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## Analysis of Gamification Models in Education Using MDA Framework

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### Abstract

Gamification nowadays is being one of techniques that can increase motivation and encourage the involvement of users, particularly in education domain that requires teaching and learning activities to be more fun and interesting. This paper surveys some analysis of gamification models. MDA framework is used to identify surveyed papers by breaking them down into three categories: mechanics, dynamics and aesthetics. Findings from the survey show there are many gamification models in education domain. However, there are some very representative gamification models could be used as a method to increase motivation, achievement and engagement in learning activities. By knowing the latest gamification models in education domain stated in this paper, it could help gamification practitioners to make new strategies in learning activities to increase students' motivation, achievement and involvement. We also suggest some gamification strategies, which combine several mechanics in such a way to create dynamics that results in all types of aesthetics outputs.

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## 1. Introduction

Gamification means adding game elements into non-gaming context<sup>1</sup>. One of the context where gamification could be applied is education<sup>2</sup>. In education, gamification is used to increase engagement and motivate students to learn. From knowledge that we received from education, more knowledge could be expanded and found. Through education we will not only receive just knowledge, but also other life aspects such as skills, beliefs and habits. The purpose of this paper is to explore gamification models proposed related to education topic and analyse them all to find a better gamification model that suited for the learning material and it can be used in future works.

Previous work that has been done was analysing gamification in such topic as Education, Online Communities, Social Network, Health, and Crowdsourcing using meta-synthesis approach to understand the concept of an object study by carefully describing and then compare and contrasting an array of sources on the topic that may be qualitative, quantitative, or mixed<sup>3</sup>. The difference from the previous survey paper is the focus of study and analysis method. This study will focus on education topic. Analysis method used in this paper is MDA framework<sup>4,5,6</sup>, which will be discussed in the next chapter. MDA is a formal approach for analysing game design by breaking them into Mechanics, Dynamics, and Aesthetics components.

In this paper, we surveyed papers about gamification that is applied in education from 2009 to 2018 from 4 domain applications: generic, STEM, history, and language. The proportion of surveyed papers based on the 4 domain applications is shown in Fig. 1. Generic means the gamification model is applicable for all subjects of education. It can be mathematics, physical education, languages, or other subjects. STEM stands for Science, Technology, Engineering, and Mathematics. The gamification model usually focuses on 1 single subject. For example, in Math subject the gamification model is directed only for algebra. Another example in technology, the gamification model is directed only for 1 specific programming language like JavaScript. Historical is pretty much self-explanatory. The gamification model focuses to learn the history of a historical character by gamifying their story. The last domain is language. The gamification model focuses to help learn specific language like English, French, Mandarin, or other languages. Some paper proposes only gamification model and some produced a prototype and tested it to students, which mostly came with positive results. The distribution of the surveyed paper according their published dates is shown in Fig. 2. Majority of the surveyed papers are published from 2014 to 2017.

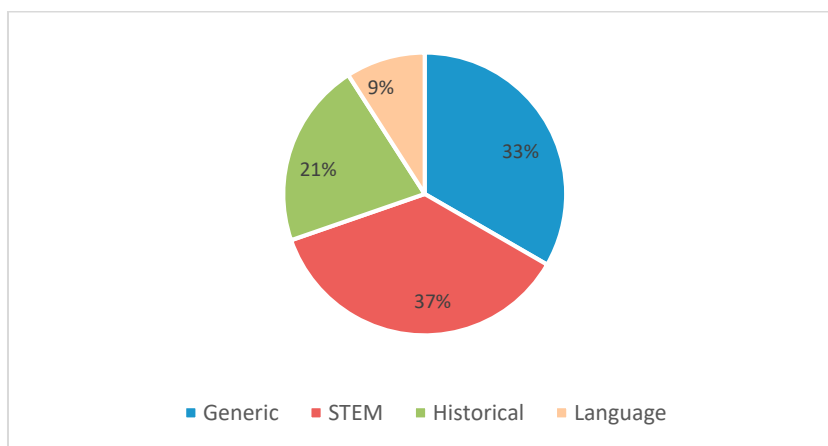


Fig. 1. Result of academical searches about gamification

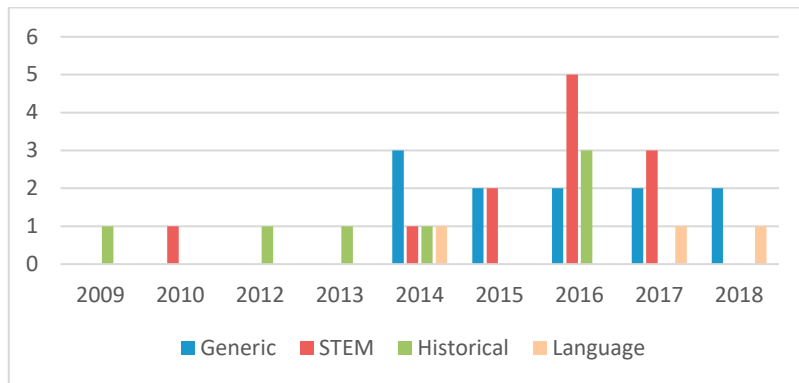


Fig. 2. Gamification models publish date

## 2. Game design framework

In game design, there are frameworks which can help designer to understand strengths and weaknesses of the game design, thus better game design could be made. One of them is MDA, which was proposed by <sup>4</sup> and introduced for the first time at Game Developer Conference, San Jose 2001-2004. MDA is a formal approach for analysing game design by breaking them into three distinct components: Mechanics, Dynamics and Aesthetics. Designers tend to see from Mechanics to Dynamics to Aesthetics, while players tend to see from Aesthetics to Dynamics to Mechanics.

Mechanics are related to the game's components, control, and courses <sup>5</sup>. Mechanics describe rules or components that implemented in games, such as basic action, algorithm, game engine, game elements, etc. Mechanics involve various action, algorithm, data structure in game engine which fully support dynamics in gameplay. For example, the mechanics of shooting game such as weapon, ammunition, and spawn points. Another example, in basketball game include balls, fouls, dribbling, and shooting. Dynamics are related to the game's context, constraints, choices, chance, consequences, completion, continuation, competition, and cooperation <sup>5</sup>. Dynamics describes how mechanics run in game based on player input and its relationship with other mechanics. Dynamics can create aesthetics for whoever played the game. For example, challenge can be created by things like compete with others combined with time pressure. Aesthetics are related to the game's challenge, commendation, confidence, cognizance, creativity, contribution, community, and compliance <sup>5</sup>. Aesthetics describes as players' feeling when playing the game. There are 8 types of aspect which is derived from the normal "fun", as <sup>4</sup> stated that "fun" is too broad to be explained in terms of players' feeling related to the game:

- Sensation: sense of pleasure as the result of trying something new;
- Challenge: being challenged to finish certain tasks;
- Discovery: finding out new things through exploration or trying new strategy;
- Fellowship: engaged in social networking;
- Expression: ability to express player's choices in game;
- Fantasy: immersion to virtual world;
- Submission: devotion to the game;
- Narrative: storyline that catch player's interest.

Another game design framework known by game designers is Elemental Tetrad <sup>7</sup> and FDD <sup>8</sup>. Elemental Tetrad breaks down any game into four aspects, which are mechanics, story, aesthetic, and technology. Mechanics describes rules and procedures that available in a game, including game goals. Story describes the chain of events happened in a game that player can follow when playing the game. Aesthetic describes the look and feel in a game. For example, character's appearance, user interface, environment design, background music, and sound effects. Technology describes the materials that make the game available, such as physical media (cards, board, paper) or digital media (computer, console). Meanwhile, FDD sees any game from three aspects, which are Formal, Dramatic, and Dynamic. Formal aspect in game are rules defined to limit player's actions. Dramatic aspect in game are components that can make player immersed in the game world, such as premise, characters, and story. Those formal and dramatic aspects

combined and induces dynamics in game world and contributes to player's gaming experience.

### 3. Gamification models in education

In this paper, 33 papers about gamification from many categories which varies from 2009 to 2018 have been analysed using MDA. We used MDA as analysis framework because gamification elements are made based of it <sup>9</sup>. MDA framework can create factors that related to learning process, which are challenge, curiosity, fantasy, and control <sup>6</sup>. The contribution of this paper is breaking down the gamification models using MDA so other researchers in gamification field or practitioners can understand the available gamification models better, and they can make more modification after understanding each component. As the mechanics is the first component, we start by analysing mechanics component first. Mechanics involved in gamification is related to player's progression, tasks, controls, and features, which can be seen in Table 1. Points is the easiest mechanics related to player's progression. Depends on what is done by player, numerical points are given to them automatically. After getting several points, player can unlock any achievement for their own character. Those points might be compared to other players' points. Thus, it creates a leaderboard to show every player who is the best player.

Table 1. Variations of mechanics in gamification model

Type	Mechanics	Papers	Number of Papers
Player progression	Points (score)	10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25	16
	Achievement (badges, trophies, reward system or other forms)	10 11 12 13 14 16 21 25 26 27 28 29 30 31 32	15
	Leaderboard	10 11 12 14 15 16 18 21 24 27 32 33	12
	Levels (level up system)	10 11 22 25 31 33 23	7
Tasks	Missions (quests, optional assignment, mission selection, collect object, or others)	11 12 21 22 34 23 24 25 26 29 30 32 33 35 36 37 38 39	18
	Mini games (quiz, puzzle)	14 16 19 20 24 35 34	7
Game content	Role-playing	22 23 24 25 26 28 35 40	8
	Unique controllers	17 23 34 40	4
	Simulation	17 20	2
	Drag and drop	36 39	2
	Turn – based	40	1
Additional feature	Feedback	13 20 25 26 29 31 36 39 40 41 42	11
	Map	17 22 24 32 35 34 37 38	8
	Background story	21 22 23 24 32 34 37 38	8
	Characters	22 23 24 32 25	5
	GPS location	13 25 32 38	4
	Obstacles and enemies	22 23 35 40	4
	Tutorials (audio, video, animation)	21 25 31 39	4
	Social media platform (chat feature or forum)	14 16 27 37	4
	Items	22 23 32	3
	Increasing difficulty	22 23 42	3
	Tooltips & hints	19 27	2
	Augmented Reality	25 32	2
	Virtual Reality	34	1

Sometimes those mechanics are combined as they are related to each other. Combination of points, achievements, and leaderboard in a game will make a competition among the players to prove who is the best player like no one ever was. Another example is a mix of level, mission, role-playing, background story, and character; mission can give points that used to increase the level of player's character in a scenario. Developers can mix and match those mechanics in order to induce dynamics stated in Table 2.

Table 2. Variations of dynamics in gamification model

Type	Dynamics Description	Papers	Number of papers
Receive badges, achievement, or other rewards	Students with the best score receive rewards such as badges, achievement or redeemable rewards to boost their motivation in learning activities	10, 11, 12, 13, 14, 16, 25, 26, 27, 28, 29, 30, 31, 32	14
Role-playing	Players can choose characters to play in the scenario provided in game	22, 23, 24, 25, 26, 28, 35, 40	8
Non-linear progression	All mission can be done separately so users could choose any mission they want to do	17, 21, 25, 31, 33, 36, 39, 42	8
	There are tutorials in many forms and player can choose to take it or not	18, 25, 31, 39	4
	In some mission that involves collecting objects, player could collect them in any order	17, 25, 39	3
Real exploration	Player must finish tasks by explore real location with the help of GPS	25, 32, 37, 38	4
In-game exploration	Player will explore the virtual environment of the game itself	17, 35, 34	3
Puzzle solving	The puzzle in this game could be done using player's own methods	16, 35, 42	3
Difficulty adjustment	Challenges that adjusted automatically based on players' performance	19, 39	2
Hints	The game will provide help to guide players during gameplay	19, 27	2
Management – simulation	Player can build their own of city/zoo/other business place by using resources like money and make sure the business itself succeeded	20, 41	2
Turn – based	During gameplay, both party will be given limited time and number of moves each turn	40	1
Adaptation system	System will adapt and change based on user data and actions, and the changes will affect gameplay directly or indirectly	27	1
Quiz system	Multiple choices with points for each correct answer. The points will be shown after each question answered	12, 15	2

From Table 2, it can be seen that rewards are the most popular type of dynamic. By rewarding something to students who have achieved something, student's motivation will be boosted and the student will repeat the same thing to stay in the current condition and make progress into better condition. The other popular dynamics are role-playing and non-linear progression. Students can choose character and start doing activities. They can start by doing something easy, or if they're curious, they can take the most difficult activities. When they complete any activities, they will get rewards according to the respective activities. Surprisingly, simulation and quiz are not popular dynamics in gamification, although they are popular in traditional learning. Simulation is used to imitate the real world that students will face similar situation in real world, while quiz is used to make a situation like a test that students should answer.

Like mechanics, dynamics also can be mixed in order to create more interesting situation. Usually role-playing, non-linear progression, exploration (either in-game world or real world), and rewards walk together in a scenario. Students can play as a character while following a scenario, exploring the world related to the game, choose activities to do with no exact order, and get rewards when they finish their activities. Hints can be combined into any type of dynamics to help players, especially new players who haven't played similar game before or never play games at all.

Table 3. Variations of aesthetics in gamification model

Type	Papers	Number of Papers
Sensation	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42	33
Challenge	10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42	33
Fellowship	10, 11, 12, 13, 14, 16, 18, 21, 25, 26, 27, 28, 29, 30, 31, 33, 34, 37, 38, 40	20
Discovery	10, 13, 29, 17, 20, 21, 22, 23, 24, 25, 26, 32, 34, 37, 38, 39, 35, 36, 40, 41	20
Fantasy	17, 21, 22, 23, 24, 25, 26, 28, 29, 32, 34, 35, 39, 40, 41	15
Narrative	14, 17, 22, 21, 23, 24, 25, 26, 32, 34, 35, 37, 38	13
Expression	10, 15, 16, 19, 20, 22, 23, 26, 27, 40, 41	11
Submission	25, 39, 42	3

From Table 3, it can be seen that all gamification model provides sensation because it's an interactive learning method that makes interesting compared to listening to lectures in class. Not only the learning method, challenges given in many forms in any gamification model gives players reasons to keep trying and thinking to finish a mission, which makes them motivated to keep learning at the same time. When they can overcome the challenges, they will feel some kind of satisfaction, which is the sensation. One example of gamification model that provide challenge is called Lyttel Inventors<sup>35</sup>. There are enemies and obstacles that players must overcome using their own character while gathering objects to complete tasks along the story and finish the game. The mechanic involved are missions, mini-games, maps, and RPG mechanics like virtual character that player controls.

Discovery is related exploring real location or virtual location inside the game, for example Explorez<sup>25</sup>. The game contains missions to explore real location inside a campus and do something after arriving at the location. One of the mission is to take certain pictures at the location and the app will automatically detect if it is the correct picture. All contents in game is written using French language so students could learn French and play at the same time. Fellowship appears when students could communicate with each other when using the gamified app. For example, in GamEducation<sup>14</sup>, students can ask each other via forum to gain points by giving correct answers. Points will be shown on a leaderboard to increase competition between students. Reward will be given to students with the highest points. Another example is 10 Downing Street<sup>26</sup>. Students have to work in a group of 6 and will take role as British Prime Minister. They have to come to an agreement that will affect the wellbeing of national ceremony. They will also debate to determine viable option to put into practice after general election. Higher level thinking within team discussion is what make the game fun.

Fantasy is the aspect when you take role of a character inside the game and explore the game world. For example, a gamification app called jLegends which requires players to code in Javascript to play the game. This mechanics will involve players' imagination to think for a while and respond the situation with the appropriate code. Luckily, this game is turn-based, so players could relax for a minute and think what is the right code to do the next action. Narrative usually comes along with fantasy. This could be found in gamification apps for historical learning, like the gamification app of history of Merong Mahawangsa, a Malaysian legendary warrior<sup>24</sup>. In each mission, there is a short story about what Merong Mahawangsa done or will do before the gameplay. Another historical app that provide similar aspect is The Keris of Vengeance<sup>22</sup>. The game is about the story of Ken Arok, king of Singhasari. It also contains role-playing mechanics where player could earn items dropped from dead enemies and boss fights. Each boss fights and levels will contain stories that attract player's attentions.

One of the app that could make user express themselves is Math-City<sup>20</sup>. Math-City is a management-simulation game also known as tycoon game where players can design their own city/office/other manageable business place using in game resources and the final objective, make sure the business itself is a success. Because of this, each player could use their own creativity and express themselves via the design of the business place inside the game. Last but not least, submission. Submission can be seen from Lingokids<sup>39</sup>, an app that help children to learn English where they could choose any mission to play by tapping cute characters or objects inside the game. The app also provides drag and drop mechanic for a mission that involves many objects that must be collected. The game also gives feedback if

an object is collected for example, virtual character gives a thumb up. All missions are repeatable so children can play their favorite mission over and over again for the fun. Another app that provides repeatable missions is GeoGebra<sup>42</sup> for learning math. Before playing the game, teachers will give tutorials to students. They can proceed on their own while the teacher watches over them. The higher the level, the harder the challenge offered to the players.

#### 4. Proposed gamification strategies

To intensify the effect of gamification, gamification designers need to mix and match various mechanics, as different combination of mechanics can give different effect to the player. We believe the best way forward is to combine several mechanics in such a way to create dynamics that results in all 8 types of aesthetics. For example, giving in game points and reward in form of badges or trophies could give students sense of achievement and greatly increases their motivation in using the app and at the same time learn the subject. Showing students points in a leaderboard could increase their sense of competition and thus work harder to reach higher place in the leaderboard, if possible to be best player like no one ever was. School work given in form of selectable missions or minigames gives sensation of playing instead of a burden. Making students feel like they are in different world via role-playing game model is also recommended because by choosing the role they want, they subconsciously express themselves and will feel motivated to keep learning using the role they have chosen. When using role-playing approach, we could add related mechanic like a map so players could explore inside the game or outside in real world. This also could be amplified with a background story to give more fantasy. Giving feedback to players for their actions could make them realize what is wrong and correct and thus, changing the course of their strategy to perform better in the future. Adding augmented reality through object recognition and social sharing features potentially improve the interactivity of the gamification model that may results in improved learning process.

#### 5. Conclusion

Various gamification models have been proposed to increase the motivation of learners as reported by many researches. We have surveyed 33 papers about gamification models in education that is applied in 4 domain applications: generic, STEM, history, and language. We analyzed the proposed models using MDA framework by breaking them into three distinct components: Mechanics, Dynamics and Aesthetics. Findings from the survey show there are some representative gamification models that could be used as a method to increase motivation, achievement and engagement in learning activities. We also suggested some gamification strategies that could be implemented for future works. We hope this paper can help gamification designers to design better gamification models in order to help learners reach their learning objectives.

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