effectiveness of the framework.

Conflict-of-Interest: There is no conflict of interest.

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Ethical Clearance: This is not applicable for this study.

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