UNIVERSITY OF NAIROBI

SCHOOL OF COMPUTING AND INFORMATICS

An adaptive gamification tool for e-learning platform

MSc Research Project

By

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DECLARATION

I, Hereby affirm that this project, as presented in this report, is entirely my own work executed by myself except where stated within the text. I declare that this project has not been presented for any other university award.

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ABSTRACT

Introduction to programming is a core foundational unit at the heart of computer science that provides students with the basic skills needed for the course. Programming by its very nature is an abstract discipline that is reinforced through psycho-motor skills. Numerous studies have shown that many students taking the course get demotivated and disengaged along the way resulting to a high failure rate and dropout. An innovative approach to programming pedagogy is needed to motivate and improve the engagement and performance of these students.

Games have been used since time in memorial as the fundamentals in cognitive development. They provide a situated problem centered learning environment (Plass, Homer & Kinzer, 2015). A gaming environment comprises defined mechanics and elements that define the game. These two can as well be applied in non-gaming context (such as in learning programming basics). The games that are utilized in learning environment are serious games and gamification.

This study aims at developing a gamification tool for e-learning platform that will recommend the right gamification elements to keep students motivated and engaged. Since students have different motivational factors based on their preference and learning style, it would require designing an adaptive tool that will cater for all students. This will call for use of artificial intelligence technics to identify and classify students, based on their personality and learning style and progressively adapt to their behaviour and actions as they interact with it.

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CHAPTER 1

INTRODUCTION

Many students are gaining interest in technical related subjects making the ratio of teacher to student to grow smaller. Mode like e-learning has been used to improve teaching of these students. It has been noted that these technical education students have been poorly performing and are usually graduating when they are not ready to practically apply their knowledge in the outside world (Naik & Kamat, 2015). They could be lacking personalization or individualized attention on each student. This leads to demotivation and disengagement of students. The learning process encourages improvement in motivation which can be achieved through personalized gamification (Roosta et al, 2016).

Play has been identified and noted to be a fundamental component in cognitive development and learning (Plass, Homer, & Kinzer, 2015). (Caillois, 1958) defines play as game and classifies games in four categories competition, chance, role-playing and risk taking. The role and manifestation of play as a child mature is elaborated by (Piaget, 1962) through several different developmental stages. This was complimented by (Vygotsky, 1978) who introduced the notion of "zone of proximal development". This notion elaborates on what learners can achieve without help and what they can't achieve at all. He noted that education is supposed to provide experiences that are within ones zone of proximal development which eventually encourages and advances personal learning. Play takes a lead in the factors that elevate user\s enjoyment and engagement which are critical in cognitive development. Their impact in learning is achieved through creation of the proximal zones.

(Brumels & T. Blasius, 2008) highlights how technology has led to transition of traditional games to video games. This is also noted by (Wan & Fang, 2007) who mentions how IT affects learning outcome of students through the teaching method and course design. (Groff, 2013) highlights the innovative technologies deployed to aid in teaching whose video games and its variant are among them. Video games aid teaching hard complex procedures by providing action-based explanations, elevating motivation, providing different learning styles, providing an interactive environment for decision making and reinforcing skills mastery (Kebritchi. & Hirumi., 2008). This was also highlighted by (Dominguez et al. 2013) who outlined the benefits of playing video games as it provides instant feedback, relevant information as needed, learning that has an impact to the learner, learning that can be controlled by own means, learning transfer among others. (Plass, Homer, & Kinzer, 2015) discusses benefits of game-based learning as motivation, establishing engagement for learning, enabling customization and personalization for adaptivity and provision of an environment

for risk taking and exploration. Despite these advantages and benefits of playing digital video games early studies which focused in negative impact revealed the challenges of increased aggression particularly those games violent in nature, decreased pro social behavior, inability to regulate the amount of time spent on games and ill health due to head mounted gear (Seaborn & Fels, 2015)

Computer games offer "an active, experiential, situated and problem-based learning environment" (Soflano, Connolly, & Hainey, 2015). The games that are utilized in learning environment are serious games and gamification. (Deterding, Sicart, Nacke, & K., 2011) gives a taxonomy to enable distinction of these as they emphasis gamification is distinct and separate from serious games and video games.

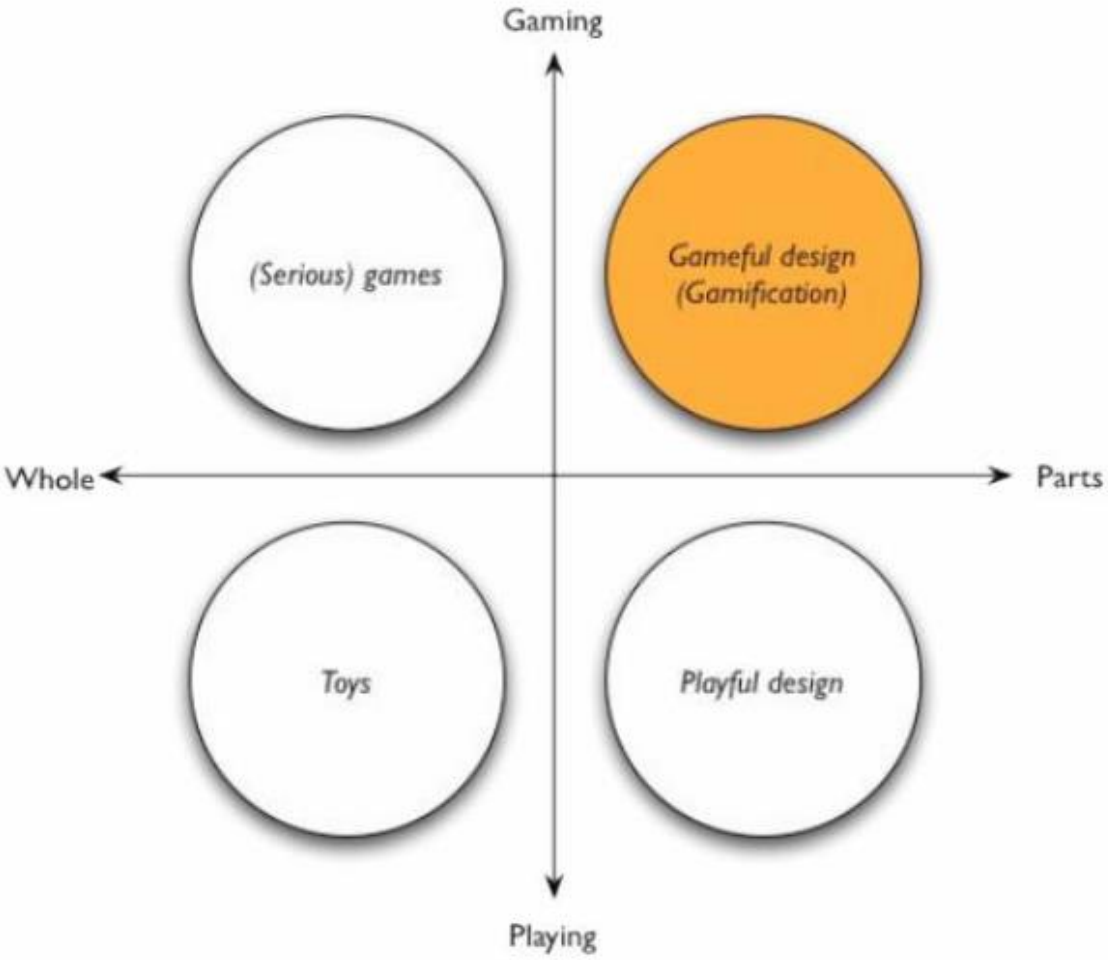


Fig 1: Classification of games

The top row of the model indicates the games governed by rules (Ludus) while the lower part focuses on those that without (Padia). The key distinction of serious games and gamification is on the way each is applied in learning. In gamification, the game **parts** (mechanics and elements) are

wrapped up and introduced in an existing learning system to enhance learner's motivation and engagement and their existence dependent on the learning system. For serious games, learning elements are the ones introduced in the game. They are **whole** games developed not for the purpose of having fun but to help to enforce learning to players. Serious games are independent of the leaning elements and can exist on their own.

Several Gamification definitions have been given by various researchers. (Deterding, et.al, 2011) provided an applicable definition of gamification by stating it as "the use of game design elements in non-game context". According to them, gamification is distinct and separate from serious games and video games. (Lee and Hammer, 2011) defines gamification as "the use of game mechanics, dynamics, and frameworks to promote desired behaviors". (Kapp, 2012) views gamification as "using game-based mechanics, aesthetics and game thinking to people motivate action, promote learning and solve problems" while (Huotari and Hamari, 2012) define gamification as "a process of enhancing a service with affordances for gameful experiences in order to support user's overall value creation". Game elements were defined as the "patterns, objects, principles, models, and methods directly inspired by games".

(Lee and Hammer, 2011) provide a basis for application of gamification in learning environment as it motivates student to participate in classroom, provide teachers tools that guide them on how to reward students and facilitate immersive learning. According to (Simões, Redondo, and Vilas, 2012), they state that gamification "aims to increase people's engagement and to promote certain behaviors". They argue that one of the main impact of gamification is its ability to enhance engagement levels among learners.

The aim of this study is to investigate the best game elements that can be used in a learning environment, use artificial intelligent techniques to adapt to individual students' preference and develop a prototype that can effectively recommend the right game elements to the students so as to enhance motivation, engagement and improve their performance.

PROBLEM STATEMENT

(Robins, Rountree, & Rountree, 2003) in their review acknowledge that learning programming is a daunting task particularly for novice programmers. Introduction to programming is a core foundational unit that provides students with the basic skills needed for every computer science the student. As (Lahtinen, AlaMutka, & Järvinen., 2005) stated, the subject becomes difficult because it requires correct understanding of the concepts, the subject matter is complex, lack of resources, lack of personalized attention and delivery of the subject matter. The resultant effect is that the student is frustrated and de- motivated , leading to disengagement in learning with the consequent failure and high drop rates on the course (Malik & Coldwell-Neilson, 2017).

Many of the developed gamification solutions are not applicable, because their architecture was purposely for many users in a given system and personalization is not considered. (Schöbel & Söllner, 2016). Motivating learners and making learning interesting to them will require focusing on individual preferences in learning. This can be achieved by personalizing the gamification elements through an individualized elements design (Burgers, et al., 2015; Ha-mari and Koivisto, 2015). To overcome this problem, it would be suitable to develop a tool that adapts to individual user preference and learning style and recommend the right gamification elements thus enhancing motivation to the novice programmers.

RESEARCH OBJECTIVES

General Objective

To improve learning motivation by designing a gamified e-learning system that uses Artificial Intelligence techniques to personalize gamification elements and adapt to learning style and personality.

Specific objectives

- To identify gamification design elements that are best suited for various learning habits and personality traits.
- To identify AI techniques that classify and progressively adapt to learners learning style and behavior.
- To develop and evaluate an adaptive gamified LMS tool that utilizes the AI techniques to provide the right gamification elements so as to enhance motivation in learning.

RESEARCH QUESTIONS

1. Which are the best gamification design elements suited for various learning habits and personalities?

2. Which AI techniques can classify and progressively adapt to learners as they interact with the learning platform?

3. Can the developed adaptive gamified tool enhance motivation among learners?

SIGNIFICANCE OF THE STUDY

Introduction to programming subject is crucial in attaining important foundations of programming for any computer science student. Innovative approach is needed to be provided special attention to these students and as it has been noted, maintaining engagement levels and interest among students is challenging especially when learning in current condition.

Introducing gamification in learning that has been specifically tailored to adapt to learner's personality and learning style will bridge the gap. The study is also significant to stakeholders involved in curriculum development. It will help them to create viable programme that ensures learners attain the industrial needed knowledge.

CHAPTER TWO

LITERATURE REVIEW

Review of player types and personality

Player types

Gamification is referred to as "applying elements and mechanics of games in order to engage a user in a task outside of a game context" (Ferro et. al., 2013). To understand impact of gamification on learners, research has been made to understand ideal player types based on their personality.

A study done by psychologists shows that player topologies are highly related to personality types. (Tuunanen & Hamari, 2014) gave various criteria on the development of digitals games players profiles. In his work, he shows that the profiles are based on psychographic and behavioral factors. (Bartle, 2003 & 2004) was the first to create a player topology based on responses he got from a real-time virtual world known as Multi User Dungeons (MUD), which was entirely text based. He went further to classify them as **socializer** accounting 75% of players, **Achievers** 10%, **Explorers** 10% and **Killers** 5%. (Fullerton, 2008) describes in her book that players fall under 10 categories named: "**competitor, collector, explorer, joker, director, storyteller, achiever, performer, artist and craftsman"**. (Caillois, 1961) had a different perspective on the player type and games. He enhanced Huizinga's work which was based on competition and developed a taxonomy which comprised four player types. These are "**Agon** (competition games that require conflict or confrontation), **Alea** (chance games that encompasses element of uncertainty), **Mimicry** (Role playing) and **Ilinx** (player perception change)". He later combined the four into two categories to differentiate the structured from freestyle play namely Paida (unstructured play) and Ludus (structured play).

Personality

Personality can be defined as "an inner tendency or predisposition for a person to act in a certain way" (Berecz, 2009). Personality study was first done by two scientists Hippocrates & Galen who believed that it could be determined biologically through four fluids found in the body namely Black and Yellow bile, phlegm and blood. (Crowne, 2009). This was termed as scientific rubbish by (Eysenck, 1970) through a critic and concluded personality is based on three super factors that comprise narrow traits. **Introversion or Exraversion, Neuroticicm or Emotional Stability and Psychoticism.**

(Cattell, 2004) developed descriptors for describing personality type with an extensive list of 4500 trait names. This list was reduced to 171 and later to 16 through Factor Analysis forming the 16 personality factors (16PF). The big five categories initially developed by Donald Fiske through testing research participants using rating scale from cattell work. These categories are used to evaluate human personality. The Five Factor Model, later developed by (Costa & McCrea, 1992) contains the big five categories which are given an acronym OCEAN (Crowne, 2009). **Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism.**

Review of Learning theories

(Smith., 1999) Proposed a taxonomy depicting four orientation of learning theories and principles namely **behaviorism** which embraces conditioning and advocates rewarding and targets. **Cognitivism** concentrates on complexities of human memory and believe defining learning in terms of behavior change is very shallow**. Humanism** focus on experimental learning and **constructivism** relies on what is already know and understood by the learners and the process of knowledge acquisition should be tailored specifically for them.

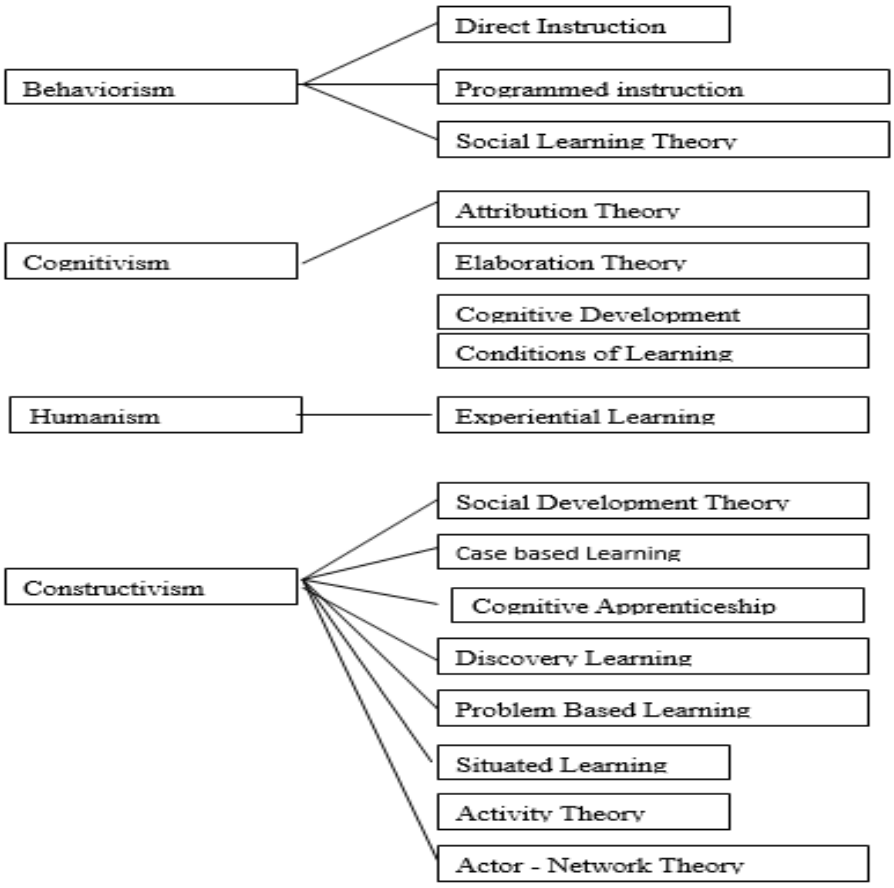


Fig 2. Learning Theories

Review of Learning Styles

Learning style can be defined as a consistent way of operating which indicates the main cause of a particular learning behaviour. It shows how students learn and what they like to study. It also shows, from instructional strategy point of view, "the cognition, context and content of learning". (Hwang, et. al 2012). This study concludes style of learning is important in an adaptive e-learning system. (Felder and Silverman, 1988) states that the model of learning style naturally manifests so well in e-learning platform and offer great benefits when compared to other models because of its generalizability, validity and reliability (Soflano, Connolly, & Hainey, 2015). (Khenissi et al., 2016) elaborates on the four dimensions of the model.

- **Active/Reflective** – how information is processed. active learner ,try out things and work with materials , whilst reflective think , examine things and materials they are theoreticians.

- **Sequential/Global** – demonstration of understanding by learners, with sequential being step by step logical and methodical learners and Global have a holistic world view of events and materials

- **Sensing/Intuitive** – how preference is perceived by learners to solve a problem. sensory learners using standard methods and procedures for solving problem , and intuitive focus on discovery of relationship and possibilities

- **Visual/Verbal** – how information is retained and represented by learners. Visual learners preferring pictorial visual content for learning, while verbal remember the spoken word / written word.

Review of Motivation theories

Motivation can be defined as "a construct that explains the energy, persistence, direction and quality of behavior" (Ryan & Deci, 2000). The scholars noted that people who are internally motivated perform better, have more creativity, persistence, vitality and general wellbeing as compared to those who are externally motivated. Self determination theory (SDT) is one of the basic and important theories of motivation. The theory purports motivation as multi-dimensional that lies on a continuum of self-determination with a range to intrinsic motivation (action based on pleasure of performing an activity), through extrinsic (action based on external outcome) from amotivation (actionless due to lack of motivation).

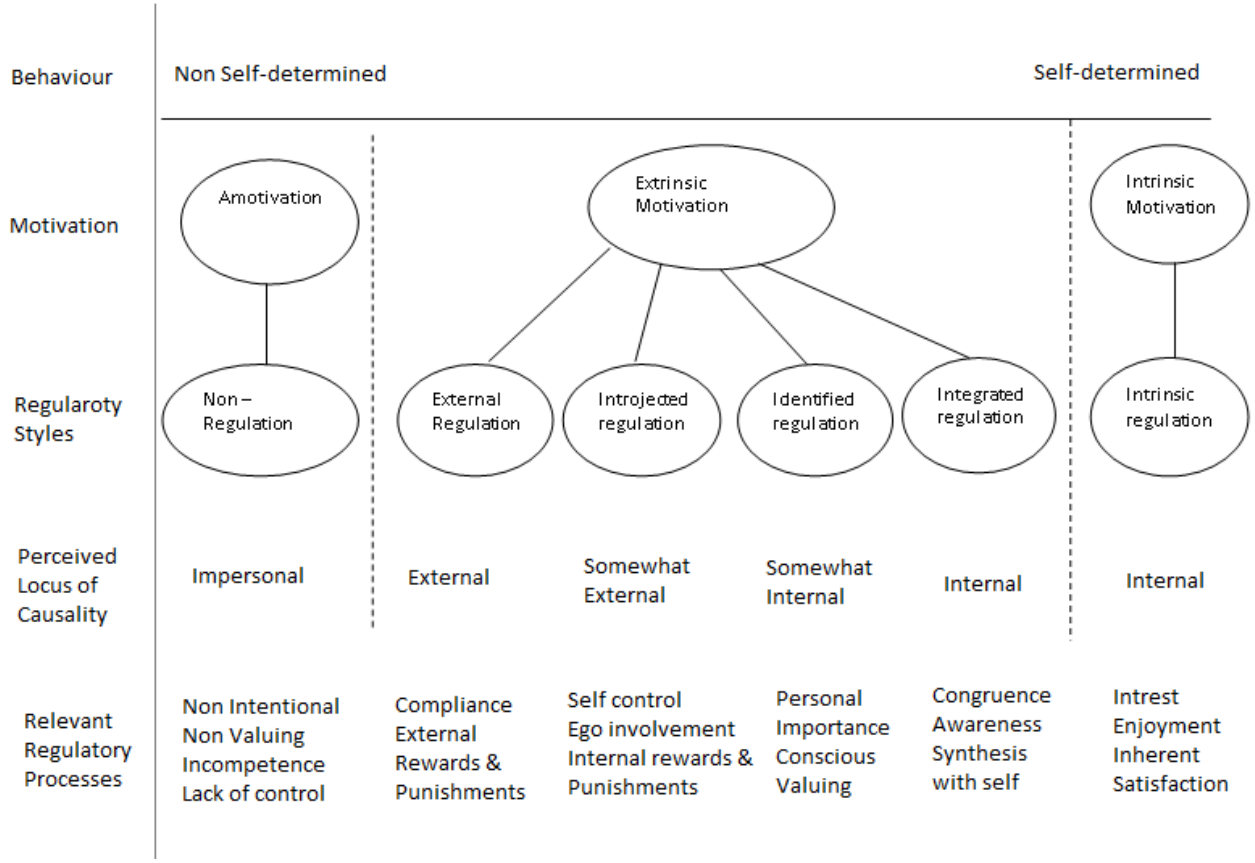


Fig 3 Continuum of Self Determination Theory

In the SDT theory, there are three suggested psychological needs of autonomy which are: Self-ownership of an individual's behavior, Competence, and Relatedness. When the three needs are fulfilled, intrinsic motivation increases with the growth and development occurring. SDT states there are Six distinct motivation types: Intrinsic, Amotivation, external regulation, Introjected regulation, identified regulation, integrated regulation. (Roy & Zaman, 2017)

Amotivated individuals are those with no need to undertake a certain behavior whereas intrinsically motivated individuals are those that find pleasure interest and enjoy the engagement of the activity. SDT is a vital in the development of gamification as it allows for the development of various strategies in the design and implement of gamification effort. (Buckley & Doyle, 2014) emphasis that motivation is a key determinant in learning.

Review on game element design

(Schöbel, Söllner, & Leimeister., 2016) deduce that many gamification projects fail because less concentration is placed on personal preference and needs. Indeed (Sailer, Hense, Mayr, & Mandl,

2017) observe that many of studies involving gamification treat it as a uniform construct , notwithstanding the diversity of gamification environments and requisite specific game design element. It is note worth that successful gamification requires non-generic elements due to their diversity but need to be specific. (Mekler et al, 2017) argued that many gamification research concentrate on impact of applying many gamification elements simultaneously. With this, it is hard to correctly know the impact that these gamification elements have to student's behavior and motivation. They posit that focusing on how specific element affect behavior is ultimately beneficial to designers as it helps them to make informed decision.

(Schöbel, Söllner, & Leimeister., 2016) sought to identify the elements most preferred by users of learning management systems and the best combination of them. Using an innovative methodology discrete choice found that indeed users have preference on some game elements (levels , points status) over others hence the need to factor this consideration in the design of gamification project .

Design of successful gamification elements for e-learning systems require deep understanding of gaming concept (Strmečki et al, 2015). They recommended gamification elements suitable for application in e-learning platforms which are:

1. **Points** – It's a form f reward system that they further grouped into five categories
    - Experience points – gained from overall learning, can be used to contribute the marks award
    - Karma – points awarded to students when they post in forum or chat important/helpful links, posts, journal, information. Awarded by other students through rating made by them. Can be used to increase student's status if redeemed.
    - Redeemable points – for loyalty purpose
    - Skills scores – extra points earnable by undertaking additional tasks.
    - Reputation scores – act as proxy for trust.
2. **badges or trophies (achievements).** – Design of badges should not be ugly, boring or pointless. In most gamified systems, badges or trophies are implemented it is not enough. Learners need to show off their achievements. Enders (2013)
3. **Customization** - Choosing own layout, fonts or icons, enhances user experience.
4. **Leaderboard** is scoreboard learners or players results. "Leaderboard is typically used in competitive activities, but it can also be used to encourage teamwork." Glover (2013)
5. **Levels indicate progress**. (Enders, 2013) defined levels as "milestones that a player achieves by completing certain tasks".

6. **Progress bars –** "They are connected to levels and serve as a percentage-based guide to learners" (Zichermann and Cunningham, 2011). Glover (2013) stated that "a good progress should outline what the learner has done and give guidance on how to improve or advance in the future".

Others include feedback, ability to provide an environment that give learners the freedom to fail. (Sailer et al, 2017) Using self-determination theory framework, they conduct a RCT in a simulated environment where different settings of game elements were analyzed with intent of understanding their effect on the fulfillment of Competence, Autonomy and Relatedness. it was confirmed that games elements do influence the competence, autonomy and relatedness aspects of motivation.

(Tondello, Mora, and Nacke, 2017a) Analysed the traits of learners who have likelihood of enjoying certain category of gamification elements with respect to age, gender, gamification type and individual traits. Lastly (Mekler, Brühlmann, Tuch, & Opwis, 2017) investigated the impact of certain gamification elements on performance, competence and motivation. These gamification elements include points, leader boards and levels. The results showed that the impact was experienced only on extrinsic motivation factors which were at play.

From the Discussion and analysis its recommended that the research design for elements to focus on the determining which gamification elements are most appropriate and their combination for teaching programming within an e-learning platform.

Table 1: Gamification Design Elements summary

Author	Summary	Strategy	Game elements used	Conclusion	Shortcomings
Ferro L., Walz S., & Greuter S. (2013).	„The Paper investigates the relationships between player types, personality types and traits, with game elements and game mechanics and discuss how this connection may impact the design of gamified systems and offer insight towards more user-oriented design objective"	Learning style, personality behavior	"None but gives a deep understanding of personality, player types and important aspects for designing game elements"	"- The choice of game elements and game mechanics in relation to more personal attributes, such as that of personality types and traits, of an individual may assist the user in utilizing elements that we believe are intrinsically motivating to the player - To understand users' preferences, Personality traits are more relevant in comparison to player types which are dynamic and change frequently depending on context and environment. "	"Used a questionnaire data to initially classify students. A slight variation in learner environment change the results in questionnaire and wrongly classify a student."
Codish & Ravid (2014)	"The paper investigates the effectiveness of game elements applied in a gamified system and highlighting ways in which designers can approach them to ensure that they improve motivation. discusses also a framework for measuring learners engagement on game elements through Gamification analytics (GA)"	demographics (gender, Age…), personality traits	Points Feedback, Progress bars leaderboards, Badges	"- A successful gamification is the one that maximizes the design objective and one that handles different motivation types among different learners"	"- Challenge of determining how personality and demographics impact individual optimization - Having different rules applied to individuals without creating sense of unfairness."
Naik & Kamat (2015)	"The paper investigates ways to improve student's engagement, increase their interest and maintain performance by combining gamified system with an	Smart sparrow - an adaptive system used by (University of New South Wales) Level up -	Badges Leaderboard, Points Progress bar	"Experiment done to four groups each with a number of students: - Traditional only, gamification only, adaptivity only, both	"- Individualization was not explored. Some students got low marks despite the benefit of both adaptivity and gamification. "

	adaptive system. It highlights mechanisms that cause addiction in game design and aims at utilizing them in learning environment"	gamified moodle plugin		adaptivity and gamification. Highest performance was realized in the group with both gamification and adaptivity."	
Roosta, Taghiyareh, & Mosharraf. (2016)	"The paper investigates the possible correlations between gamification-elements and learners' personality, interests and motivation type. It also investigates the role of personalization in improving learners motivation. Uses the Achievement Goal Questionnaire-Revised (AGQ-R) to assess learners motivation."	"Achievement Goal Questionnaire-Revised (AGQ-R), Personality"	Badge, Feedback, Leaderboard, Point, Progress bar	"Used T statistics for means comparisons of the Two Groups grades. Showed there a significance in performance for Gamification using Categorization approach and Random Gamification With personalization, motivation and interest to participate in learning activities was observed to have increased."	"Used a questionnaire to assess students' motivation. the method is not effective. A slight variation in learner environment would change the responses."
Daniel S., Andrija B. and Daniel R. (2015)	„The paper investigates various gamification design elements and their suitability for usage in e-learning systems. It highlights the theories and models previously developed and the 5 phases of designing gamification elements for an e-learning system. "	Moodle Plugins, feedback questionnaire	Points, Badges, Leaderboards, Levels, Challenges, Trophies	"- A key for successful gamification implementation is the correct selection of design elements and cooperation of experts in the fields of education, technology, pedagogy, design and finance. - Results showed that students enrolled in the gamified version of the online module achieved greater learning success."	"- focused only to socializers who account 75% of player types and left out the achievers, explorers and killers. "

Table 2: Summary of game elements deployed

Author	**Summary**	**Game Elements Deployed**	**Conclusion / Results**	**Shortcoming or challenges**
(Mekler, Br¨uhlmann, Opwis, & Tuch, 2013)	„The Study sought to establish whether specific game elements (points, leaderboard, levels) influence user' s intrinsic motivation. "	points, leaderboards levels	"ANOVA approach Elements do not influence motivation but rather are indicators "	"- Limited No of Elements Not implemented in E-learning "
(Schöbel, Söllner, & Leimeister., 2016)	"The study sought to identify which elements users of learning management systems prefer. With regard to amount and combination of gamification elements"	Goals Time Pressure Points Badges Status Leaderboard Level Virtual Character Loss Aversion Virtual Goods	"discrete choice task that follows the best-worst scaling method, results show users prefer some elements "	"Not experimental and not deployed in actual systems, used self-reported results."
(Sailer, Hense, Mayr, & Mandl, 2017a)	"Using self-determination theory framework, they conduct an RCT in an online simulation environment. By deliberately varying different configurations of game design elements, and analyzed them in regard to their effect on the fulfillment of basic psychological needs Competence, Autonomy, relatedness "	points, badges, Leaderboard, performance graphs, meaningful stories, avatars and teammates.	" a single factor, multivariate analysis of variance (MANOVA) and post-hoc Scheff_e-tests results show that elements affect the SDT elements"	"The Study used Simulation for Implementation "
(Tondello, Mora, & Nacke, 2017b)	"They proposed a classification of eight groups of gameful design elements using an exploratory factor analysis based on participants' self-reported preferences Survey, further they provide an overview of which design elements work best on demographic factors of gender, age, gamification user type, and personality traits. "	59 gamification elements	"Exploratory Factor Analysis, interpretation, finally hierarchical clustering to determine the game elements Preferences by user's WRT age, gender "	"Not experimental and not deployed in actual systems, used self-reported results. "

Review on gamification adaptivity and AI Techniques used

(Naik & Kamat, 2015) argue that individualized or personal training is of immerse benefit to the learner, due to the fact that all learners differ in preference, style and abilities with regard to the learning processes with technology mediated or not. Failure to take cognizance of this leads to learner disinterest, frustrations and disengagement. (Burgers et al, 2015; Roosta, Taghiyareh, & Mosharraf., 2016) argue that to overcome this challenge, an implementation of suitable system that matches designed gamified elements to the users preferences needs to be realizes. (Cheng, Lin, & She, 2015) avers by recommending that games and gamification projects should aspire to have an individualized design for adaptive elements for personalized needs. (Codish & Ravid, 2014) posit for the need of adaptive gamification for successful gamification projects. Adaptive gamification is part of adaptation in computing. In examining adaptation (Naik & Kamat, 2015) references it as the flexibility and ability of the system to change learning environment to aptly suit the characteristics' of the individual either implicitly or explicitly . (Soflano, Connolly, & Hainey, 2015) elaborate on two categories of adaptation namely adaptivity and adaptability. He states that adaptability is the ability of the user to changes systems settings to customize to one's preferences while adaptivity "refers to ability of the system to identify the user preferences or characteristics and alter its behavior accordingly". (Shute & Zapata-Rivera., 2012) define an adaptive education system as one that monitors crucial traits of the learners and create necessary adjustments to learning environment that improve learning. These systems are based on three models: the learner profile/model – student ability and traits, the taught model – learnable content and instructional model – how learning content is availed to the learner (Oxman & Wong, 2014). An adaptive environment for learning require accurate data on student model/profile, their affective state and personal traits is required. This data can be used to inform designers the pedagogy for adaptive system and give the system the capabilities for dynamic self-learning (Khalid et al, 2017).

Artificial intelligence (AI) techniques models are useful in attaining such capabilities and several researchers have highlighted techniques that are suitable for adaptivity. (Darryl & Michaela, 2016) suggested use of back propagation neural network to adapt to player character based on change in environment. They also suggested use of radial basis to classify cluster algorithm to classify players. (Xu, Wang & Su, 2002) posit that Fuzzy logic can be used to model student profiles. Can also be used to evaluate learning objectives and outcomes (Kavi et al, 2003: Chang & Sun, 1993). Other AI techniques used are Iterative Dichotomiser 3(ID3) for predicting students' performance (Adhatrao et al, 2013), Self-organizing maps (SOM) with Back Propagation to establish the connection between learners objectives and learners needs and come with appropriate for each user.

(Beetham & Sharpe, 2013), Bayesian Network (BN) to categorize users and quantify if a student can complete a certain activity. (Moreno et al, 2005), Student behaviour prediction using Hidden Markov Model, (Morteza &Anari, 2012) and Genetic Algorithm (GA) can be useful when it comes to understanding end user preference, want and needs. (Argyri & Decades, 2009)

Table 3: Summary of the Adaptivity Frameworks Analysis

S. N	Author	Study desription	Basis of adaptivity	Theoretical underpinning	Implemented as a exp/ survey/rct	Deployed in e-learning platform	Game elements deployed	Analytics Or metrics Results	Shortcoming or challenges
1.	(Ferro, Walz, & Greuter, 2013)	"The Paper investigates the relationships between player types, personality types and traits, with game elements and game mechanics and discuss how this connection may impact the design of gamified systems and offer insight towards more user orientated design objective"	Learning style , personality behavior	"The Various theories on Player typologies (Bartle, fullerton, caillois)" "Personality types and traits by Eysenck Raymond Cattell, Five Factor Model"	None	None	None	"A Matrix Table outlining the relationship between Personality trait & types and Game elements and mechanics"	- Not Validated empirically
2.	(Codish & Ravid, 2014)	"Proposes an adaptive gamification framework which includes gamification analytics (GA) elements"	Playfulness	- "IS theory of utilitarian and hedonistic Systems , MDA Framework "	Proposal	None	Proposes to use Points Feedback , Progress bars leader boards	None	None

3.	(Monterrat, Lavoué E., & S., 2015)	"Focuses on a generic and adaptive gamification system that can be plugged on various learning environments. The game elements can be Automatically adapted, based on an analysis of the interaction traces"	Player types	"Bartle Player classification Makes use of adaptation Engine based on player model "	Proposal	None	Uses concept of epiphyte	None	Evaluation
4.	(Luo, Yang, & Meinel, 2015)	"explore a reward-based reinforcement method for e-learning environments to sustain long-term motivation. The proposed model calculates the probability of gaining points and searches for an effective learning activity"	Reward difficulty	"Implicitly refers to SDT , user centered design, theory of game addiction mechanism"	"Experiment with a common reward model and an intermittent reinforcement model "	Tele-task e-learning Platform	Points Badges , leaderboards	The model was better than the common reward model	Not Optimized for e-learning platform
5.	(Naik & Kamat, 2015)	"study Focuses how to devise a solution that can address the problems of meeting individual needs of the student as well as keeping away the disengagement and disinterest of the students."		"None but Uses the Adaptive framework "	Experiment with 3 control groups	Yes Moodle	Leaderboard, levels, badges, points	"Demonstrated that the combined gamification and adaptive systems is better than individual setup"	Adaptive + gamification system separate , not in built
6.	(Roosta, Taghiyareh, & Mosharraf., 2016)	"The paper investigates the possible correlations between gamification-elements and learners' personality Categorization Based on Leaner's personality focusing on Motivation Style using the Achievement Goal Questionnaire-Revised (AGQ-R)."	Personality trait	"Not explicitly referred to but references to Myer-Briggs, Jung, Freud "	Implemented as Experiment using RCT	Implemented a Gamified LMS called DoosMooc	Badge , Feedback , Leaderboard, Point , Progress,	"Used T statistics for means comparisons of the Two Groups showed there a significance in performance for Gamification using Categorization	No gamification adaptation framework

								approach and Random Gamification “	
7.	(Schöbel & Söllner, 2016)	“Show a gamification approach to adapt gamification elements to the individual motivation structures of IS users”	Motivational affordance	Uses SDT, TPB	Research in progress		Avatars levels ,badges ,		No gamification adaptation framework
8.	(Shi & Cristea, 2016)	“approach gamification in social adaptive technology enhanced learning through proposing different motivational gamification strategies based on SDT”		“Uses Self Determination Theory esp Relatedness , competence , Autonomy”	“Experiment with Control after which there a survey for perceived motivation “	Implemented in Topolar	Variety of elements	“Show that the perceived motivation were attained “	No gamification adaptation framework
9.	(Jia, Xu, Karanam, & Voida, 2016)	“The Paper investigates the relationships among individuals’ personality traits and perceived preferences for various motivational affordances used in gamification.”	- Personality traits	- The Personality trait theory of OCEAN and	Experiment , no RCT	Deployed in a gamified APP	Game elements as termed as motivational affordance .Used (Hamari, Koivistoa, & Sarsa, 2014)	“Correlational test and regression analysis . Various traits +vely related to certain Motivat-ional affordance”	No gamification adaptation framework for LMS
10.	(Buckley & Doyle, 2017)	“Research examines the impact that different learning styles and personality traits have on students'; (1) perceptions of, (2) engagement with and, (3) overall performance in a gamified learning intervention developed using a prediction market .No personalization effort “		“Used The Personality trait theory of OCEAN and the The Learning style theories esp Felder and Silverman”	Experiment , no RCT	Deployed in a gamified APP	All Game elements used	“Correlational test for Personality traits and gamification as a whole Learning styles a gamification as a whole “	Need for Nuanced Study for effects of specific game elements

Architectural Model

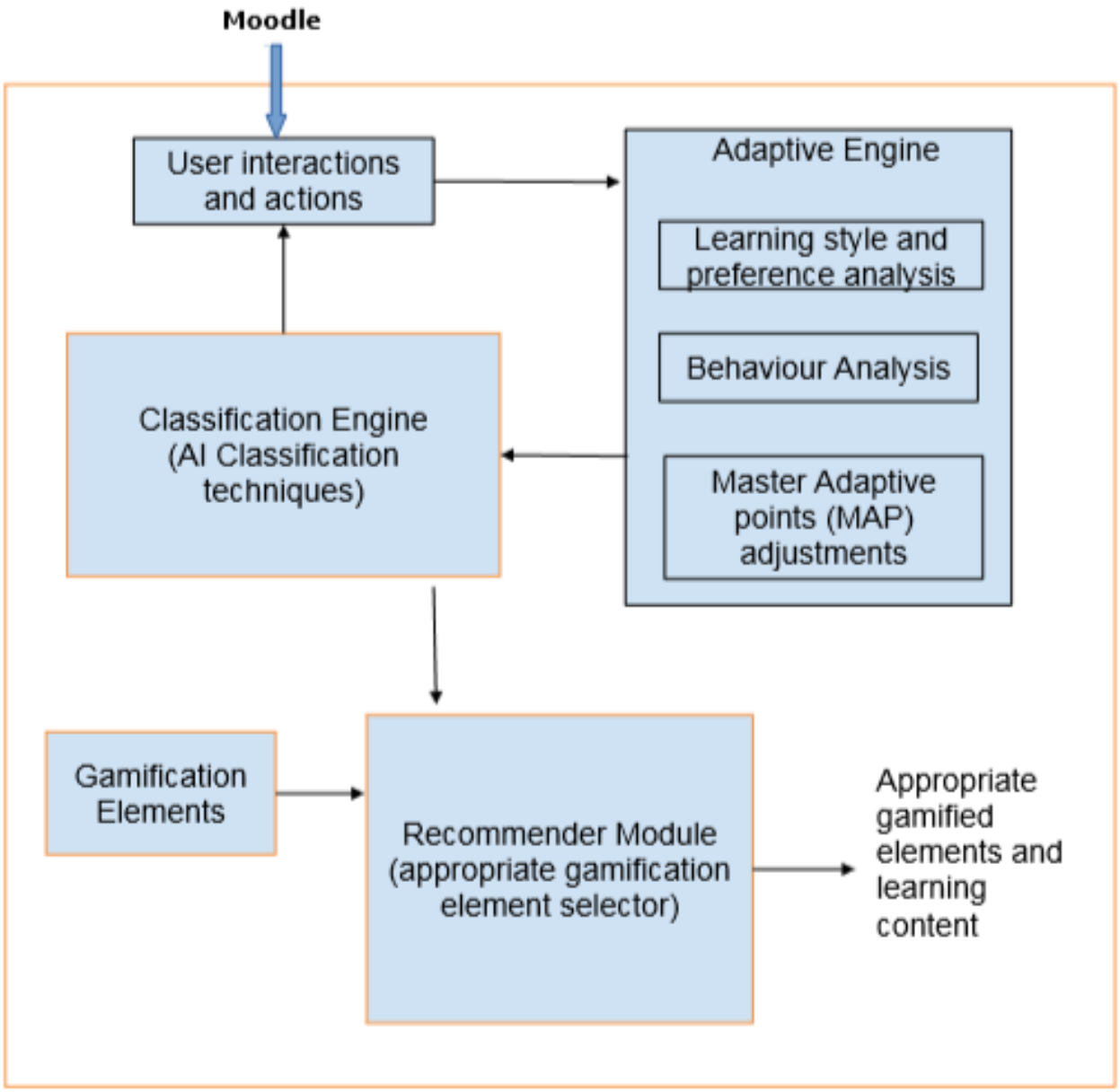


Fig 4: Architectural model

CHAPTER THREE

METHODOLOGY

Research Design

Research design as defined by Kumar, "is a plan, structure and strategy of investigation that tend to answer the research questions or problems" (Kumar, 2015). It is also referred to as "the way a study is planned and constructed, the procedures and techniques employed to answer the research problem or question." (KUMSSA, 2004). It does not just demonstrate the architecture of research but also resources, cost and time required to perform the research.

This study will employ Design Science Research Methodology (DSRM) because its repetitive nature and the way it employs specific guidelines for evaluation.

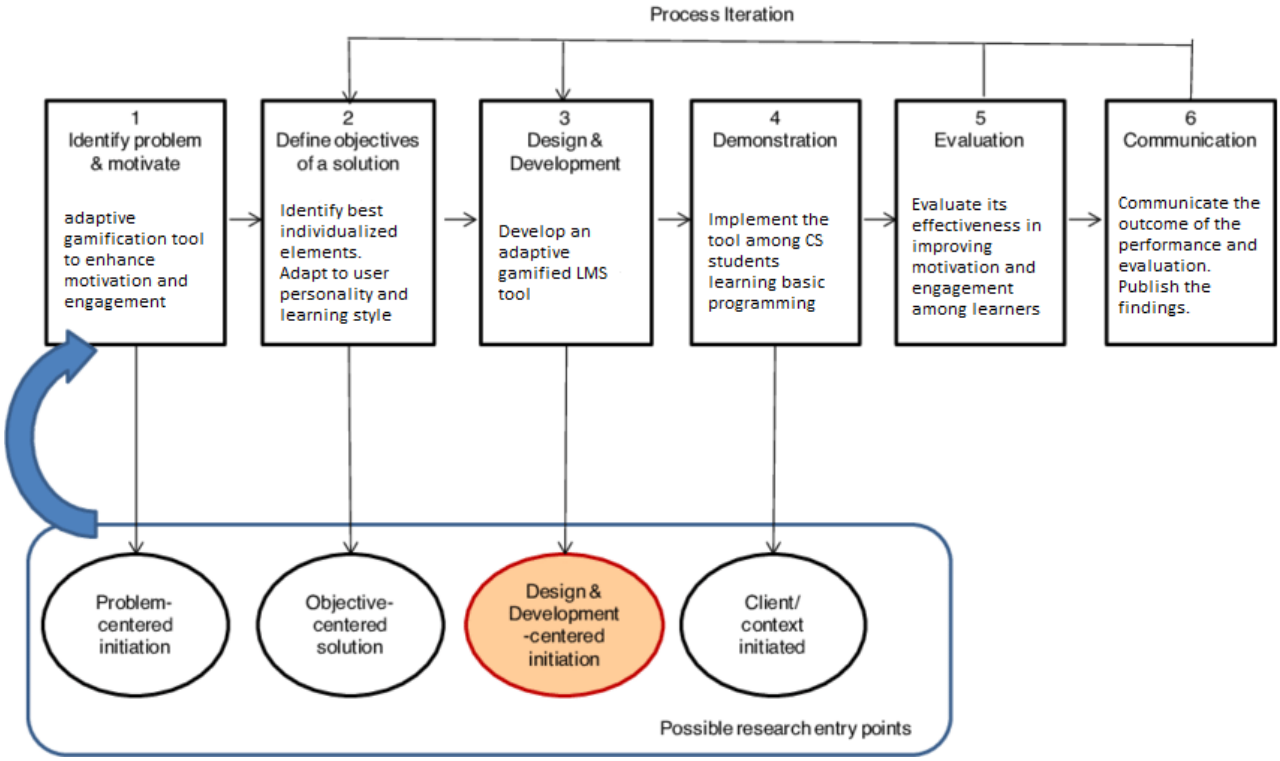


Fig 5: "Design Science Research Methodology process model" (Peffers et. al., 2007)

In relation to this study, the DSRM process is elaborated as below:

1. "Problem identification and motivation" – Having a gamification tool that will improve the motivational level of learners studying basic programming. The tool needs to cater for the difference in motivation and learning style among students thus adapt to their personality.

2. Objective of the solution definition – Identifying gamification elements that are best suited to motivate students based on their preference and personality and progressively adapt to their learning behaviour.
3. Design and Development – Develop a LMS prototype that will use AI techniques to adapt to users preferences and recommend the right gamification elements to enhance motivation and engagement.
4. Demonstration – apply the tool to a sample size of computer science students and demonstrate its work-ability and applicability.
5. Evaluation – evaluating the results against the problem stated to identify its efficiency in improving motivation and engagement.
6. Communication – The results of the prototype performance after evaluation will be communicated and findings published.

The Process

The student logs into Moodle platform as usual to access learning content in the enrolled units. The system retrieves his previous system activeness from logs and passes them as parameters to the AI Classifier which already has a list of available clusters. With this, the classifier predicts the best cluster for the student and passes it to the recommender module. Based on the cluster passed, the recommender module enrolls the student to the course that has appropriate gamification elements. If the student has fewer records from the logs (new student) or has been classified far from the right clusters, he/she is enrolled to a course for new users. This course is intended to identify the right cluster for these students as they keep on interacting with the system.

The fact that system analyze and classify students at real time, forms the basis of adaptivity. With consistent system use, the logs from real-time interactions will be used to adapt the student progressively to the right cluster thus access to the right gamification elements. With this we can monitor the student's motivation and engagement level.

Pre Study

Data mining

Mining of data was done from logs of a live e-learning platform. Total records of 89,000 were extracted

CC	CD	CE	CF	CG	CH	CI	CJ	CK	CL
Assignments	Chats	Course	Files	Folders	Forum	Page	Quiz	URL	Total
89	0	66	7	6	9	0	148	0	325
0	0	2	0	3	0	0	1	0	6
19	0	24	0	0	0	0	87	0	130
16	0	34	0	2	1	0	124	0	177
69	0	57	21	0	0	1	114	0	262
23	0	53	9	1	2	14	90	0	192
40	0	67	11	3	1	9	157	1	289
15	0	20	2	0	0	0	168	0	205
19	0	21	2	0	0	0	135	0	177
21	0	31	0	3	0	0	86	0	141
18	0	16	0	0	0	0	60	0	94
31	0	29	2	0	1	2	118	0	183
20	0	22	2	4	2	0	99	0	149
36	0	81	4	2	1	6	120	1	251
27	0	12	0	0	0	0	90	0	129
9	0	16	0	0	0	0	146	0	171
42	0	24	0	0	0	20	78	0	164
9	2	33	21	2	1	2	84	0	154
62	0	35	1	0	0	2	122	0	222
25	0	30	0	0	0	0	127	0	182
13262	58	16840	1280	486	253	1470	56046	71	89766

Fig 6: Data extract from moodle logs

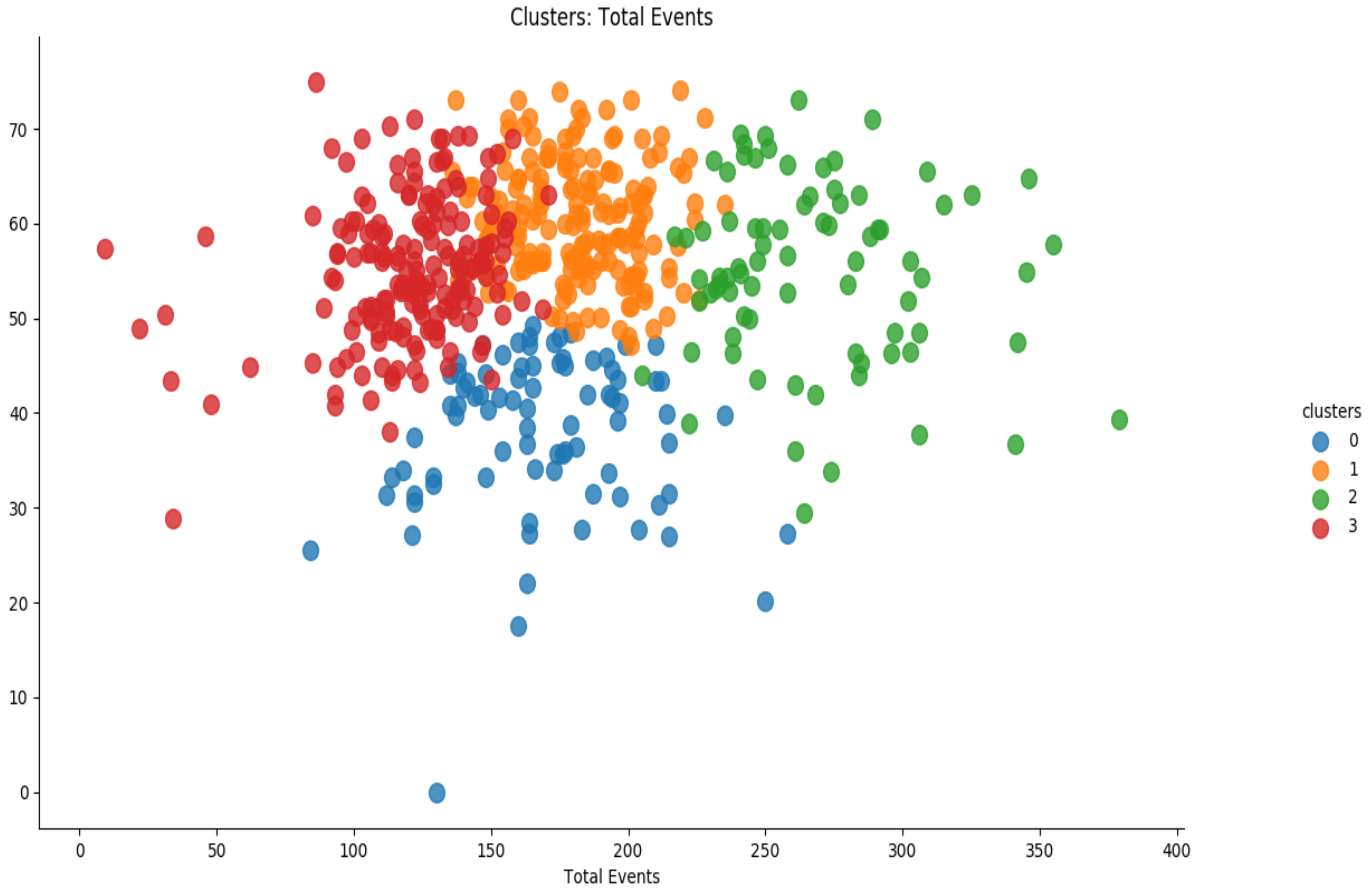
After extraction, total students found were 530 who were used for our clustering algorithm. Their data was cleaned, transformed to appropriate format and loaded to a clustering algorithm.

B	C	D	E	F	G	H	I	J	K
Assignments	Chats	Course	Files	Folders	Forum	Page	Quiz	URL	Total
14	0	25	1	0	0	2	94	0	136
19	1	53	4	2	1	3	178	0	261
21	1	29	2	1	0	2	106	0	162
17	0	36	2	8	1	2	110	0	176
39	1	63	5	0	3	11	155	0	277
8	0	16	1	0	1	0	58	0	84
47	0	57	1	0	1	0	102	0	208
32	0	23	0	0	0	0	86	0	141
9	0	12	1	1	0	0	63	0	86
22	0	24	1	0	1	0	70	0	118
23	0	25	3	0	0	2	108	0	161
35	0	29	2	0	0	5	75	1	147
17	0	16	1	0	0	2	119	0	155
16	0	27	0	0	0	0	107	0	150
16	0	30	3	6	0	0	61	0	116
15	0	16	0	0	0	0	79	0	110
39	2	69	17	0	3	5	180	0	315
20	0	36	5	2	1	4	84	0	152
22	0	52	0	0	1	0	73	0	148
39	1	29	0	0	0	0	92	0	161
18	0	18	0	0	0	0	133	0	169
48	0	38	1	1	0	0	131	0	219
29	0	34	0	8	0	35	86	0	192
13	0	13	0	0	0	0	67	0	93
62	0	38	3	2	0	8	64	0	177

Fig 7: Data mining per student

Machine Learning Algorithms used

Clustering – K-Means Algorithm



The clustering algorithm created another field (Clusters) that formed the basis for classification.

A	B	C	D	E	F	G	H	I	J	K	L	M
	Assignments	Chats	Course	Files	Folders	Forum	Page	Quiz	URL	Total	Marks	clusters
:h	14	0	25	1	0	0	2	94	0	136	51.925	3
no	19	1	53	4	2	1	3	178	0	261	36	2
:igen	21	1	29	2	1	0	2	106	0	162	61.975	1
	17	0	36	2	8	1	2	110	0	176	53.6	1
no ouma	39	1	63	5	0	3	11	155	0	277	62.1	2
ni Nyutu	8	0	16	1	0	1	0	58	0	84	25.5	0
njeri	47	0	57	1	0	1	0	102	0	208	67	1
:i katanu	32	0	23	0	0	0	0	86	0	141	62.7	1
ni mwenga	9	0	12	1	1	0	0	63	0	86	75	3
oro	22	0	24	1	0	1	0	70	0	118	34	0
kinyi	23	0	25	3	0	0	2	108	0	161	44.85	0
d mbarak	35	0	29	2	0	0	5	75	1	147	60.3	1
nyambura	17	0	16	1	0	0	2	119	0	155	59.5	3
ogude	16	0	27	0	0	0	0	107	0	150	57.95	3
mucheru	16	0	30	3	6	0	0	61	0	116	44.55	3
gichangi	15	0	16	0	0	0	0	79	0	110	56.925	3
munene	39	2	69	17	0	3	5	180	0	315	62.05	2
ala maluki	20	0	36	5	2	1	4	84	0	152	61.2	1
a j	22	0	52	0	0	1	0	73	0	148	44.2	0
gi wakarura	39	1	29	0	0	0	0	92	0	161	61.05	1
	18	0	18	0	0	0	0	133	0	169	56.1	1
	48	0	38	1	1	0	0	131	0	219	74.1	1

Fig 9: Classification Algorithm - K Nearrest Neighbours (KNN)

After clustering, the generated data was used to train a classifier which is now used to predict the right cluster for a new student (instance) with an accuracy of about 90%

```
root@x73rm:/home/x73rm3000/Desktop/ML/Moodle_AI# python KNN.py
   Assignments  Course   Quiz  Total   Marks
0         21.0    29.0  106.0  162.0  61.975
90.0
89.53099481878188
Student classified in cluster:  1
```

Fig 10: Classification of a new instance

Cluster interpretation and gamification elements used

Achievers - Characterized by a larger participation that is above the recommended threshold.

In this case students are much ahead of others in terms of performance and engagement and they clearly dominate the top. They are the role models as compared to other clusters.

Gamification elements used

- **Level Up, Stash, Progress bar, Badges**

Disheartened students – Characterized by students who started off with high motivational level but somehow along the way, they fell behind. Their mean is close to achievers but performing poorly.

Gamification elements used

- **Level Up, Progress bar, Ranking**

Underachievers - Students, typically with the lowest participation. These students also scored lowest indicating a low interest level in the course engagement and are highly demotivated

Gamification elements used

- **Level Up, Leaderboard, Progress bar**

Inquisitive (Explorer) – Curious how students who have a high interest in exploration and investigation of things especially when they are new to them. They get motivated through a sense of discovery instead of being directed on what is required of them.

Gamification elements used

- **Level Up, Stash, Hidden picture, Badges**

System implementation (Integrating to Moodle)

Recommender Module

This module acts as intermediary between php and python. It send data to and from python and take appropriate measure based on the classification made by the KNN classifier. When student logs in, it sends the data to the ML algorithms and get feedback which it uses to determine where to enroll the student for access to the right gamification elements.

Research Site

The features above were integrated to a live Moodle system of Kenyatta University and students exposed to the functionalities mentioned. Data collected from student interaction with the system was used to determine the effectiveness and efficiency of the system.

Research Population

The study involved four classes of first year Computer Science students from Kenyatta University. Only two classes were selected for study because of the large number. Students in the classes were grouped with one group having 185 students while the other having 124.

Population Sample

A hundred students were subjected in the study by interacting with the gamified system. Stratified type of sampling was used to select this population sample. This type of sampling was selected because it recognizes the differences in the target population, representing all the target strata making it effective for the study.

The sampled students were subjected to traditional mode of online learning provided with a questionnaire to identify their experience with normal online learning platforms. Logs from moodle platform were also extracted to identify their engagement level from system's perspective. Gamification elements were introduced to a live course were taking. With help of the AI classifier, they were grouped according to the base clusters and provided the right gamification elements as per allocation. They interacted with the platform for a period of one week where another questionnaire was provided. Logs were as well extracted for analysis.

Data collection tools

These tools were used to collect the data;

1. Moodle Platform Systems logs played key role in providing data used by artificial intelligence techniques.
2. Questionnaire was used to collect feedback from students who participated in the study.

Parameters to measure success of the system

Parameters used to measure the importance and success of the system were:-

- **Improvement of responses from the two questionnaire** – one administered before the study was conducted and the other after experiment was done.
- **The engagement level** - If the gamification elements recommended increased their engagement on the system means improvement in motivational level.
- **Feedback from students** - Important to ascertain if the system had any impact to their learning experience

CHAPTER 4

RESULTS AND EVALUATION

Classifier grouped students at real time and assigned them to respective clusters. An improvement in cluster allocation was evidenced within the first week of system interaction as shown in figure 7.

The system started off with allocation of 116 students in the underachievers cluster, 35 dishertenned and 7 achievers. In one week's time, the numbers continuously adjusted at realtime with 6 newly *adapted underachievers identified and disheartened group increasing to 50.*

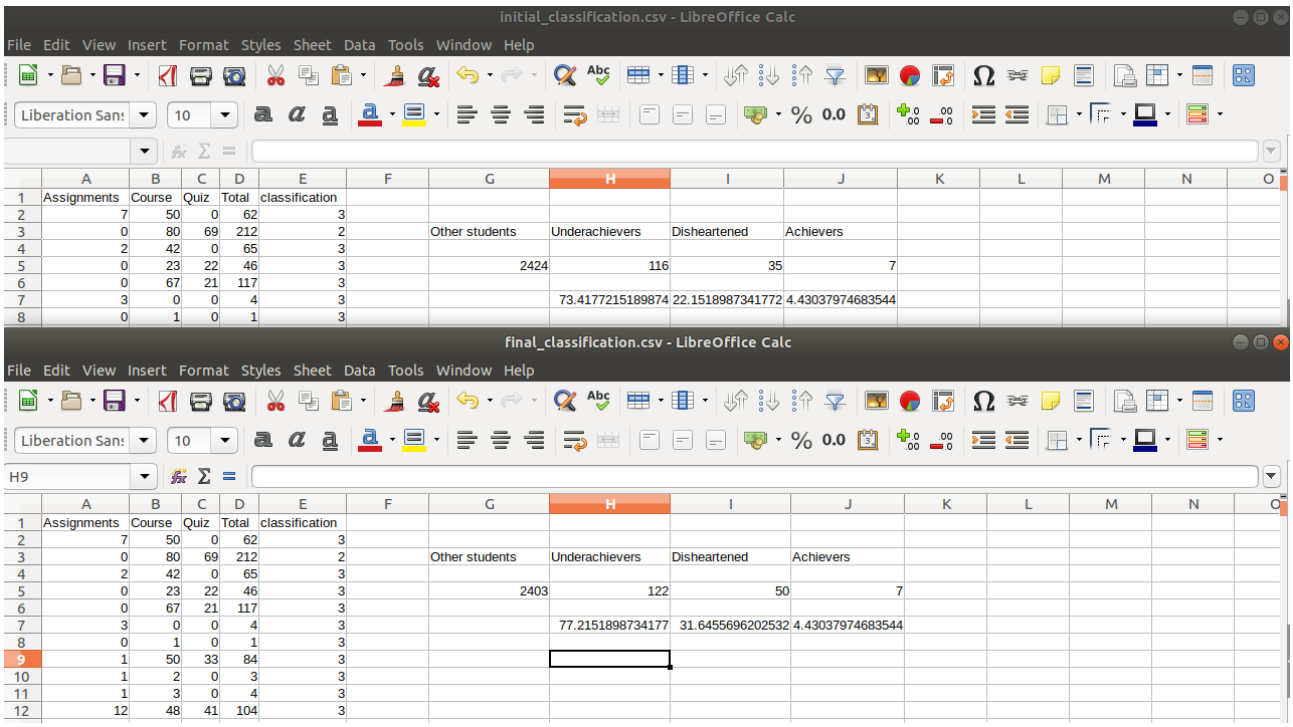


Fig 11: Adaptivity of students from as they interact with the system

To test the tool, two classes of computer science students at Kenyatta University were subjected to the study. The two questionnaire administered to students before and after study showed significant improvement in students responses after they interacted with the gamified platform. Students of age group 21 – 25 and 26 - 30 were the most participants and used laptop and smartphone to access the online platform with a percentage of 29.64 and 28.46 respectively. (See figure 12)

Out of the responses, 139 acknowledge that they do play games and 68% denotes that playing a game can assist them in learning. This number increased to 74% after being subjected to a gamified system as shown in figure 13 and 14

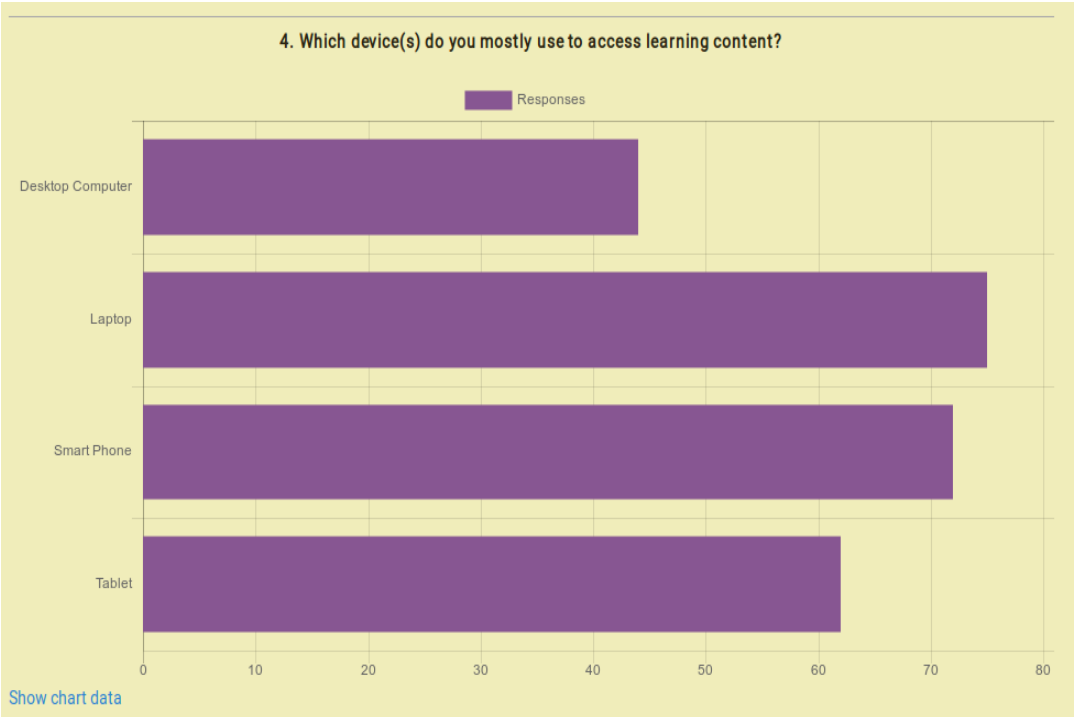
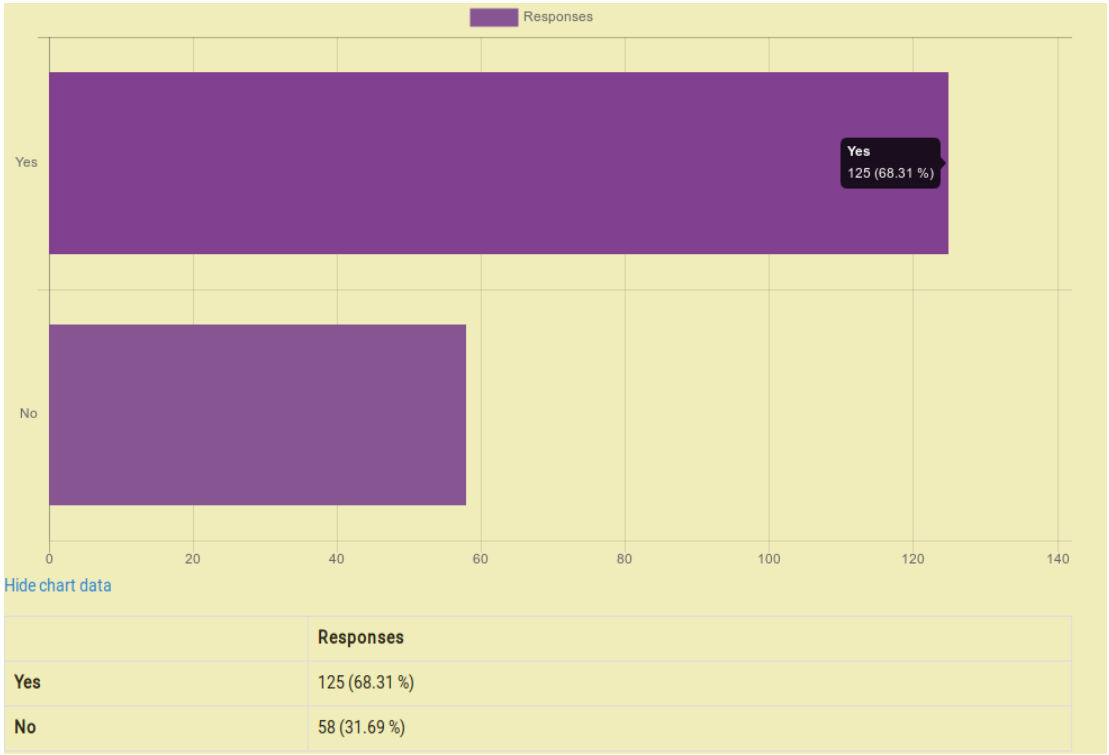
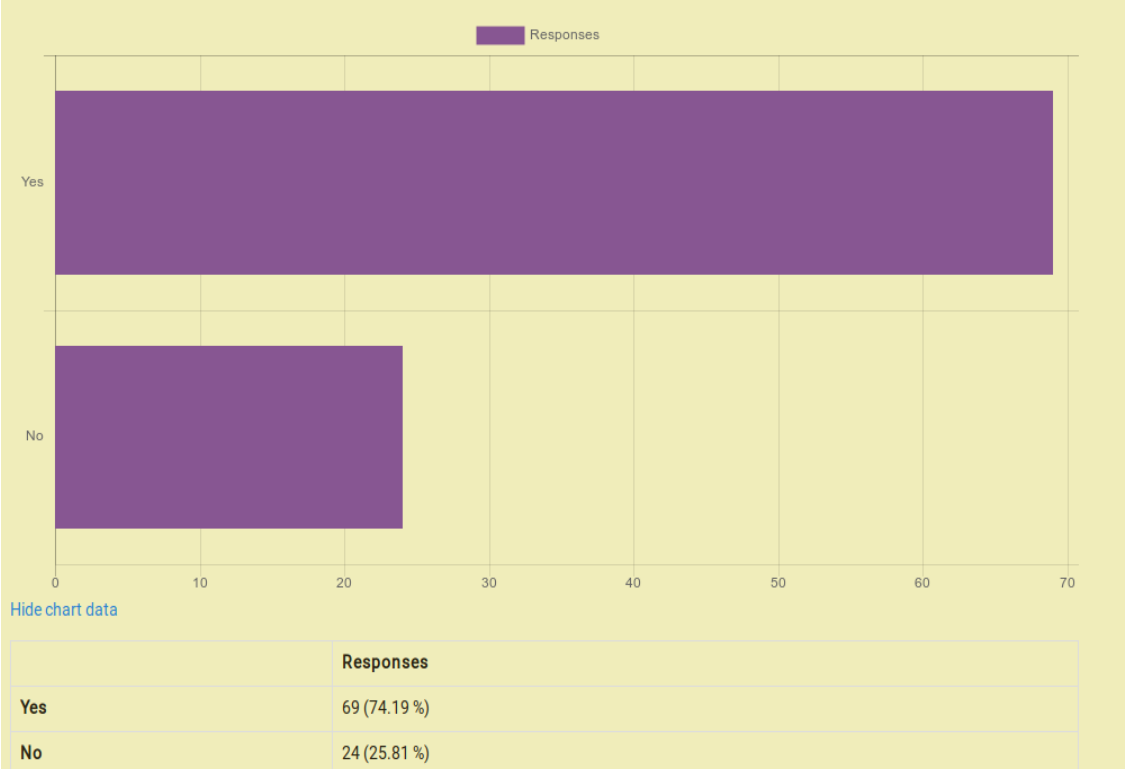


Fig 12: Devices used to access platform - KU Moodle Platform



	Responses
Yes	125 (68.31 %)
No	58 (31.69 %)

Fig 13: Pre-study analysis on impact of game in learning – KU Moodle Platform



	Responses
Yes	69 (74.19 %)
No	24 (25.81 %)

Fig 14: Post Study analysis on impact of game in learning - KU Moodle Platform

Gamification tools also showed great motivation among students. In one group, students had attained over 11,000 experience points which were attained by interacting with the system. The leaderboard made students to keep their position on top (See below) but wasn't the case for everyone. Some were motivated by ranking based on certain aspects while others were just okay without the elements. All these were provided to cater for the difference in their motivational factors.

Some games were implemented as well to enhance motivation and monitor if they will have impact in learning. These games includes crossword which challenged students to master terminologies in the unit. It was observed that students were participating even at odd hours and their level of engagement helped them gain experience points and be classified to other clusters.

Rank	Level	Participant	Total	Progress
1	7	ADHIAMBO HELLEN O	11,136xp	8,509xp to go
2	7	LANDO ELVIS O	11,085xp	8,560xp to go
3	7	Dr. Tom Destiny Namwamba	10,533xp	9,112xp to go
4	7	WAFULA RUSSEL A	10,500xp	9,145xp to go
5	6	KATUMBI KYENGO A	9,207xp	1,027xp to go
6	6	IRENE OMONDI	7,743xp	2,491xp to go
7	6	SOLOMON ODUNDO B	7,647xp	2,587xp to go
8	6	AHMED ZENA A	7,488xp	2,746xp to go
9	6	MITATI AMBROSE K	7,086xp	3,148xp to go
10	6	GIKUNYI NJERI S	6,954xp	3,280xp to go
11	6	KITHIA WAMBUI S	6,555xp	3,679xp to go

Fig 15: Leader board game element – KU Moodle Platform

RANKING

Weekly | Monthly | General

Pos	Fullname	Points
1	KIMANZI	102.0
2	Rachel Jikwanyi	51.3
3	CECILIA	32.0
4	ISSACK	28.0
5	Mary Njoki	25.0
6	Sylvia kavindu	16.0
7	ISEU	12.0
8	MUCHIRI	10.0
9	GICOVI	8.0
9	RUTH WAMBUI	8.0

Fig 16: Ranking game element - KUMoodle Platform

Ranking based on assignment upload/ submission and messages sending to either a chat or posting to a forum

CHAPTER 5

CONCLUSION

As seen, using gamified platform is indeed necessary for keeping students engaged in online platform. The gamified system used should not just focus on general game elements for students but personalized ones and keep adapting the student's learning behaviour as motivation kicks in. As per objectives of this study, we were able to identify gamifiction elements suitable for recommending to learners according to their learning behaviour, apply appropriate AI techniques to cluster students based on their behaviour and progressively classify them and finally create a platform for implementing these features.

Study limitations and recommendations

Gaining access to the server of running platforms and installing necessary ML packages became a challenge and this resorted to applying the features on one system. Using other classifying methods such as Neural network were not viable because of the small amount of data obtained. The algorithm was over fitting with every trial.

In future, other efficient ML techniques will also be applied as access to a large dataset is availed and the gamified tools to be integrated with other LMS platforms.

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QUESTIONNAIRE

1. What is your gender?
2. Kindly choose your age group
3. Have you studied or studying any online unit on Kusoma platform?
4. Which device(s) do you mostly use to access Kusoma platform content?
5. How often do you:
    a) Read or send emails
    b) Chat online on social media (e.g. Facebook, Whatsapp, Twitter etc)
    c) Search encyclopedia websites such as Wikipedia
    d) Search for educational resources and information online
    e) Participate in a quiz on Kusoma platform
    f) Participate in group discussions or forums on Kusoma platform
    g) Play a game
6. Do you think playing educative games or gamifying Kusoma platform can keep you engaged and assist you in learning?
7. How often do you use Kusoma platform in a given week?
8. Please choose the online activities that you have ever participated in on Kusoma platform
9. Which among the listed activities do you face challenges in on Kusoma platform?
10. Which among the listed activities do you use comfortably on Kusoma platform?
11. Please state the challeges you experienced while interacting with online activities on Kusoma platform
12. Learning through Kusoma platform is fun and enjoyable
13. I enjoy learning because the Kusoma platform adjusts to my style of learning
14. I prefer learning through Kusoma platform than in a physical class
15. I usually go through every content posted in a course on Kusoma platform
16. I get demotivated when doing some activities through Kusoma platform
17. I like how we compete on Kusoma platform based on how much participation one makes.
18. I like how I am being rewarded and ranked based on how much I participate on Kusoma platform.
19. The added game features and learning games on Kusoma platform keeps me engaged and motivated.
20. I take time to engage on Kusoma platform because I think that online activities are interesting
21. I take time to engage on Kusoma platform because peer learners give me opportunity to interact with them and learn
22. I take time to engage on Kusoma platform because I feel good when doing learning activities

23. I mostly follow learning activities on Kusoma platform because I do not want my classmates to leave me behind
24. I always comply with timeline set for activities on Kusoma platform
25. I complete activities on Kusoma platform because I don't have any choice
26. I complete activities on Kusoma platform because I am supposed to do it
27. I would prefer to have social media integrated with on Kusoma platform rather than using them separately for learning
28. Which medium would you prefer for feedback from Kusoma platform?