

Development of Rubric to Measure Children's 21st Century Skills in Digital Game-Based Learning

Laili Farhana Md Ibharrim*, Maizatul Hayati Mohamad Yatim, Nor Zuhaidah Mohamed Zain

Faculty of Art, Computing & Creative Industry, Sultan Idris Education University, Malaysia

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Abstract This study aims to depict how academic expert evaluation was conducted to develop a rubric for measuring children's 21st century skills when designing digital games. The 21st century skills that are related to game design are i) learning skills and innovation; ii) information, media and technology skills; and iii) life and career development skills. The rubric was developed based on cognitive, psychomotor and affective domains of learning. Six academic experts in the field of children's education, educational measurement and educational technology for children were recruited as evaluators of this rubric. Cohen's Kappa Coefficient formula was used to validate the results. The finding showed that each skill level should measure analytically and specifically based on game design activity. Researchers also found that children's skill can be enhanced by adopting the concept of digital game-based learning (DGBL), especially through game design activity. The rubric of children's skills would be essential in learning and teaching process in the future to produce a generation of knowledgeable, and skilled children while developing holistic personality accordance to the 21st century education.

Keywords 21st Century Skills, Children, Digital Game-Based Learning, Digital Game Design, Rubric

is not to deny the role of teachers in disseminating knowledge; rather technology advancement could lead to positive changes, creating robust learning to fulfill children's learning needs [2]. Unfortunately, the 21st century skills of Malaysian students are quite unsatisfactory [3]. Thus, if children in Malaysia are more exposed to the use of learning courseware previously, teachers can try adapting digital learning as a medium for learning through digital game-based learning (DGBL).

In recent years, gamification is a term that has garnered massive attention in the community of educators. The gamification process is related to the concept of DGBL, which is claimed to be fitting as one of the 21st century teaching and learning approaches [4]. Consequently, more empirical research should be conducted to precisely and systematically measure the children's skills in DGBL practice. Thus, this article aims to depict how a rubric was developed as a measuring tool to assess children's mastery of 21st century skills. The rubric was developed during the design process of a digital game for the use of classroom learning. This study focuses on the development process of the rubric which comprises a library research, a feasibility study and an expert evaluation of rubric measurement. The research findings would contribute to the instrumentation of 21st skill measurement for children, particularly through the integration of technology and education.

1. Introduction

Quality education requires consistent and on-going effort. The 21st century skills comprise skills needed by children to face the challenges in learning and in life. In this regard, children are the youngest generation, hence they need to be exposed to the elements of the 21st century skills, like creative and innovative thinking, wise decision making, adaptability, the ability to communicate effectively and the ability to work collaboratively [1]. Education in the 21st century requires changes that are in line with the rapid advances in technology. However, this

2. Conceptual Framework for the Research

The conceptual framework for this research comprises two phases – the rubric development phase and the testing phase, as shown in Figure 1. The objective of library research and a feasibility study is to explore on children's skills in game designing that focuses on cognitive, psychomotor and affective domains. Two combined topics that represent DGBL approach which are 21st century skills and digital game design process that addressed during the rubric development phase.

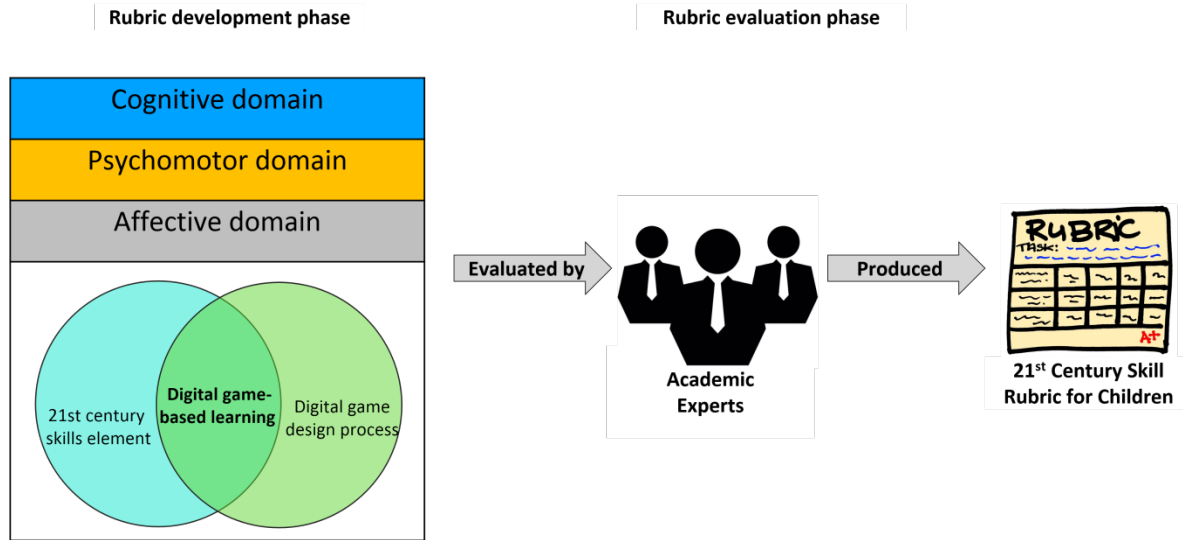


Figure 1. Conceptual Framework

Thereafter, during the testing phase, the developed rubric was evaluated by experts who comprise academic experts in the field of children’s education, educational technology and digital game design for children. The Cohen’s Kappa Coefficient analysis [5] was used as the formula to determine the validity of the rubric to ensure that the rubric is suitable to be used for children. After analyzing the findings, the objective of this research is fulfilled with the creation of an instrument that can be used to measure 21st century skills among children through the process of designing.3. Library Research

2.1. Measuring Children's Skills

Measurement in education requires specific indicators and evaluation to ensure the results obtained are accurate, valid and precise. When measuring the 21st century skills among children, the meaning of “21st century skills” differs across individuals, depending on the purpose measurement. For instance, Claro et. al [6] stated that information skills, communication effectiveness as well as ethical and social impact are most significant dimensions in the measurement of 21st century skills grounded on information and communication technology (ICT).

There are three basic components to measure skills, which are cognitive, psychomotor and affective domains [7]. The list of cognitive skills should be based on the revised Bloom’s taxonomy which emphasizes on both lower order thinking skills and higher order thinking skills among children [8] as shown in Figure 2. Children’s psychomotor skills can be determined by their level of motor skills [9] as illustrated in Figure 3, while their affective skills can be determined by children’s attitude [10] as shown in Figure 4.

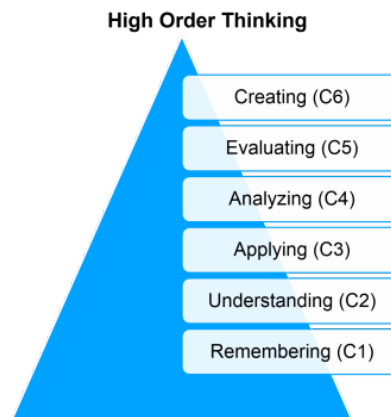


Figure 2. Cognitive Domain

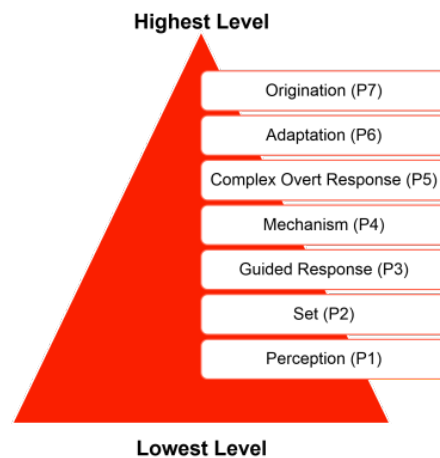


Figure 3. Psychomotor Domain

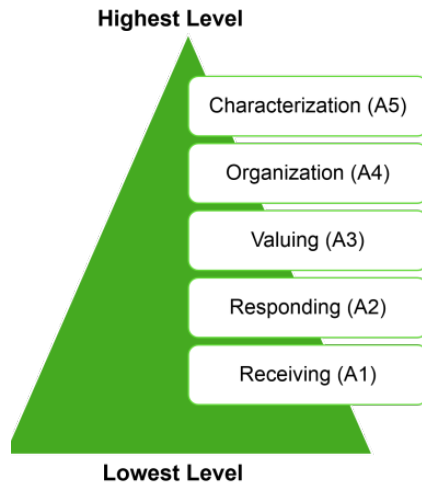


Figure 4. Affective Domain

There are many forms of measurement that can be used to measure skills, including portfolio, self-assessment, achievement assessment diary, open response and rubric [11]. A rubric is a score-based measuring approach which enables teachers to conduct evaluation in a more organized, consistent and directed way based on specific criteria [12,13]. The consistency of scores in a rubric could measure children's skills holistically and analytically. According to Akcaoglu, game design rubric is a form of instructional tool which consists of six elements: goal, rules, assets, space, play mechanics and scoring [14]. The rubric was created to provide a clear prediction on the score that a child needs to achieve, which may help the child to provide response and conduct self-assessment. Therefore, a consistent rubric should have high validity and reliability [15].

2.2. 21st Century Skills in Digital Game Design Process

The world's today regards the 21st century skills as an added value of an individual. In the field of information technology and innovation, the 21st century skills refer to the ICT skills developed through teaching and learning process to produce innovative and creative human resources [16]. In the meantime, playing is one form of natural skill for children. play is deemed as an active process where children are actively involved mentally, physically and emotionally in the game related activities [17]. Children can develop their skills independently based on experiences they gain as they plan and design digital games [18]. The design and development phases of a digital game provide great potential to develop an active and productive learning environment, which offers opportunities for children to expand and expose their skill spectrum. Furthermore, digital game design process may improve self-efficiency and productivity skills among students [3]. Thus, the design and development of digital games can help children to prepare themselves to face

real-life challenges in the 21st century [19-21].

Learning in a universal and active environment is inherent in cultivating the 21st century skills among the future generation, as suggested by Ministry of Education Malaysia. These skills include learning skills and innovation, information, media and technology skills, life and career development skills [20, 22]. Children nowadays are facing great challenges that they are not only required to compete with their peers, but also needed to compete with technology. Thus, the 21st century skills would create a comprehensive package of skill set for children in the effort to develop the next generation which is competent, creative, innovative and efficient.

2.3. The Digital Game-Based Learning Approach in the Design Process

Children can benefit from the integration of digital games in their learning environment as they will be able to recall and retain the learning outcome better. Gamification is a process which uses decision-making elements in formal and fundamental activities such as education, which are not considered as game in the first place [4]. The gamification process would apply playable elements in those activities. Through this process, children can adopt the DGBL approach which enables them to design a game and develop the 21st century skills as well as cultivate positive attitude in gaming environment that is designed for educational purpose [23].

Based on the aspects of relation to the learning approach, Kafai stated that children can apply constructivist learning based on how they present idea and express feeling during the design process [24]. Children are also able to control their thinking as it the design process encourages them to plan and manage learning during the design process. This claim is supported by [25,26] which showed that children could develop their thinking skills and develop their critical capacity for digital literacy. This is evident during the design process where children need to plan the goal and rules of the game, identify the design of gameplay, determine the design of game response, select an appropriate gaming domain and develop a structure of narrative story-telling. Moreover, the digital game design activity is an excellent way to increase motivation [27] helping students to develop an in-depth knowledge [3], as opposed to just playing a game for fun. The activity also can stimulate creativity and creative thinking skills among children, helping them to navigate their future life.

3. Feasibility Study

Feasibility study is an important process in identifying real phenomena in a study, particularly in planning the methodology and developing the measurement instrument [28]. The study is commonly carried out during the initial

phase, before conducting the actual research. A feasibility study can help researchers to reduce errors and time, cost and energy wastage when conducting the real research.

In practice, the feasibility study was conducted with 20 children in pairs (10 males and 10 females), aged 10 years old. The parents of participants have filled out the consent form as approval provided by Research Management and Innovation Center to ensure that this study is in line with the true ethics of research. The participants were given a task to develop a digital game using a game development software. By using a checklist, the researcher, who was assisted by five facilitators, observed how the participants complete their task. Then the participants were interviewed to identify the skills involved in the digital game design process.

Table 1. 21st Century Skills Found In The Digital Games Design Process

21st Century Skills	Skills Element	Sub Skills	
Learning skills and innovation	Basic skills	Drawing Reading Listening	Counting Writing Visualizing
	Thinking skills	Creative Thinking Critical thinking Reasoning Imagination	Decision making Predicting Problem solving
Information, media and technology skills	Technological skills	Exploring Organizing	Planning Designing
	Literacy skills	Visual literacy Global literacy Digital literacy	Technology literacy Information literacy
	Motor skills	Soft Motor	
Life and career development skills	Social skills	Collaboration Interaction Independence	Motivation Emotion

Through the observation of game design process and semi-structured interview, the study found a set of the 21st century skills, as shown in Table 1. In terms of learning skills and innovation, the children demonstrated basic skills through drawing and reading, while practicing creative and critical thinking skills when solving problems. Meanwhile, information, media and technology skills were identified through technological skills when the participants planned and organized steps for designing game. Their literacy and motor skills were observed when using computer hardware and software to develop the game. As for life and career development skills, the participants used social skills to collaborate, interact and motivate each other in the process of designing the digital game.

4. Validation from Experts

After obtaining the set of the suitable 21st century skills through library research and the feasibility study, a rubric was developed to match every skill with specific level in the cognitive, (C1 to C6), psychomotor (P1 to P7) and affective (A1 to A5) domains, as illustrated in Table 2.

Cohen's Kappa Coefficient [5] analysis was used as the formula to analyze the validity of the skill elements in order to develop the rubric. This analysis was crucial in determining whether or not the expert evaluators' agree with the validity of the rubric, so that the rubric can achieve its intended objective, i.e. to yield precise and consistent measurement [15]. Six expert evaluators were recruited from three knowledge disciplines: children's education, educational measurement and educational technology for children. Table 3 illustrates the level of agreement obtained based on skills categories and level of domains in the proposed rubric.

Table 2. Example of 21st Century Skills Rubric for Affective Domain in The Digital Games Design Activity

21 st Century Skills	Skills Elements	Sub Skills	Domain Level	Item
Life and career development skills	Social skills	Collaboration	A5 (Characterization)	The children were able to blend all their roles whole-heartedly when executing the task collaboratively
			A4 (Organization)	The children were able to organise their task collaboratively during the game design process.
			A3 (Valuing)	The children were able to share their values with their design partners during the game design process.
			A2 (Responding)	The children were able to understand each given role during the game design process.
			A1 (Receiving)	The children were able to accept their partners during the game design process.

Table 3. Results of Cohen's kappa Coefficient on The Validity of Rubrics For Measuring Children's 21st Century Skills in Digital Game Design Activities

Expert Evaluator	Kappa (κ) Value	Agreement Scale
Evaluator 1: Expert in the field of children's education	.75	Good
Evaluator 2: Expert in the field of children's education	.73	Good
Evaluator 3: Expert in the field of educational measurement	.69	Good
Evaluator 4: Expert in the field of educational measurement	.46	Moderate
Evaluator 5: Expert in the field of educational technology for children	.97	Excellent
Evaluator 6: Expert in the field of educational technology for children	.83	Excellent

Based on the Kappa value shown in Table 3, two experts in the field of children's education stated that the rubric showed an excellent level of validity. However, items regarding the children's existing experiences and skills during the first conducted activity should be improved. This supports [29] who stated that the best game design activity should provide new knowledge and experience for the children to optimize their development. There was a significant critical difference between the agreement of expert evaluators from the field of educational measurement. They claimed that at some levels, certain keywords are not suitable for the children's age group. This was crucial to identify the rubric that can achieve the objective and can easily be used in real life situation [15]. Meanwhile, the expert evaluator from the field of educational technology for children agreed that the rubric was excellent and suitable to be used as it can measure the children's skills during the game design process [7]. All in all, the rubric is found suitable to be used to measure children's skills during the digital games design process. Nonetheless, the rubric needs to be refined as suggested by the expert evaluators in order to develop a precise, comprehensive and easy- to- use rubric.

5. Conclusions

The integration of technology in education plays an integral role in establishing a 21st century learning environment that can benefit children. In line with the rapid growth of digital games, the DGBL approach planned inside the game design process can be applied to stimulate creativity and specific 21st century skills among children. Furthermore, the potential of children potential as a game designers can be improved through in-class activities, which in turn can provide new experiences in the learning aspect of their daily lives. The digital games design activity may generate and stimulate creativity among children. To ensure this aspiration could be fulfilled, a rubric was developed as an educational measurement tool to assess the 21st century skills among children holistically and analytically. The use of correct

educational measurement tool can match the children's learning needs, so that their skills would be in line with the latest digital development. As a result this digital generation will become a multi-skill generation as a result of using a fitting learning approach in line with 21st century education.

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