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Application of the Bloom's Taxonomy in Online Instructional Games

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Abstract

The Bloom's Taxonomy was introduced in 1956 and the taxonomy for the cognitive domain was revised in 2000. The comparison of the original and revised taxonomy indicates several modifications such as the change in the level names, the arrangement of the levels and the number of dimensions. The cognitive domain of the original and revised Bloom's Taxonomy has currently been applied in the design of online instructional games. The paper examines how the Bloom's Taxonomy has been applied in various instructional games and propose how it can be applied in the development of instructional games for learning grammar. Recent studies reveal the Bloom's Taxonomy has been applied in the instructional game development by designing instructional games based on learning objectives and learning outcomes that were previously written using the Bloom's Taxonomy, and as the basis in creating the game levels. It is evident that the application of the Bloom's Taxonomy in the instructional game design fulfil the educational features of instructional games. Therefore, it is significantly important to propose on how the Bloom's Taxonomy need to be applied in the development of instructional games especially for learning grammar in order to ensure efficient game development for effective learning.

Keywords— Bloom's Taxonomy, Cognitive, Online Instructional Game, Language, Grammar

Introduction

Instructional games are used for educational purposes. They can be in the conventional or digital forms. With regard to digital games, they can be either be played offline or online. In this paper, instructional games refer computer games that are played online or offline. Instructional games must have two features which are enjoyable and educational (Garris et al., 2002; Bellotti et al., 2013; Backlund & Hendrix, 2013; Boyle et al., 2016). The principal objective of playing instructional games is to promote learning, but it takes place in the enjoyable learning

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environment. Therefore, instructional games should have distinctive educational elements to ensure that students learn progressively when playing them.

Instructional games are designed to assist students in learning the course content Learning content in a course is usually presented from easy to difficult in term of the hierarchy of cognitive difficulty. This has long been accomplished in education by the application of the Bloom's Taxonomy. After its introduction in 1956, it has commonly been used worldwide for classifying curricular objectives and test items with the aim to indicate the scope of the objectives and items across various categories (Krathwohl, 2002). Currently, it has been prevalently utilised in the design of instructional games (Bellotti et al., 2013). Thus, the paper aims to examine on how the Bloom's Taxonomy has been applied in various instructional games and propose how it can be applied in the development of instructional games for learning grammar.

Literature Review

The review on the Bloom's taxonomy is only restricted to the cognitive domain. The original taxonomy is referred as the Bloom's Taxonomy. While the revised taxonomy is referred as the Revised Bloom's Taxonomy.

The Bloom's Taxonomy was developed in 1956 by a committee under the leadership of Dr. Benjamin Bloom. According to Bloom et al. (1956), it is a framework that was initially developed to facilitate universities to exchange test items in order to build up banks of test items that evaluate the same educational objectives. He defines it as a system of hierarchical classification of human cognition. It consists of six levels that are organized from the simplest level to the most complex level and the simple level is prerequisite for the more complex level (Bloom et al., 1956). It only has one dimension. The levels arranged from the simplest (1) to the most complex level (6) and their definition (Lorin et al., 2000) are shown in Table 1:

Table 1: The original Bloom's Taxonomy

Level	Description
Knowledge	To remember or retrieve material that has been learnt before
Comprehension	To be able to grasp or construct meaning from material
Application	To be able to utilise learnt material, or to apply material in new and concrete settings
Analysis	To be able to classify or distinguish the components of material into its parts whereby its structure of organisation to aid the understanding of the material
Synthesis	To be able to put components together for building up a coherent or unique new whole
Evaluation	To be able to judge, check, and even critique the material value for a given objective

The Bloom's Taxonomy is unidimensional and is presented graphically in Figure 1: The original Bloom's Taxonomy
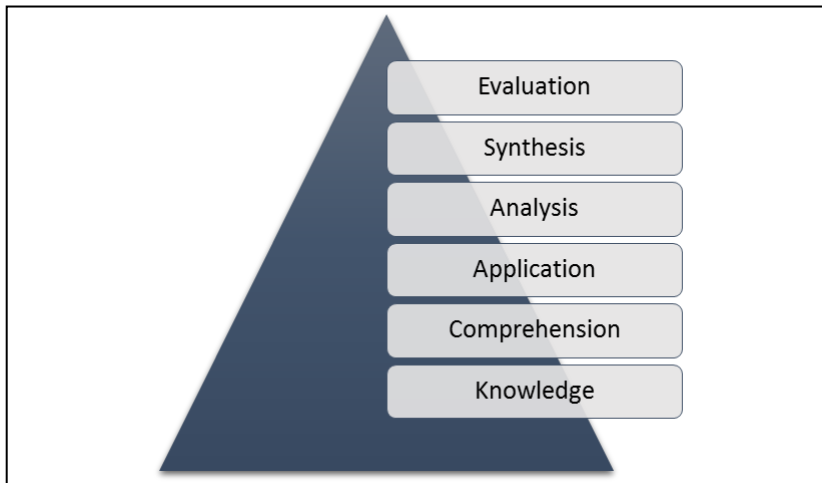
Figure 1: The original Bloom's Taxonomy

The Bloom's Taxonomy was discovered to have several weaknesses (Krathwohl, 2002). He claims that the Knowledge level is dual in nature, not like other levels. Therefore, Knowledge is not listed in the Revised Bloom's Taxonomy, but it becomes another dimension. It is categorized in four different types named as factual, conceptual, procedural, and metacognitive. Thus, the Revised Taxonomy has two dimensions named as the knowledge dimension and the cognitive process dimension.

The Revised Bloom's Taxonomy was introduced by Lorin et al. (2000). It still has six levels, but with several changes. The sixth level in the Bloom's Taxonomy (Evaluation) is placed in the fifth level in the Revised Bloom's Taxonomy. Another change is the naming of levels is changed from using nouns (the Bloom's Taxonomy) to using verbs (the revised Bloom's Taxonomy). The levels remains in the arrangement from the simplest (1) to the most complex level (6) and their definition (Krathwohl, 2002) are as shown in Table 2 :

Table 2: The original Bloom's Taxonomy

	Level	Description
1.	Remember	To retrieve appropriate knowledge from long-term memory
2.	Understand	To determine what the meaning of instructional messages that come in the form of oral, written, and graphic communication
3.	Apply	To perform or use a procedure in a given setting
4.	Analyse	To break down material into components and distinguish how the components are associated to one another and to a whole structure or purpose
5.	Evaluate	To judge according to criteria and standards
6.	Create	Putting elements together to form a novel, coherent whole or make an original product

Krathwohl (2002) states that by combining the two dimensions, a table called Taxonomy Table can be formed for categorizing objectives, activities, and assessments. He explains that the table enables the instructor to see a presentation of a course clearly, concisely and visually. He claims that a completed table entries can help in the course evaluation to improve the curriculum planning and the instruction delivery. The Revised Bloom's Taxonomy is presented in Figure 2: The Revised Bloom's Taxonomy (Adapted from Munzenmaier & Rubin, 2013, p. 22). It is adapted from Munzenmaier & Rubin (2013, p. 22). The original source from Munzenmaier and Rubin is taken from the website of Iowa State University Center for Excellence in Learning and Teaching (http://www.celt.iastate.edu/pdfs-docs/teaching/RevisedBlooms Handout. pdf).

		THE KNOWLEDGE DIMENSION			
		Metacognitive	Procedural	Conceptual	Factual
THE COGNITIVE PROCESS DIMENSION	Remember	Recall	Recognise	List	Remember
	Understand	Predict	Clarify	Classify	Summarise
	Apply	Use	Carry Out	Provide	Respond
	Analyse	Deconstruct	Integrate	Differenciate	Select
	Evaluate	Reflect	Judge	Determine	Check
	Create	Create	Design	Assemble	Generate

Figure 2: The Revised Bloom's Taxonomy (Adapted from Munzenmaier & Rubin, 2013, p. 22)

The Revised Bloom's Taxonomy is more comprehensive to describe the levels of learning. This is because learning is classified into levels through two dimensions which are types of knowledge and cognitive process. According to Munzenmaier and Rubin (2013), the revision of the taxonomy is significant to reconsider the value of the taxonomy in the development of accountable programmes, the alignment of curriculums, and the design of assessments. Moreover, Munzenmaier and Rubin (2013) state that it is important to revise the original taxonomy based on new learning understanding and new instructional methods. Since the use of online instructional games has increasingly gained interest for learning, the Revised Bloom's Taxonomy is notably applicable for this new learning approach that takes place in the new learning environment which occurs virtually.

Methodology
Research papers related to the application of the Bloom's Taxonomy in the design of instructional games were obtained from Google Scholar. The Google Scholar search was limited to papers published from 2010 until 2017. The two sets of keywords used to search for the papers were "bloom's taxonomy" AND "serious games", "bloom's taxonomy" AND "instructional games" and "bloom's taxonomy" AND "digital game". Then, the analysis was carried out on how the Bloom's Taxonomy was applied in the design of instructional games.

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Results and Discussion
Search result s
The results of research papers for the first, second and third set of keywords were 322, 45 and 17 respectively. However, the researcher could only obtained seven relevant papers that were available in full text and could be accessed for free. It is found that the number of free and full-text research papers on the application of the Bloom's Taxonomy in designing instructional games obtained from Google Scholar is limited. To confirm that there are limited research papers published on the application of the Bloom's Taxonomy in the design of instructional games, the researcher conducted an analysis of search results from Scopus (https://www-scopus-com) using the same sets of keywords, and revealed the following trend shown in Figure 3: Analysis of search results from Scopus for the sets of keywords (bloom's taxonomy" AND "serious games", "bloom's taxonomy" AND "instructional games" and "bloom's taxonomy" AND "digital game") from 2010 to 2017 The number of research papers published from 210 to 2017 were only 18. The analysis evidently indicates that the research on the application of the Bloom Taxonomy in the instructional game design has still been very limited although the taxonomy has great potential for the design of educational features in instructional game.
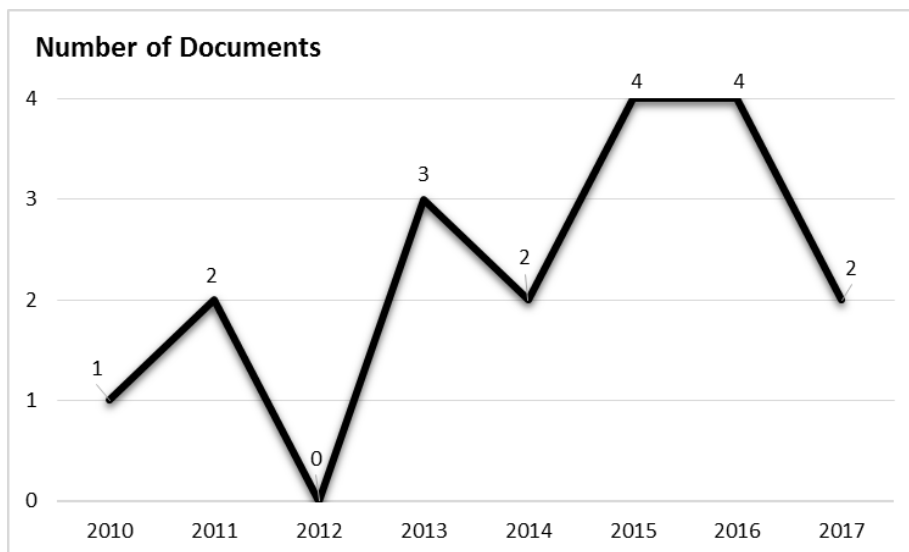

Figure 3: Analysis of search results from Scopus for the sets of keywords (bloom's taxonomy" AND "serious games", "bloom's taxonomy" AND "instructional games" and "bloom's taxonomy" AND "digital game") from 2010 to 2017

How the Bloom's Taxonomy has been applied in instructional games
Buchanan, Wolanczyk, and Zinghini (2011) designed a few casual games using Flash for cyber security training based on six different levels of learning objectives as defined by Bloom's Taxonomy in the curriculum. The types of games were puzzle (knowledge), shooting

(comprehension), puzzle and problem solving (application) and capstone exercise (analysis, synthesis, evaluation). When designing the games, they took into account game interaction types that would support the basic objectives of learning for specific skills and tools. They believe that games essentially need to have a well-defined concept of specific learning objectives that can help the game designer during the development of initial concept. Thus, they state that the development of these games must integrate content, learning objectives of instructional design and engaging game design in order to enhance students' participation in practicing and developing their skills.

Roslina, Rasimah, Hasiah, and Azizah (2011) designed two types of mini games (crossword and shooting) to learn Introductory Programming. The games were designed based learning outcomes in the learning content that applied three lower levels of the Bloom's Taxonomy (knowledge, comprehension and application) in order to address the pedagogical needs in the game design. Roslina et al. report that students were motivated to highly to learn using the games. Students also had positive attitude toward using games and using games enhanced their cognitive development in order to think critically and challenge their understanding about the subject.

Hwang, Sung, Hung, Yang, and Huang (2013) used a knowledge engineering approach for differentiating a set of learning targets to design instructional games on the knowledge classification of plants. Higher levels of the Revised Taxonomy (analyse, evaluate and create) were used in the game play by creating games with three levels: fist-level task, second-level task and third-level task. They claim that this can promote knowledge learning of different learning objectives in the interesting and meaningful way. They revealed that the games enhanced students' learning attitudes and learning achievements. Moreover, students found the games enjoyable and provided realistic learning environments for developing skills and establishing knowledge.

Petit dit Dariel, Raby, Ravaut, and Rothan-Tondeur (2013) argue that instructional games need to apply learning theories and pedagogical approach in order to achieve specific learning objectives. Therefore, they combined the Bloom's Taxonomy with Gagne's Nine events of instructions to design instructional games for nursing that include knowledge: recalling information, comprehension: explaining and predicting, application: solving problems and using information, analysis: seeing patterns or concepts and understanding organisational structure, synthesis: building a structure, putting parts together to form a whole, particularly in creating a new meaning or structure, and evaluation: comparing and making judgements about the value of ideas or materials. They state that the pedagogical approach permit students to progress from the least complex level, and they move on to higher levels as their knowledge competencies increase. They explain that students could repeat the level if the learning objectives were not achieved. Thus, their games have levels whereby the lower level is prerequisite for the higher level in order to allow students learn progressively in terms of cognitive levels of difficulty.

Söbke and Londong (2015) did not design any game, but they utilized an elementary social network game called Fliplife. Therefore, they conducted a study on Fliplife for over three years from May 2011 to September 2014. They state that although Fliplife is not a universal tool

applicable for learning, they discovered that Fliplife indirectly applied the Bloom's Taxonomy in its design. Hence, they could map out the learning outcomes that can be obtained in Fliplife using the Bloom's taxonomy (cognition, motor skills and affective) and communicative. In this regard, they argue that although social network game are easily accessible and have limited game appeal, the games may have pedagogical values.

Loftin, East, and Lamb (2016) created an instructional game known as "Touching Triton" for learning six common, complex diseases. Students are given a role as an employee of a company to analyse provided data for the crew of six persons who will participate in a long-term mission to the largest moon of Neptune which is known as Triton. Based on the provided data, students need to achieve the final game objective that is to pack preventative and treatment supplies for the mission. The development of the game emphasizes on the educational value that is achieved by the game activities based on the model of revised Bloom's Taxonomy. The activities provided in the game cover the Knowledge Dimension (factual, conceptual, procedural and metacognitive) and Cognitive Process (remember, understand, apply, analyse, evaluate and create).

Vahldick, Mendes, Marcelino and Roberto (2017) developed an instructional game that they term it as serious casual game for learning an introductory programming course at higher education level. The game context is cafeteria where the employee serves the customers. The player of the game will control the employee, and computer will control the customers. The player needs to complete missions such as taking the customer orders, preparing food or drink, charging the customer's account, giving back the customer's change and communicate with the customer. In designing the types of tasks in the missions, the first five levels of the original Bloom's Taxonomy are utilized in order to address consistency, clarity and conciseness in the teaching process.

It is evident that both the original and revised Bloom's Taxonomy are applied in in the design of instructional games. The application of the Boom Taxonomy apparently adds the educational values to instructional games by addressing the needs for pedagogical feature in order to promote learning. Table 3 summarises how the taxonomy is utilized the instructional game design in previous studies:

Table 3: How the taxonomy is utilized the instructional game design

	How the Bloom's Taxonomy was utilised	Author
1.	Used the learning objectives written using the taxonomy to design games in learning various skills, subject matter, knowledge and tools	Buchanan et al. (2011)
2.	Used learning outcomes in the learning content to design mini games	Roslina et al. (2011)
3.	Used the taxonomy to design game levels	Hwang et al. (2013) Petit dit Dariel et al. (2013)
4.	Indirectly applied and has incidentally matched with the learning outcomes of a course	Söbke and Londong (2015)
5.	Used to indicate educational value	Loftin, East, and Lamb (2016)
6.	Used to address consistency, clarity and conciseness in the teaching process.	Vahldick, Mendes, Marcelino and Roberto (2017)

It is evident that The Bloom's Taxonomy and the Revised Bloom's Taxonomy are used to align the game play with learning objectives. Whitton (2010) states that instructional games are principally designed to achieve specific learning objectives and learning is intended to take place, unlike in entertainment games where learning is expected to occur incidentally. Therefore, she cautions that the main challenge in instructional game design is on how to ensure the objectives within games support learning objectives. She suggests that learning objectives, learning activities and game objectives need to be mapped in order to help the game designer to select a suitable type of games and interactions that can support learning objectives.

The taxonomy apparently can create game challenge since the taxonomy comprises six levels of cognitive difficulty that requires the mastery of the levels in hierarchical manner. Hamari et al. (2016) explains that the ideal setting of instructional games is learning to solve complex problems that normally starts from easy tasks and the task difficulty is increased progressively. In this case, the taxonomy is potentially useful to develop the progressive challenge. The taxonomy can evaluate cognitive achievement as the result of learning in a hierarchical manner from less complex to more complex levels whereby the less complex level must be must be mastered first before the more complex level.

In general, learning objectives are organised from the less complex level to the more complex levels, and students are expected to master all levels accordingly (Bloom et al., 1956; Krathwohl, 2002). Thus, they can be used in creating progressive difficulties such as in the form of game levels. Moreover, they are suitable to be applied in the development of instructional games for games of lower and higher thinking skills (Buchanan et al., 2011; Roslina et al., 2011;; Hwang et al., 2013; Petit dit Dariel et al., 2013; Söbke & Londong, 2015).

How the Bloom's Taxonomy can be applied in the development of instructional games for Learning Grammar

Learning grammar is considered the most boring part of language learning (Jalali & Dousti, 2012). Instructional games has the potential to break the dullness of conventional classroom routines (Mukundan, Kalajahi, & Naghdipour, 2014). Therefore, providing instructional games for learning grammar is essential in language learning. Thus, the application of the Bloom's Taxonomy in the instructional game design for learning grammar is crucial to promote effective learning. As a result, it is a need to propose how the Bloom's Taxonomy can be applied in instructional games for learning grammar in order to facilitate the development of instructional games for effective learning.

The Revised Bloom's Taxonomy is proposed to be applied in designing instructional games for learning grammar. It is because of two reasons (Munzenmaier & Rubin, 2013). First, it is to refocus the original taxonomy in the accountable programme development, the curriculum alignment and the assessment design. Second, it is to update the original taxonomy based on the understanding of new learning and methods.

Munzenmaier and Rubin (2013, p.29) list various action verbs for digital learning activities based on the Revised Taxonomy. The verbs are shown in Table 4: Action verbs for levels in the Revised Taxonomy as follow.

Table 4: Action verbs for levels in the Revised Taxonomy

	Level	Action Verbs
1	Remember	define, describe, find, identify, label, list, locate, match, name, outline, point to, select, show, state, study, what, when, where, which, who, why
2	Understand	compare, conclude, contrast, define, demonstrate, describe, estimate, explain, identify, interpret, paraphrase, predict, retell, rewrite, summarize, understand
3	Apply	adapt, choose, construct, determine, develop, draw, illustrate, modify, organize, practice, predict, present, produce, select, show, sketch, solve, respond
4	Analyse	analyze, ask, classify, compare, contrast, correlate, diagram, differentiate, edit, examine, explain, group, identify, infer, monitor, observe, order, outline, reason, review, select, sequence, sort, survey
5	Evaluate	assess, choose, compare, conclude, consider, construct, contrast, critique, determine, estimate, evaluate, explain, interpret, justify, prioritize, prove, recommend, relate, summarize, support, test, verify
6	Create	arrange, collect, combine, compose, connect, construct, coordinate, create, design, develop, explain, formulate, frame, gather, generate, graph, imagine, incorporate, integrate, interact, invent, judge, make, model, organize, plan, portray, produce, publish, rearrange, refine, reorganize, revise, rewrite, summarize, synthesize, test, write

There are some action verbs in the table that appear in several levels for example "identify" is in Remember and Understand, "explain" is in Understand and Analyse, and "compare" is in Analyse and Evaluate. Some action verbs are not suitable for writing the instructions for grammar questions and learning objectives in the instructional games for learning grammar. Therefore, it is important to select the most appropriate verbs from Table 4 to be used in the design of instructional games for learning grammar. This may help game designers to use the appropriate action verbs. Moreover, game designers can also avoid using redundant verbs for different game levels.

Figure 4: Action Verb for Instructional Games: Grammar (AVIG: Grammar) illustrates the proposed action verbs and types of questions that are suitable for instructional games for learning grammar. The chart is named as Action Verbs for Instructional Games: Grammar (AVIG: Grammar). It is proposed as follow:
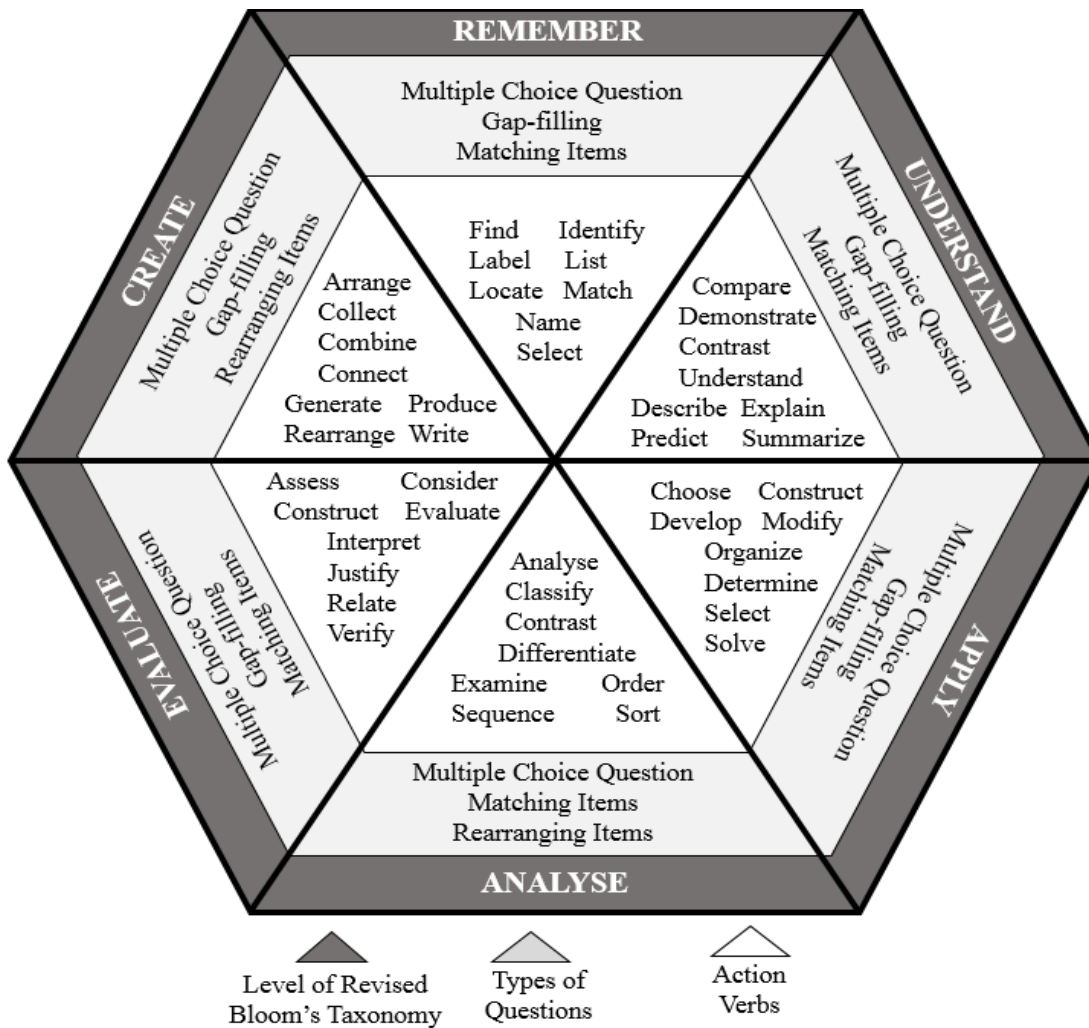
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Figure 4: Action Verb for Instructional Games: Grammar (AVIG: Grammar)

Conclusion

The Revised Bloom's Taxonomy is suitable to be applied in the design of instructional games as learning occurs in the new environment which is online replacing the conventional classroom where learning involves face-to-face instruction. The revised taxonomy provides a clearer classification of levels through two dimensions namely cognitive dimension and knowledge dimension. The proposed Action Verb for Instructional Games: Grammar (AVIG: Grammar) is hoped to help game designers in creating effective instructional games for learning grammar. Future research on the development of instructional games especially in learning grammar should consider to utilize AVIG: Grammar as it may ease the process of selecting the suitable action verbs for writing the instructions and choosing the appropriate learning activities in the instructional games according to the levels in the Revised Bloom's Taxonomy.

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