

## A NEW APPROACH OF LEARNERS' ASSESSMENT USING BLOOM'S TAXONOMY-BASED SERIOUS GAME

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### Abstrak

Naskah ini mendeskripsikan skenario, spesifikasi agen, peta pengetahuan, implementasi *serious game* berbasis taksonomi Bloom (BoTySeGa), serta tanggapan pengguna terhadap game yang dibangun. Pembangunan BoTySeGa bertujuan menyediakan alternatif alat penilaian yang dibutuhkan dalam penilaian pembelajaran di SD. Pembangunan mempertimbangkan aspek: pengetahuan permainan, materi bangun datar jajaran genjang siswa SD kelas 5, dan domain kognitif menurut Bloom. Level tantangan disusun mengikuti aspek domain kognitif Bloom yang diaplikasikan di jenjang SD (pengetahuan, pemahaman dan aplikasi). Game yang dihasilkan diuji melalui uji penerimaan pengguna (UAT) untuk meyakini semua fungsi dan fitur berfungsi dengan benar. Uji juga mencakup tanggapan pengguna yang dilakukan menggunakan kuesioner skala Likert dengan lima pilihan dan lima belas item pertanyaan. Uji dengan melibatkan 85 pengguna diperoleh hasil bahwa BoTySeGa memenuhi spesifikasi kebutuhan penilaian pembelajaran. Dengan rentangan skor tanggapan 5 – 75; rata-rata skor tanggapan dari pengguna sebesar 59,93 dan berada dalam kategori tanggapan "Positif".

*Kata kunci:* Penilaian Pembelajaran, Taksonomi Bloom, Permainan Serious.

### Abstract

*This paper describes: a scenario, agent specification, mapping of knowledge domain, an implementation of Bloom's taxonomy-based serious game (BoTySeGa), and players' response against the game. The development of BoTySeGa is pursued to the availability of an alternative assessment tool for learning in elementary school. It considers aspects: game knowledge, subject matter of parallelogram for 5<sup>th</sup> grade elementary school learners, and cognitive domain of Bloom's taxonomy. BoTySeGa's level of challenge is structured accommodates cognitive domain of Bloom for elementary school learners (knowledge, comprehension, application). To make sure that all functions and features work well; we conducted user acceptance test against the game prototype. We also took players' response to BoTySeGa utilizing five-points Likert-type of questionnaire. The questions are distributed in 15 items. User acceptance testing involving 85 learners of 5<sup>th</sup> grade elementary school shows that BoTySeGa has fulfilled the learning assessment requirement. With the response score ranged from 5 to 75; it is found that the average score of players' response to the implementation of BoTySeGa in learning is 59.93. This response value falls within "Positive" category.*

*Keywords:* Learning Assessment, Bloom's Taxonomy, Serious Game.

## INTRODUCTION

A good assessment is an important part of learning, since it guides students' learning. Misleading assessment potentially leads to incorrect learning approaches conducted by students [1][2][3]. For a long time; assessment has been approached as psychometric issue and purposed for measuring learners' achievement of certain curricular goals. The assessment is mainly focused on validity and reliability as its main criteria. This perspective is referred to as assessment of learning. For learning in the 21th century; we need the implementation of assessment for learning (AfL). Assessment Research Group (ARG) defines AfL which is known as formative assessment as the process of seeking and interpreting evidence for use by learners and their teachers to make decision of learners position in learning, approaches which are conducted by students as the best way to reach the competence. In this perspective; assessment is approached as an educational design issue [4]. Assessment is implemented as a subsequent of learning environments and is required for assuring the existence of constructive alignment between learning, instructional approaches and assessment. When it is properly implemented; research results show that AfL gives beneficial effect on learning [5]. AfL is being taught as a promising pedagogical approach for enhancing students learning [6] due to enquiry process involving the active search for evidence of capability and understanding, making sense of such evidence, and exercising judgment for wise decision making about next steps for students and teachers [7].

Confidence to practice a highly effective pedagogical approach in learning is realized in North America, Western Europe, Australia, and Asia [6] [7]. In contrast with previous research results; AfL practice in learning has identified some problems. The problems involve time and class sizes, teacher misconceptions of AfL philosophy, theory and practice, and perceived misalignment between system accountability priorities and teachers' assessment practices [6] [7] [8] [9] [10]. In case of a big class size and limited time of assessment there is a tendency that less data are available for creating decision. This condition implies that a more subjective assessment is needed for creating a decision [3].

It is defined that assessments with technologies aid are those that integrate authentic experiences, involving digital media, with

incorporation of performance measurement, learning and knowledge. It creates a detailed record which is analyzable. Teachers and students use its results to improve learning [11]. Game and game technology are assessments with technology aid which is poised to educate and train students at all levels. One such game among others believed as developing technology is a serious game [3]. Serious Games (SGs) have the potential to offer both an effective and motivating educational experience [12]. Serious game is different from entertainment game due to the existence of assessment component [13] [14] which is really required in learning [13]. It provides an opportunity for players to transferring technology and recording player behavior while playing the game [14]. The history of the application of game technologies in education can be tracked at [15] [16] [17] [18] [19] [20] [21] [22]. But, instructors do not fully embrace serious game in learning. What is it being thought as missing in serious game is the availability of pedagogical and assessment engines [3]. Since the serious game provides learners to practice and apply skills needed in the real world than we need to promote the use of serious game in learning.

Utilization of Bloom's taxonomy in the development of online assessment questions was done by [23]. The domain is based on the hierarchy of thought processes. Each of it requires a more complex thinking than the one preceding it. Thus, in developing item of assessment, we keep in mind that students think, make connections, question the information included in the problem, process the information, and reflect on their answers [23]. It was found that the use of Bloom's taxonomy in learning curriculum framework could increase achievement of learners [24]. Learning should move from the simple to the complex, from the known to the unknown. Each unit should provide a foundation for the units that follow, with increasing complexity and performance milestones that define progress toward the goal of the fully qualified practitioner [25]. Well designed multiple choice questions incorporating different learning domains of Bloom's taxonomy may be a potential method of assessing critical thinking skills in large classes of students [26].

Due to there is no previous research that applies Bloom's taxonomy into serious game; we

propose the development of Bloom's taxonomy-based serious game (BoTySeGa). The game integrates a Bloom's taxonomy-based assessment framework into game technology. We also adjust level of difficulty challenges considering the player experience in the previous challenge. Three levels of difficulty problems are defined as: low, middle and high. The limitation on the number of level is to deal with the creation complexity of game's problems.

Complexity of thinking of players which is required in solving challenges of BoTySeGa is structured from the simplest to the most complex. The Bloom's taxonomy-based assessment framework is combined with adjustment level of difficulty problems; if it is integrated in serious game is potentially avoids players' early frustration or boredom in playing the game and improve learning outcome [27]. Gameplay data which are recorded using assessment framework are more detailed. It creates less subjective element to be in decision making and approach which will be conducted in learning.

The following sections discuss: literature review, research methodology of the development of BoTySeGa, results, and concluding remark.

## LITERATURE REVIEW

### Bloom's Taxonomy

Bloom's taxonomy is a hierarchy of learning objectives which was published originally by Benjamin Bloom in 1956. The taxonomy involves three aspects of learning domain such as: affective, cognitive, and psychomotoric. Emphasis is given to the second of those three domains of Bloom's taxonomy. At the domain; Bloom categorizes six levels of educational objectives. Those levels are: knowledge (C1), comprehension (C2), application (C3), analysis (C4), synthesis (C5) and evaluation (C6). The first three levels are classified as lower order thinking skills and the others as higher order thinking skills. Each level measures different level of thinking skill complexity. Summary of Bloom's taxonomy is depicted at Figure 1.

In 2000; Anderson and Krathwohl revised Bloom's taxonomy. No addition or reduction in the number of learning objective appears in the revised of Bloom's taxonomy. It is different from the original one as the replacement of



Figure 1. Bloom's Taxonomy Objectives of Cognitive Domain [28]

nouns with verbs for the naming of level. One principle change in the revised Bloom's taxonomy is the switchover the fifth and the sixth level followed by replacement of a word synthesis with create. The six level of the cognitive domain of revised Bloom's taxonomy involves: remember, understand, apply, analyze, evaluate and create. Summary of this revised taxonomy is depicted at Figure 2 and more detailed information of each level is described in Table 1.

Bloom states mastery in a category as the capability to demonstrate skills or abilities defined as objectives in the category. Those skills or abilities are listed from a simpler to more complex of thinking skills.



Figure 2. Revised Bloom's Taxonomy Objectives of Cognitive Domain [28]

It implies the necessary appearance of simpler skills for mastery in more complex skills [29].

### **Serious Game and Constructivism Theory**

Early in its evolution; the "serious game" oxymoron pinned to games which are used for education, training, health or public services could be found in a Swedish novel "Den allvarsamma leken" whose English title is "The Serious Game". The novel was written in 1912. Other similar idea could also be found in [30]. The "serious game" oxymoron with a meaning closest to its current meaning used firstly in a book written by [31] entitled "Serious Game". From then on, many creations are found in conjunction with "serious game" oxymoron. They all follows the lead set by white paper Ben Sawyer entitled "Serious Games: Improving Public Policy through Game-based Learning and Simulation" [32]. Other definition of "Serious Games" found in [33], [34], [35], [15]. They commonly deal with the idea that serious games are different from other game due to its ability to transfer knowledge.

Market of serious game technology has been rapidly growing during the twenty first century. A number of 1265 games were produced at an

eight year time interval (2002-2010) [36]. What is thought to make serious games rapid growth recently is its potential to assist the implementation of constructivism paradigm in learning [37]. In constructivism paradigm; learners themselves construct knowledge in the way suitable for them as the attempt that they make sense of their experience. It also changes learners' mental model from passive to active process information. Constructivism paradigm is suitable with Piaget [38] and Vygotsky theory [39]. Piaget theory states that learning is held through active exploration and occurred when there is mismatch between theory and experience. Meanwhile; Vygotsky states that learning occurred in social context and the interaction between learners and their peers is necessary part of learning process.

To guarantee serious games assist in the implementation of constructivism paradigm during the learning process; its design should involves the following techniques: modeling, reflection, strategy formation, scaffolded exploration, debriefing, and articulation as depicted at Figure 3 [37]. In the first; people commonly learn through modeling technique. It is a form of demonstration (in the form of simulation or video) followed by impersonation.

Table 1. Summary of objectives of Revised Bloom's Taxonomy [27]

<b>Objectives</b>	<b>Definition</b>	<b>Verbs</b>
Create	Retrieve knowledge from long term memory	Assemble, construct, create, design, develop, formulate, write
Evaluate	Construct meaning from instructional messages, including oral, written, and graphic communication	Appraise, argue, defend, judge, select, support, value, evaluate
Analyze	Applying a procedure to a familiar task	Appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test
Apply	Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose	Choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write
Understand	Make judgments based on criteria and standards	Classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase
Remember	Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure	Define, duplicate, list, memorize, recall, repeat, state

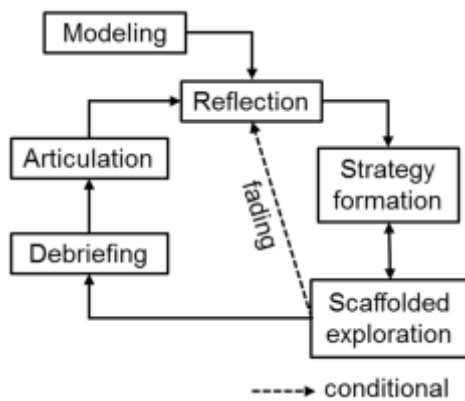
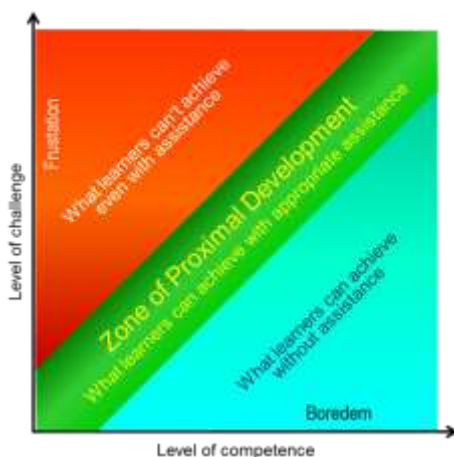


Figure 3. Constructivist Serious Game Framework [37]

Learners observe and construct a conceptual model of the process required to achieve learning objectives. This technique is frequently used in assisting the creation of learners' progress through Zero Proximal Development (ZPD) process (Figure 4).

Reflection compares learners' experience in problem solving with an expert, their peers or ultimate goals. It implies the assurance for the existence of observer who records learners' experience in playing games. Outcome of reflection technique is a decision making whether a new strategy formation is required in game playing. Strategy formation is attributed with changing in intelligence reorganization adjusted for new ideas. Learners should be smart in reorganizing their intelligence to produce accurate strategic playing in problem solving. Scaffolding exploration directs learners to a modus of problem solving suitable for themselves.



Figutr. 4. Zone of Proximal Development [40]

Scaffolding is aimed at building the learners ability in problem solving independently. The assistance of instructors is gradually reduced in the scaffolding exploration. Players should remember that each action involves risk and there is a requirement to inform how they should play and monitor their progress continuously. In case of a player has achieved the learning objective; instructor's support could be reduced (faded). Many consider debriefing to be the most critical part of the simulation experience. Without this debriefing time, the effectiveness of the activity may be greatly diminished, as some learners will see the activity as a standalone event and not properly connect it to other aspects of the class. If presented appropriately, debriefing helps the students deconstruct the activity and then connect it into their mental models. With Articulation is defined as a players' forum to share experience among them.

## RESEARCH METHODOLOGY

Our research methodology involves the following steps: designing game's scenario of BoTySeGa, designing BoTySeGa's game engine, defining states and procedures conducted in each engine, mapping knowledge content into BoTySeGa's challenges, composing challenges' database, and implementing the game development package (Figure 5). The tool applied for the development is RPG XP game development package.

We conducted user acceptance testing (UAT) before requesting feedback from players to guarantee that the game is fulfilling the requirement. Eighty five Players' responses to BoTySega were gathered utilizing a Likert-type questionnaire. The players are learners of 5<sup>th</sup> grade of two elementary schools in Singaraja i.e. SD N 3 Banjar Jawa and SD Laboratorium Undiksha. Questions are stressing on psychological aspects of players while playing BoTySeGa. The questions are distributed in 15 items of five points. Those points are: strongly agree (SS), agree (S), undecided (R), disagree (TS), and strongly disagree (STS). Players' responses are quantified by assigning score 1 to 5 to the corresponding unit.

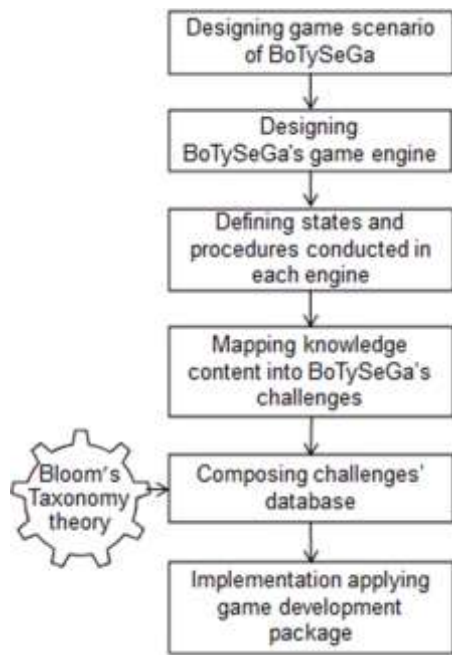


Figure 5. Zone of Proximal Development

Finally; average score ( $\mu$ ) of 85 respondents are matched to categorization interval which is composed involving the value of ideal mean ( $m_i$ ) and standard deviation ( $sd_i$ ) as follows.

$$m_i = \frac{1}{2}(li + hi) \tag{1}$$

$$sd_i = \frac{1}{6}(hi - li) \tag{2}$$

$li$  is the lowest and  $hi$  is the highest score. The category interval on those both values are:

$m_i + 1.5sd_i \leq \mu$	Highly positive
$m_i + 0.5sd_i \leq \mu < m_i + 1.5sd_i$	Positive
$m_i - 0.5sd_i \leq \mu < m_i + 0.5sd_i$	Average
$m_i - 1.5sd_i \leq \mu < m_i - 0.5sd_i$	Negative
$\mu < m_i - 1.5sd_i$	Highly negative

### Game's Scenario of BoTySeGa

Game scenario of BoTySeGa is composed as follows. Players are about to be ready to play

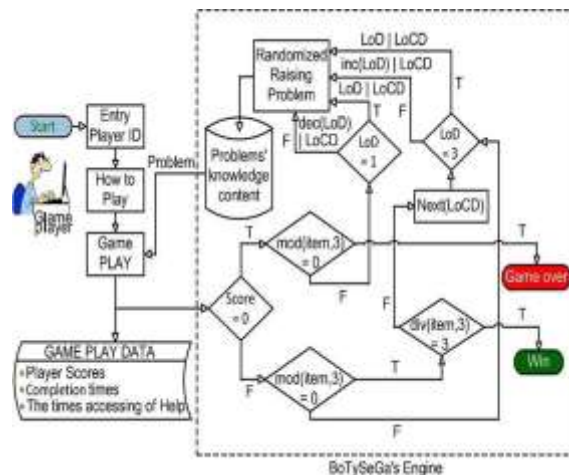


Figure 6. The Design of BoTySeGa Engine

the game after typing their identifier at login process and learned how to play the game. They are allowed to navigate student agent movement to the left, right, bottom, up, or following the instruction that is displayed at pop-up dialog. In Addition, they are also challenged to solve nine problems. The nine problems are distributed into three different stages of the game. Those, who solve problems correctly, are the winners.

The first problem on BoTySeGa is the problem with the middle level of difficulty of C1 cognitive domain. Players who passed in the first problem will be challenged with the second problem of the similar cognitive domain but with higher level of difficulty. Otherwise, players will be challenged with the similar cognitive domain and the lower level of difficulty. The game generates three problems in each of the cognitive domain. Filtering is conducted in the third problem; in which a correct solution will bring players to continue to the next cognitive domain, otherwise stop up in the current domain. Probability of correctness, state, and description of each players' solution in each problem of a cognitive domain is shown in Table 2. Those players who are passed in C3 cognitive domain are stated as the winners.

Players are also permitted to access Help before submitting problem solution. Players' experience are recorded as game play data applying database application system.

Table 2. The Mechanism of Cognitive Domain Changes

No	Probability			State	Description
	first	second	Third		
1	0	0	0	Fail	Totally fail
2	0	0	1	Pass	There is learning process although it takes long time
3	0	1	0	Fail	It is not significant that there is learning process at learner's individual
4	0	1	1	Pass	There is enough learning process at learner's individual
5	1	0	0	Fail	Exactly there is no learning process
6	1	0	1	Pass	There is learning process although there is still doubt
7	1	1	0	Fail	Gradually shown that there is learning process
8	1	1	1	Pass	Learner with excellent start and keep in excellent condition until end

### BoTySeGa's Game Engine Design

Design of BoTySeGa's game engine is depicted at Figure 6. In general, we developed two agents inside BoTySeGa game engine, those are: BoTySeGa and student agents.

BoTySeGa's agent equipped with four functions such as: problem selection, setting LoD, filtering players who may proceed to the next level of cognitive domain, and recording player experience. Meanwhile; student agent consist of functions for: login access, access to the Help, and submit a solution.

Furthermore, BoTySeGa is equipped with problems and gameplay database. Challenges' database is created to storage 45 items of challenges. Those items are of three level of cognitive domain and three level of difficulty problem. Gameplay database records players experience while playing the game.

### State Design and Procedure of BoTySeGa's Game Engine

It has been described in the previous section that BotySega's game engine involves two agents. Each of them is equipped with functions. Functions, states of functions, and procedure which is designed in each agent are described below.

#### *The BoTySeGa Agent*

The first function in BoTySeGa agent is a function to select a problem among problems saved in problems database. Input parameters of problems selection's agent are level of

difficulty problem (LoD) and cognitive domain (LoCD). Agent selects one among five problems associated with input parameters. Procedure attached at problem selection agent is defined at the following algorithm.

```
// Algorithm of selection a
problem
Input: LoD, LoCD
Output: selected problem
Process:
    par1 = LoD
    par2 = LoCD
    randomly select a problem with
    the difficulty level = par1
    and cognitive domain = par2
```

We group the level of difficulty problem in BoTySeGa into three groups. Those are: low, middle, and high. Except for the first problem, the determination of level is based on player experience at the previous problem. Typically, players who are passed at the previous problem will be challenged to solve a problem of a higher level of difficulty. Otherwise they will be challenged to solve a problem of a lower level. In case they are passed to solve a problem with the highest level of difficulty or failed with the lowest level, they will be faced with a problem of the similar level of difficulty. The function output is used as an input parameter of problem selection function. The procedure of determining a level of difficulty problem is shown at the algorithm below.

```
//Algorithm of determining
problem's level of difficulty
Input: PrevLoD, score
Output: LoD
Process:
```

```

If player submits an incorrect
solution of a problem then
  if current problem is of the
  lowest level of difficulty
  then player will be faced with
  a problem of the similar level
  else
  player will be faced with a
  problem of a lower level
  endif
Else
  if player solves problem of
  the highest level then player
  will be faced with a problem
  of the similar level
  else
  player will be faced with
  aproblem of a higher level
  endif
Endif

```

Bloom's taxonomy states that learners' mastery at a cognitive domain affects their mastery on the next domain. BoTySeGa accommodates this state by the way of permitting only players who are passed from a cognitive domain proceeded to the next level. Filtration process whether a player is permitted proceeds or stop in a certain level of cognitive domain refers to the condition which is shown in Table 2. Filtration algorithm is shown as follow.

```

//Algorithm of Authorized Players'
Filtration
Input: Score, LoD, LoCD, item
Output:LoD, LoCD
Process:
  If player submits an incorrect
  solution of a problem then
    if it is the last chance of a
    level of a cognitive domain
    then status = "Game Over"
    // player sends incoorect
    solution at the last chance
    else
    if the problem is of the
    lowest level of difficulty
    then player will be faced
    with a problem of the
    similar level
    else
    player will be faced with
    a problem of a lower level
    endif
  endif
Else
  //players send correct solution
  If it is the last chance of a
  level of cognitive domain
  then status = "Win"

```

```

else
  if player solves problem
  of the highest level
  then player will be
  faced with a problem of
  the similar level
  else
  player will be faced
  with aproblem of a
  higher level
  endif
endif
Endif

```

Players' experience within each problem of BoTySeGa is logged into external database and saved as a game play data. Primarily; BoTySeGa logs the values of three attributes of game play data. Those are: score, completion time, and the time of accessing Help. Score is recorded in ordinal data type ranging from 0 to 3. Meanwhile completion time and the time of accessing Help are recorded in ratio data type. The recording algorithm of players' experience is the last function of BoTySeGa's agent. It is shown in the following algorithm

```

//Algorithm of recording game play
data
Input: LoD, LoCD, correct_answer
Output:Score, Completion time,
the time of accessing Help
Process:
  Do While not (submit solution)
  Timer on
  On submit solution do
  If solution is correct then
  Case the difficulty Level
  of problem:
    Low : score = 1
    Middle : score = 2
    High : score = 3
  Endcase
  Else
  Score = 0
  Endif
  Completion time = Timer
  End
  On accessing Help do
  The time of accessing Help
  = Timer
  End
End

```



### Student Agent

BoTySeGa defines login access to guarantee uniqueness of data existence for each player. The condition is set in order to make sure that a player relates to the only one learning characteristic. It implies that the only data of player that was not saved beforehand is allowed to pass login access. Player typing username and password to make login access into BoTySeGa is described in the algorithm.

```
// Algorithm of Login Access
Input: user, pass
Output:username, password
Process:
  Open game play database
  Check whether user and pass
  are saved beforehand
  If not (exist) then
    username = user
    password = pass
  Append username, password
Endif
```

Access to the Help is designed to facilitate players to construct knowledge by themselves. Access is done when a player loses the information required in problem solving. Procedure of access to the Help is conducted as in the following algorithm

```
// Algorithm of Login Access
Input: problem ID
Output:time
Process:
  Time = timer
  Open problems database
  Display Help for problem with
  ID equal to problem ID
  Append time
```

In addition to time in accessing the Help; BoTySeGa also records the players' experience in the form of score and completion time. The value of these attributes triggered through the process of clicking an answer among the four available answers. The algorithm below is the procedure of submit a solution which is designed in BoTySeGa.

```
// Algorithm of Submit a
solution
```

```
Input:
Output:answer
Process:
  Return player's answer
```

### Mapping Of Knowledge Distribution in BoTySeGa

Knowledge that is involved in serious game is a parallelogram. It is a subject matter of 5<sup>th</sup> grade elementary school learners. Problems are grouped based on two dimensions, i.e.: cognitive domain and level of difficulty. The only the first three of the six cognitive domains of Bloom's taxonomy are adopted in BoTySeGa. Those three domains represent the level of game challenge. Players are faced with three problems in each level of game. The problem could be of low, middle, or high level of difficulty. The grouping of BoTySeGa's problems in two dimensional matrix is shown in Table 3.

Indicators which are implemented in grouping of BoTySeGa's problems are defined in Table 4. Those indicators are arranged on consideration with Bloom's cognitive domain, competency standard of subject matter, and problem's level of difficulty.

### BoTySeGa's Challenges Database

Forty five multiple choice problems are arranged for the BoTySeGa. Those problems are of nine elements of two dimensional matrix of problems distribution. The problems are arranged from six definitions of competencies standard of parallelogram (Table 5).

Table 3. Two Dimensional Matrix of Problems Distribution

Level of problem difficulty	Cognitive Domain		
	C1	C2	C3
Low	C <sub>1L</sub>	C <sub>2L</sub>	C <sub>3L</sub>
Middle	C <sub>1M</sub>	C <sub>2M</sub>	C <sub>3M</sub>
High	C <sub>1H</sub>	C <sub>2H</sub>	C <sub>3H</sub>

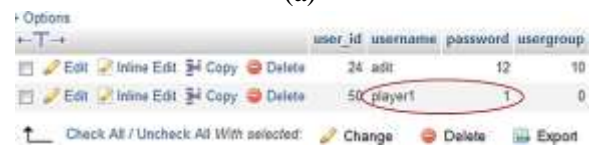


Table 6. UAT Scenarios of BoTySeGa

No	Scenario	Input	Expected output
1	Leave name or absence number empty	Name or absence number is empty	Released the hint for asking player to input name or absence number before taking permission for playing game.
2	Input name or presence number that is already exists in database.	Name or presence number that has been already exist in database	Released the hint to let player know that the name or presence number is already exist in gameplay database.
3	Input name and presence number that have not existed in game-play database.	Name and presence number that have not existed in gameplay database.	Player's name and presence number is saved in gameplay database.
4	Bring playing character to non-playing character with navigation	Bring playing character to non-playing character without navigation	No response released by game system
5	Bring playing character to non-playing character without navigation	Bring playing character to non-playing character with navigation	Game system releases pop-up communication to encompass playing character movement
6	Send a wrong solution for the third problem of a cognitive domain	A wrong solution for the third problem of a cognitive domain	Game system releases "Game over" state and stop playing up to current level
7	Send a right solution for the third problem of a cognitive domain	A right solution for the third problem of a cognitive domain	Game system continuous playing to the next cognitive domain except for the highest domain (application).
8	Send a right solution for the third problem of the third cognitive domain	A right solution for the third problem of the third cognitive domain	Game system releases a winner state and stops the game.



(a)



(b)

Figure 7. Pass login Access

On the contrary; Figure 8 (a-b) depict players are not permitted due to the recorded player's data in player's database.

### Non-playing character with vs. without Navigation

There are a number of non-playing characters created in BoTySeGa. Some of them are completed with knowledge to navigate players. Playing character must communicate to non-playing characters equipped with knowledge to navigate the player.



(a)



(b)

Figure 8. Fail Login Access

This approach is designed to encompass players' movement in their adventure. BoTySega implements this scenario involving pop-up menu in which information about "where to go or what to do next" is displayed.

Screenshot in case of player meets non-playing character with navigation knowledge is shown at Figure 9 (a), otherwise at Figure 9 (b).

**Continue to the next or Stop up to current level**

Based on Bloom; learning hierarchy starting from simple to complex knowledge/skill. The hierarchy implies that mastery in previous cognitive domain is entirely important to be master in a cognitive domain.

BoTySeGa applies Bloom's hierarchy into a rule which is in charged with filtering of player whom is continued to the next level of cognitive domain or stop up at the current level with "Game Over" state. Filtration mechanism refers to principles contained in Table 2.



(a)



(b)

Figure 9. Two Classes of non-Playing Character



(a)



(b)

Figure 10. A case of Continue to the next level

Screenshots in case of a player is permitted to continue to the next level and the game play data are shown at Figure 10 (a-b). In case of a player should stop up at current level; the screenshot and data are shown at Figure 11 (a-b).



(a)



(b)

Figure 11. A case of stop up to current level

### Winner State

BoTySeGa defines two states of the end of game i.e.: player wins or loses the game. The players who win the game completely solve nine challenges and send a right solution on the last chance.

A Screenshot in case of a player win the game is shown at Figure 12. The data in case of a player in a win state is shown at Figure 13.

### Players' Response to BoTySeGa

$li$  and  $hi$  scores for 15 questions of five point successively are 15 and 75. Hence the five intervals response categories are:

- $60 \leq \mu$  Highly positive
- $50 \leq \mu < 60$  Positive
- $40 \leq \mu < 50$  Average
- $30 \leq \mu < 40$  Negative
- $\mu < 30$  Highly negative

Based on the data of 85 respondents; it is obtained that the mean value of response score is 59.93. The mean value falls within positive category. This value is close to lower value of highly positive category i.e. 60.

### CONCLUSION

This paper has described the development of Bloom's taxonomy-based serious game which is named BoTySeGa. The game was designed with dynamic level of difficulty and gives consideration to learning hierarchy of Bloom's taxonomy in challenges leveling.



Figure 12. A Winner Game State

Among eight scenarios proposed to test against BoTySeGa, it is found that there is a match between expectation and output results. We found it at all eight scenarios. It informs that the game has fulfilled the requirement specified in game scenario. We also prove that players response positively to the usage of serious game as an assessment for learning. It is shown by average score of players response i.e. 59.93, which is involved is "Positive" interval of category. Hence the implementation of Bloom's taxonomy-based serious game should be taken for consideration as a tool in learning especially in assessment.

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user_id	username	password	usergroup	banned	soal1	soal2	soal3	soal4	soal5	soal6	soal7	soal8	soal9	waktu1	waktu2	waktu3	waktu4	waktu5	waktu6	waktu7	waktu8	waktu9
24	adit	12	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
54	PassPlayer	6	0	0	0	1	2	0	0	0	0	0	0	3	13	36	0	0	0	0	0	0
56	FailPlayer	7	0	0	2	0	0	0	0	0	0	0	0	5	15	12	0	0	0	0	0	0
57	winPlayer	8	0	0	0	1	2	0	2	3	3	3	3	2	13	24	4	8	28	20	8	29

Figure 13. A Winner Game Play Data

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