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A Multi Criteria Decision Making approach to integrate Gamification in Education

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***Abstract*—The use of modern technologies and digital environments in the classroom creates new opportunities for the teaching and learning process. Gamification is one of them. Student engagement through different gamified assessment activities is one of the proven advantages of gamification, and hence, research in education has accepted gamification as a technical innovation to boost student engagement. Educators recognize that assessments are a fundamental part of learning because they help them determine whether or not educational goals are being achieved. Currently, there are numerous online assessment applications that integrate gamification that are available and readily accessible, among which certain applications are more popular in the academic community. Every application has common and unique features, which makes it very difficult for the instructor to choose the best application for assessment using gamification. The proposed research work identified four different popular gamification applications (Quizizz, Kahoot, Socrative and Quizwhizzer) and compared six different features of them to find the best gamification application for assessing student performance. To address the objective of the research, this study uses the Analytic Hierarchy Process (AHP) method, one of the well-known Multi-Criteria Decision Making (MCDM) techniques. The study implements MCDM with six different criteria, where each criterion is addressed by more than three subcriteria. The study's findings demonstrate that Quizwhizzer is the best gamification application for assessing student performance. The research study also extends the analysis to the selective needs of the instructors on these platforms.**

***Keywords*— Gamification in Education; Quizizz; Kahoot; Quizwhizzer; Socrative; MCDM-AHP.**

***JEET Category*— Research**

I. INTRODUCTION

TO succeed in the 21st century, the education sector must adjust to the needs, preferences, and orientations of digital natives. With the advent of the digital revolution, students were no longer motivated to learn or engaged in the learning environment. According to the report, conventional methods can't resolve this problem, and motivation and engagement in learning aren't possible (Göksün & Gürsoy, 2019). In order to improve learners' motivation and engagement, "gamification" is introduced into the education system as a way of enhancing learners' motivation and engagement. Gamification refers to applying game-like activities in non-gaming environments (López & Tucker, 2018).

Gamification has a variety of advantages for education. They are enhancing the crucial participation and drive of the participants to work consistently; providing instant feedback; providing constant intellectual stimulation due to the students' constant interaction with the computer; creating challenging opportunities; fostering a healthy spirit of competition; enhancing creativity; aiding in problem-solving; visualizing simulations; as well as raising interest in engaging in class; providing a better communication channel between teacher and student, etc. (Gee, 2007; Oliva, 2016; Torres-Toukoumidis et al., 2018). In addition, gamification provides a novel assessment method since it measures students' knowledge range throughout the learning process rather than just at the end of the course (Roslan et al., 2021).

There are numerous gamification applications available in the education sector. They are Arcademics, Blinkist, Brainscape, Classcraft, ClassDojo, Coursera, Didactic City, Duolingo, Goose Chase, Kahoot, Khan Academy, LeetCode, Minecraft: Education Edition, Pear Deck, Play Brighter, Quizizz, Quizlet, QuizWhizzer, Skillrack, Socrative, TEDEd, Tinycards, Trivinet, Udemy, Yousician, and Virtonomics (Gupta, 2016; Loayza, 2019). Most of the gamification factors are influencing a wide range of users towards the gamified learning environment, like points, badges, leaderboard, streaks, avatars, and hints (Lo & hew, 2020). The selection of existing gamification platforms would be a challenging task for the instructors to meet the needs of the students. Also, to develop a customized gamified environment, extensive research is needed to identify the influencing features available on the existing platforms.

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Hence, an understanding of the existing popular gamification assessment platforms is needed to select among them and create a customized learning environment that incorporates all the influencing features of the existing platforms. The objective of this research is to identify effective gamification environments that incorporate features to attract new users and to suggest appropriate gamification applications depending on the selective need. The identified features of existing applications can be included while developing a customized gamified environment in the future for effective student engagement.

II. LITERATURE REVIEW

As technology grows quickly, teachers must be more inventive and creative when designing learning models and implementing them in the classroom (Wahyuningsih et al., 2021). Students report high boredom rates and state that the learning process is exhausting and uninteresting, and they prefer to incorporate important elements including usefulness, knowledge, engagement, enjoyment, motivation, and ease of use into their learning process (Acosta-Medina et al., 2021).

Gamification could be a potential way for educators to engage their students in the learning process in a creative way (Carnero, 2020) that incorporates the learning elements as required by the students. Additionally, gamification offers a fresh approach to evaluation since it gauges students' level of understanding during the course rather than simply at the end (Roslan et al., 2021). Several gamification applications are available for education (Carnero, 2020). Some of the gamification applications (Quizizz, Kahoot, Socrative and Quizwhizzer) are found to be commonly appearing in research works (Degirmenci, 2021; Lim & Yunus, 2021; Wang & Tahir, 2020; Zhang & Yu, 2021; Lim, 2017; Awedh et al., 2015; Faijah et al., 2022; Hamid et al., 2022) that use these platforms for intermediate assessments. These platforms provide gamification dynamics in many forms. Quizizz is useful in a variety of ways, but it excels at facilitating learning in an enjoyable, engaging, and meaningful setting (Degirmenci, 2021). Quizizz offers a great deal of potential to be used for a variety of purposes, such as testing and in-class activities (Lim & Yunus, 2021). Kahoot! can encourage student engagement and participation in class while also enhancing the learning environment (Wang & Tahir, 2020). It can facilitate the development of a quick and simple classroom response system and encourage the use of creative methods (Zhang & Yu, 2021). With the help of Socrative, students are more motivated to learn (Lim, 2017). Additionally, it aided in their awareness of their degree of conceptual understanding, made it easier for them to grasp the ideas, and markedly accelerated their learning (Awedh et al., 2015). Using QuizWhizzer as a learning medium, students can interact with each other through an interesting, interactive game that emphasizes cooperation and communication (Faijah et al., 2022). It engages students and increases their attention, motivation, and focus (Hamid et al., 2022). These types of gamification tools improve student communication with their teachers and peers and foster cooperative information sharing between them (Awedh et al., 2015). From the literature study, it is obvious that the selected platforms are used in many research studies, and these platforms are more suitable for further analysis. Hence, this research study picks up these four platforms for a detailed analysis of the intended purpose.

This research work aims to rate the specified learning environments (Quizizz, Kahoot, Socrative, QuizWhizzer) with specific criteria that are crucial factors influencing the new users, followed by an analysis of the same. The sub-criteria of each criteria are formulated and used in analyzing the specified gamified learning environments. Analytic Hierarchy Process, a Multi-Criteria Decision-Making approach is applied to these observed factors of the learning environments, termed as alternatives, to identify the best gamification application among these four with respect to the perspective of a new user. Also, this research study recommends selecting appropriate platforms based on the selective needs of the instructor using the results.

III. RESEARCH QUESTION

With the intended research purpose, the following Research Questions (RQ) are proposed to address the specific objectives of this study:

RQ1. Among the four gamification assessment platforms identified, which of the platforms is recommended based on the decision criteria chosen for this research work?

RQ2. How can the results of this experimental study be interpreted considering the selective needs of the instructors?

IV. EXPERIMENTAL METHODOLOGY

To answer the proposed research questions, the Analytic Hierarchy Process (AHP) method is used, which is one of the Multi-Criteria Decision Making (MCDM) techniques (Oztaysi et al., 2019; Carnero, 2020). MCDM is one of the most popular decision-making tools used in many fields for many different purposes (Ozsahin et al., 2021) and one of the most well-known and often-used multicriteria procedures is the analytical hierarchy process (AHP). This method integrates the procedures of assessing alternatives and aggregating them to locate the most pertinent ones (Saaty, 1994). It is used to rank alternatives or to select the best option from a set of alternatives. Rankings and selections are made in light of an expansive goal that is divided into a number of criteria (Ramanathan, 2004).

Among the four alternatives selected, the structuring of alternatives and the corresponding weight allocation between them need to be formulated. To perform this formulation, criteria for analyzing the gamification environment have been observed and structured (Carnero, 2020). Weightage has been assigned to those criteria according to the level of influencing features in the alternate environments. Both the criteria and alternatives, with their respective weights, were sent to the Analytic Hierarchy Process software from SpiceLogic Inc. The complete formulation process is shown in Fig. 1.

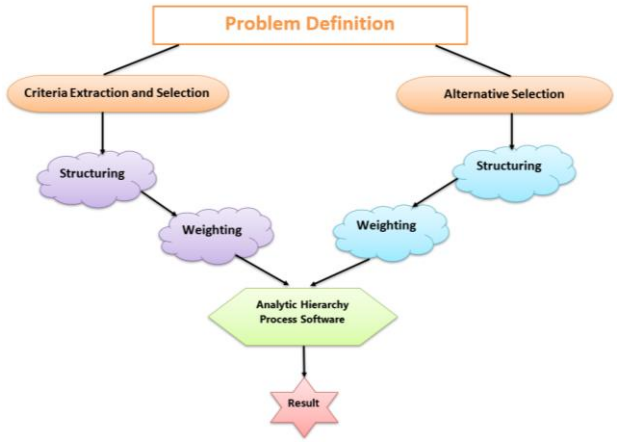


Fig. 1. Step by step approach

A. Criteria Extraction and Selection

The following decision criteria were formed after analyzing the gamification literature (Hamari et al., 2014; Kim, 2014; Çakıroğlu et al., 2017; Kusuma et al., 2018; Wang, 2020; Carnero, 2020) and taking into consideration the outcomes of the actual application of gamification in the classroom with the evaluated alternatives as shown in Fig. 2:

- **Designing Questionnaires (DQ):** Factors indicating the creation of a flexible questionnaire
- **Analyzing and Reporting the Results (ARR):** Factors that are related to versatility in assigning a score and the ability to obtain the results in the form of reports
- **Engaging Student through Gamification (ESG):** Elements of the gamification that are used to engage the student throughout the assessment
- **Impact of Gamification in Student Performance (IGS**): Gamification elements that motivate the students and create an impact on student performance
- **Question Bank from the Library for Adaptation (QBA):** The availability of the public questionnaire and the ability to add the questionnaire to the library
- **User Friendly (UF):** User friendliness and ease of use of the alternate learning environments

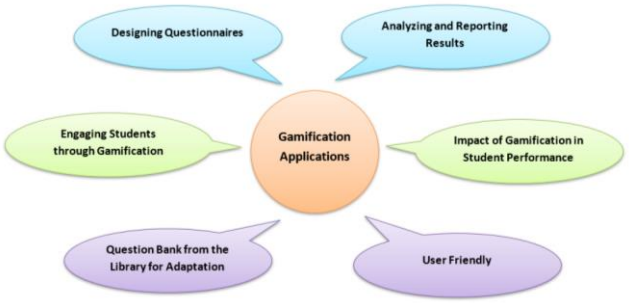


Fig. 2. Extracted decision criteria for gamified assessment platforms

1) Structuring the Criteria

After extracting the criteria, each criterion must be structured with the sub-criterion. According to the related research studies, (Carnero, 2020), the sub-criteria for the six criteria are identified as shown in Fig. 3. For example, the criteria "**Designing questionnaire"** consist of nine different sub-criteria: "Inclusion of all possible question types in a Questionnaire", "Use of images in the questions", "Use of videos in the questions", "Additional explanations for each question Without Character limit", "Ability to download the questionnaire as a file", "Instructor can set a time limit", "Instructor can set maximum number of responses per student", "Instructor allow each student to complete the questionnaire independently – no need to wait for others to response", "Ability to save question to question bank". Similarly, **Analyzing and reporting result** criteria consist of eight different sub-criteria: "Each question can receive a separate score", "Download the Excel document containing participants' answers to each question with their name", "Number of correct responses is used for evaluation", "The time taken to respond the questionnaire is considered evaluation", "Positive value for correct answer", "Negative value for incorrect answer", "Outcome from the platform's review", "During the game, the names of players can be concealed in the score list". Similar to this process, each criterion is defined with relevant sub criteria.

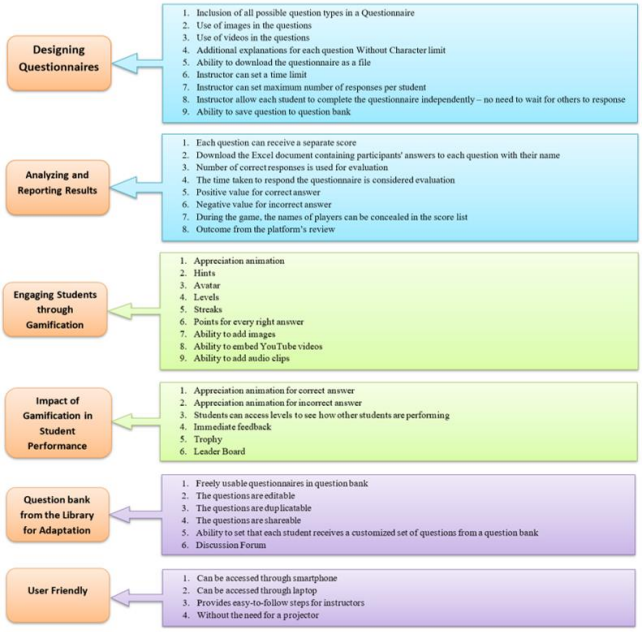


Fig. 3. Structuring the decision criteria with subcriteria

2) Weighting the Criteria

In AHP, fixing the weightage for each criterion plays a very important role. The weightage for each criterion is given manually based on the level of influence of the feature in a gamified environment. Among the six criteria, **IGS** (Impact of Gamification in Student performance**)** and **ESG** (Engaging Student through Gamification) are given higher weightage than other criteria as these two criteria deal with gamification elements, which is the purpose of this research study. **DQ** (Designing Questionnaire) and **ARR** (Analyzing and Reporting Results) are given next priority as these two deals with the primary functionalities of any assessment platform. **UF** (User Friendliness) is placed next and finally **QBA (**Question Bank from the Library for Adaptation) is placed. Based on the weight

given to each criterion, a pairwise comparison matrix is constructed. It is a square matrix that consists of pairwise comparisons of all possible combinations of criteria tabulated in Table I. For example, the value of comparison between **DQ** and **QBA** is 3, which states that flexibility in designing questionnaires is three times more important than question bank availability.

Using a pairwise comparison matrix, a relative priority between the criteria is computed, which is shown in Fig. 4. To determine the relative priority of the criteria, normalize each column of the pairwise comparison matrix of the criteria using sum normalization, and then compute the arithmetic mean for each row of the normalized comparison matrix of the criteria. The relative priority values [0.15, 0.15, 0.27, 0.27, 0.06 and 0.09] are given based on the weightage of the features in this research study. IGS and ESG are given the same higher priority (0.27) as they directly imply gamification features, while DQ and ARR are given equal priority next to the highest (0.15). This is followed by the user-friendliness of the alternatives and finally, the question bank generation facility.

TABLE I
PAIRWISE COMPARISON MATRIX OF CRITERIA

	DQ	ARR	ESG	IGS	QBA	UF
DQ	1	1	0.5	0.5	3	2
ARR	1	1	0.5	0.5	3	2
ESG	2	2	1	1	4	3
IGS	2	2	1	1	4	3
QBA	0.333	0.333	0.25	0.25	1	0.5
UF	0.5	0.5	0.333	0.333	2	1

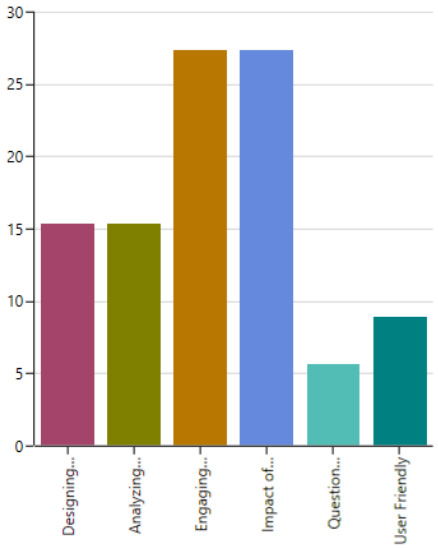


Fig. 4. Relative Priorities (%) of the Criteria

B. *Alternative Selection*

With the MCDM approach, the alternatives are already selected, as discussed in the literature review section shown in Fig. 5. They are Quizizz, Kahoot, Socrative and Quizwhizzer respectively.

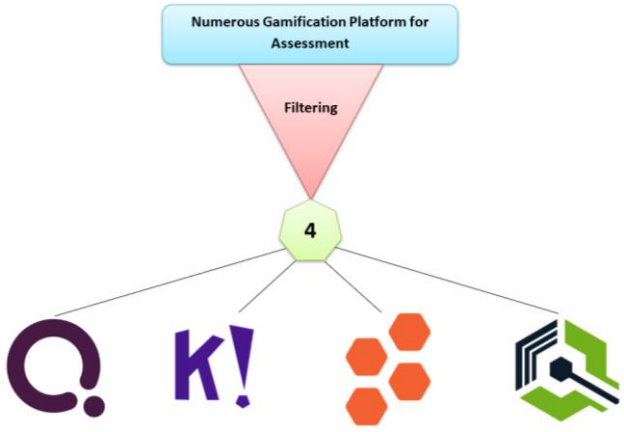


Fig. 5. Alternative Selection

1) *Structuring the Alternative*

The proper way of structuring the alternatives is helpful in assigning weight to them. Here the alternatives are structured based on the sub-criteria within the criteria present in the application in terms of a 4-point Likert scale: if the sub-criteria within the criteria are 100% satisfied by the application, then it is represented as E (excellent); if the application satisfies 75% of the criteria, then it is represented as G (good); if the sub-criteria within the criteria are 50% satisfied by the application, then it is represented as M (moderate); or if the application satisfies 25% of the criteria, then it is represented as P (poor). The chosen alternatives, along with their level of satisfying the criteria, are tabulated in Table II.

TABLE II
STRUCTURING OF ALTERNATIVES

	Quizizz	Kahoot	Socrative	Quizwhizzer
DQ	E	G	G	E
ARR	E	G	M	E
ESG	G	G	P	E
IGS	G	G	P	G
QBA	E	G	M	M
UF	E	E	E	E

2) *Weighting the Alternative*

In an Analytic Hierarchy Process, fixing weightage for alternatives with respect to each criterion plays a vital role in deciding which alternative is best among all other alternatives with respect to the criteria.

Among the four alternatives with respect to DQ criteria, Quizizz and Quizwhizzer are given higher weightage than other alternatives as these two alternatives satisfy 100% of the sub-criteria present within the DQ criteria and Kahoot and Socrative are given next priority as these two satisfy 75% of the criteria. Similarly, the weightage has been assigned to four alternatives with respect to all the other criteria with the help of an alternative structure. Based on the weight given to each

alternative with respect to each criterion, a pairwise comparison matrix is constructed. Table III shows the pairwise comparison matrix of alternatives with respect to DQ criteria. For example, the value of comparison between Quizizz and Kahoot is 2, which states that flexibility in designing questionnaire in Quizizz is two times better than Kahoot. Similarly, for alternatives with respect to all other 5 criteria, a pair wise comparison matrix is computed and consolidated into a single table (Table IV). The process of consolidating all six pairwise comparison matrixes of alternatives with respect to each criterion is shown in Fig. 6.

In order to calculate the relative priority of the alternative with respect to each criterion, a normalized comparison matrix for the alternative with respect to each criterion is computed using sum normalization by normalizing each column of the pairwise comparison matrix of the alternative with respect to each criterion and then the final priority or relative priority for the alternative with respect to each criterion is assigned by computing the arithmetic mean for each row of the normalized comparison matrix of the alternative with respect to each criterion. A relative priority between the alternatives with respect to each criterion is computed and tabulated in Table V, and the relative priority in terms of percentage is shown in Fig. 7. For example, the relative priority between the four alternatives with respect to DQ criteria is shown in Fig. 7(a).

TABLE III
PAIRWISE COMPARISON MATRIX OF ALTERNATIVES WITH RESPECT TO DESIGNING QUESTIONNAIRE CRITERIA

DQ	Quizizz	Kahoot	Socrative	Quizwhizzer
Quizizz	1	2	2	1
Kahoot	0.5	1	1	0.5
Socrative	0.5	1	1	0.5
Quizwhizzer	1	2	2	1

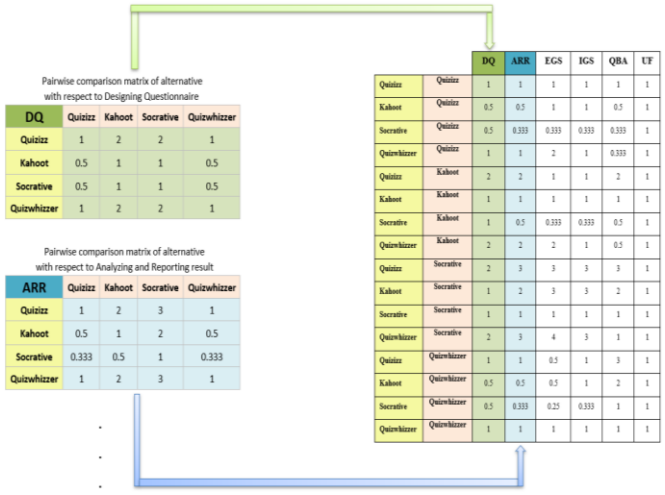


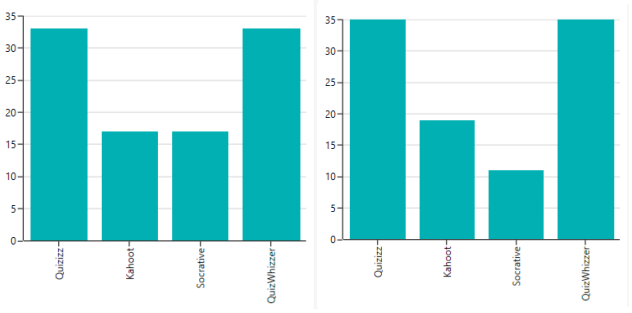
Fig. 6. Process of Consolidating Pairwise Comparison Matrix of Alternative

TABLE IV
CONSOLIDATED PAIRWISE COMPARISON MATRIX OF ALTERNATIVES WITH RESPECT TO EACH CRITERIA

		DQ	ARR	EGS	IGS	QBA	UF
Quizizz	**Quizizz**	1	1	1	1	1	1
Kahoot	**Quizizz**	0.5	0.5	1	1	0.5	1
Socrative	**Quizizz**	0.5	0.333	0.333	0.333	0.333	1
Quizwhizzer	**Quizizz**	1	1	2	1	0.333	1
Quizizz	**Kahoot**	2	2	1	1	2	1
Kahoot	**Kahoot**	1	1	1	1	1	1
Socrative	**Kahoot**	1	0.5	0.333	0.333	0.5	1
Quizwhizzer	**Kahoot**	2	2	2	1	0.5	1
Quizizz	**Socrative**	2	3	3	3	3	1
Kahoot	**Socrative**	1	2	3	3	2	1
Socrative	**Socrative**	1	1	1	1	1	1
Quizwhizzer	**Socrative**	2	3	4	3	1	1
Quizizz	**Quizwhizzer**	1	1	0.5	1	3	1
Kahoot	**Quizwhizzer**	0.5	0.5	0.5	1	2	1
Socrative	**Quizwhizzer**	0.5	0.333	0.25	0.333	1	1
Quizwhizzer	**Quizwhizzer**	1	1	1	1	1	1

TABLE V
RELATIVE PRIORITY FOR EACH ALTERNATIVE WITH RESPECT TO EACH CRITERION

	Quizizz	Kahoot	Socrative	Quizwhizzer
DQ	0.333	0.167	0.167	0.333
ARR	0.351	0.189	0.109	0.351
ESG	0.239	0.239	0.089	0.433
IGS	0.3	0.3	0.1	0.3
QBA	0.455	0.263	0.141	0.141
UF	0.25	0.25	0.25	0.25



(a) (b)

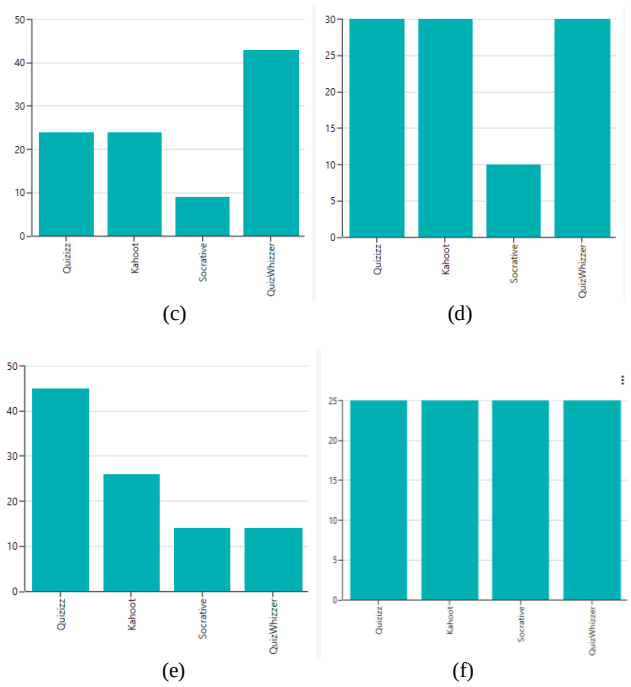


Fig. 7. Relative Priorities (%) of the Alternative with respect to (a) Designing Questionnaire (b) Analyzing and reporting results (c) Engaging Students through Gamification Criteria (d) Impact of gamification in student performance (e) Question bank from the library for adaptation (f) User friendly

C. Analytic Hierarchy Process Methodology

After structuring and weighting the criteria and alternatives, it is ready to be sent to the Analytic Hierarchy Process Software.

Step 1: Defining, structuring and weighting the criteria and alternatives

As discussed in an earlier section, defining, structuring and weighting the criteria and alternatives are entered and the relative priority is computed.

Step 2: Verify the consistency among the pairwise comparisons.

The consistency ratio is the consistency between the pairwise comparisons, which is used to indicate the inconsistencies present within the criteria. The accuracy of preferences (alternatives) derived from pairwise comparisons is adversely affected by inconsistency within them (Abel et al., 2018). Using a pairwise comparison matrix, consistency is computed. The consistency ratio is calculated using the following equation – equation 1:

Consistency ratio = Consistency Index / Random Index

Where,

Consistency Index = (principal Eigen Value – n) / (n-1)

Random Index = random value with respect to number of items used for comparison (Saaty, 1994)

principal Eigen Value = average of Eigen vector

n = dimension or size of the pairwise comparison matrix

Eigen Vector = matrix multiplication vector / relative priority vector.

Matrix multiplication vector = pairwise comparison matrix X relative priority vector

Step 3: Calculate the overall priorities for the alternatives based on the relative weights from pairwise comparisons.

The default MCDM method in the software is chosen to find the overall priorities for the alternatives (final weighted sum) with the help of the multi-criteria utility function (equation 2).

U(Alternative) = ∑ ([relative priority of criteria] * [relative priority of alternative with respect to that criteria])

V. RESULTS AND DISCUSSION

In this section, the result of the analytical hierarchy process is discussed. As discussed in the earlier section, a pairwise comparison is performed among the criteria and alternatives, and the consistency between them is computed using equation 1.

The consistency between the criteria is 0.006, and the consistency between the alternatives with respect to each criterion is tabulated in Table VI.

TABLE VI
CONSISTENCY RATIO OF ALTERNATIVE WITH RESPECT TO EACH CRITERION

Criteria	DQ	ARR	ESG	IGS	QBA	UF
Consistency ratio of Alternative	0.000	0.003	0.007	0.000	0.003	0.000

A consistency ratio of below 10% indicates acceptance of the inconsistencies present within the criteria and the alternatives with respect to each criterion, which means that the inconsistencies present within the criteria and the alternatives with respect to each criterion do not affect the result (Saaty, 1994).

This section discusses the answers to the proposed research questions and the appropriate results.

A. RQ1: Among the four gamification quiz platforms identified, which of the platforms is recommended based on the decision criteria for assessment?

To obtain the final result, the overall priority of the alternative has to be calculated. As discussed earlier in the methodology section, based on the relative priority, a weighted sum is calculated for each alternative with respect to each criterion using equation 2, and it is visualized in the form of a stacked column chart as a weighted attribute chart, which is shown in Fig. 8.

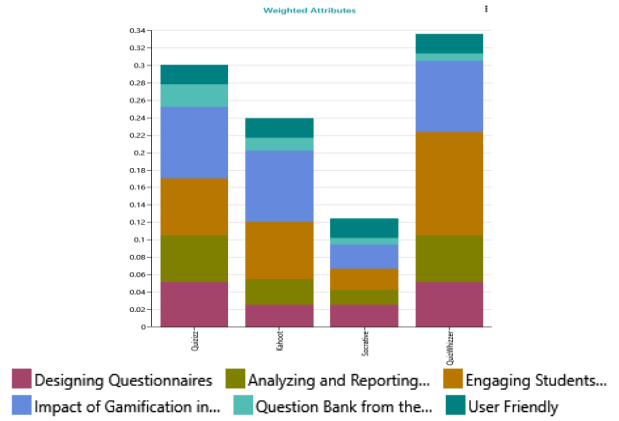


Fig. 8. Weighted sum of each alternative with respect to each criterion

For example, the overall priority (weighted sum) of Quizizz is
$U_{(Quizizz)}$ = (0.15 * 0.333) + (0.15 * 0.351) + (0.27 * 0.239) + (0.27 * 0.3) + (0.06 * 0.455) + (0.09 * 0.25)
= **0.04995** + **0.05265** + **0.06453** + **0.081** + **0.0273** + **0.0225**
= 0.29793 ≈ 0.30

Normally, the priority chart is the main chart that is used by the software most of the time to visualize the best option. It is a basic column chart that shows the calculated overall priority, and QuizWhizzer has the higher weightage, which is shown in Fig. 9 (a), and the software also recommends the best alternative among all the other alternatives in the recommendation module, as shown in Fig. 9 (b). From the priority chart and recommendation module, it is clear that Quizwhizzer is the best gamification platform for assessing student performance.

(a) (b)

Fig. 9. Result from the AHP software (a) Priority chart (b) Recommendation module

B. RQ2. How can the results of this experimental study be interpreted considering the selective needs of the instructors?

The result of MCDM depends on the weightage given to the criteria and alternatives. If the weightage of the criteria differs, the final result will also differ. For example, if the instructor wants to give more importance to adaptation of questions, Quizizz will be the best option for them; if the instructor mainly focuses on the user friendliness of the application, then all four alternatives can be preferred. Comparing these 4 alternatives without considering the gamified environment present with them, the Quizizz will be the best application for assessing the student's performance, as shown in Fig. 10. QuizWhizzer and Quizizz have neck-to-neck competition, but QuizWhizzer moves one step forward because of its engaging elements. When engagement of the students through gamified activities in the application is not considered, Quizizz becomes a better option than QuizWhizzer, which is shown in Fig. 11. When the weightage of criteria in QuizWhizzer is removed or disabled, it is clear that next to QuizWhizzer, the second-best gamification application for assessing the student's performance is Quizizz, as shown in Fig. 12 (it is the radar chart that is used to visualize the weightage of each criterion for an alternative).

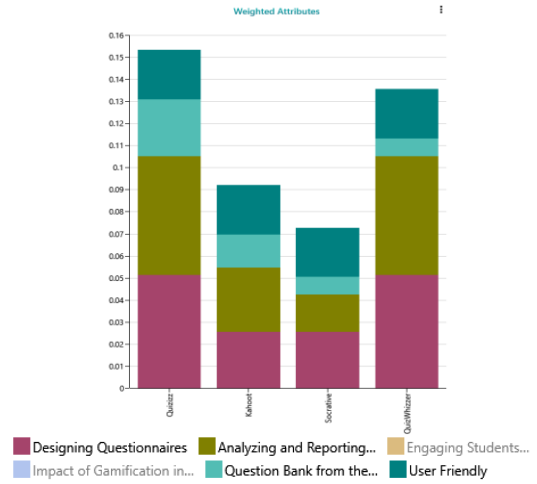


Fig. 10. Weighted sum of each alternative with respect to DQ, ARR, QBA and UF criteria

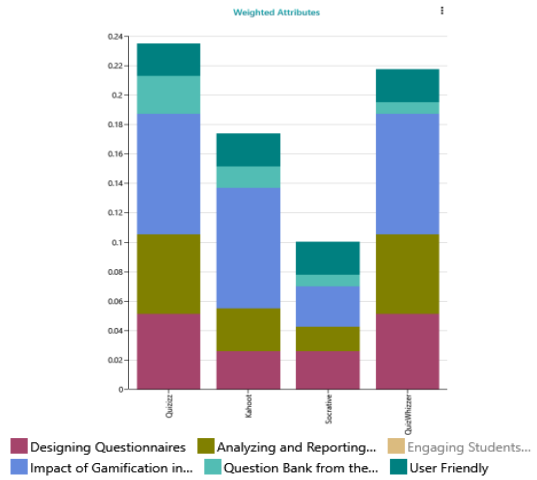


Fig. 11. Weighted sum of each alternative by disabling the ESG criteria

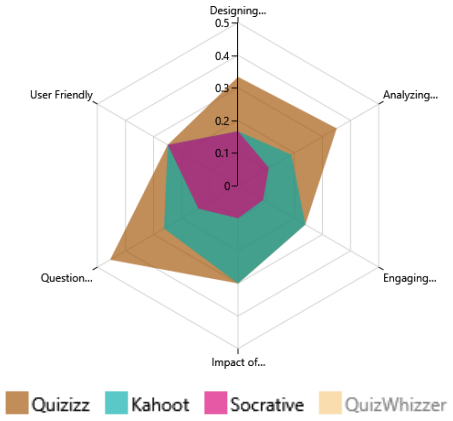


Fig. 12. Disabling QuizWhizzer from the competition

VI. CONCLUSION

This study mainly focuses on finding the best gamification application for assessing students. This study uses the AHP method, one of the MCDM techniques, to find the best gamification application among all others by providing six selected criteria (features) and four selected alternatives

(gamification applications). The selection of criteria and alternatives and the weighting of those criteria and alternatives are used as explained in this study. As the proposed research work is aimed at finding better environments with gamification, the results obtained from the methodology show that Quizwhizzer is the best gamification application for assessing the student compared to Quizizz, Kahoot and Socrative. However, the criteria shall be adapted to the selective needs, and the decisions shall be changed accordingly. The main limitation of this research work is that it compares only four alternatives. Also, this study compares all components of these platforms, including free and paid versions. The future work of this research is to develop customized gamified applications focusing on student engagement and performance improvement with gamification dynamics by adding more features for analyzing both. Also, there is scope for mimicking some of the features of Quizwhizzer to motivate the users to increase student performance, engage the user throughout the content, and attract new users towards the customized gamification application.

APPENDIX

All the mathematical calculation performed here can be accessed at https://rb.gy/mn05n

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REFERENCES

Abel, E., Mikhailov, L., & Keane, J. (2018). Inconsistency reduction in decision making via multi-objective optimisation. European Journal of Operational Research, 267(1), 212-226.

Acosta-Medina, J. K., Torres-Barreto, M. L., & Cárdenas-Parga, A. F. (2021). Students' preference for the use of gamification in virtual learning environments. Australasian Journal of Educational Technology, 37(4), 145-158.

Awedh, M., Mueen, A., Zafar, B., & Manzoor, U. (2015). Using Socrative and Smartphones for the support of collaborative learning.

Çakıroğlu, Ü., Başıbüyük, B., Güler, M., Atabay, M., & Memiş, B. Y. (2017). Gamifying an ICT course: Influences on engagement and academic performance. Computers in human behavior, 69, 98-107.

Carnero, M. C. (2020). Fuzzy multicriteria models for decision making in gamification. Mathematics, 8(5), 682.

Degirmenci, R. (2021). The use of Quizizz in language learning and teaching from the teachers' and students' perspectives: A literature review. Language Education and Technology, 1(1), 1-11.

Faijah, N., Nuryadi, N., & Marhaeni, N. H. (2022). Students' Responses to QuizWhizzer Educational Game to Strengthen Mathematical Concept Understanding Ability. Journal Of Education And Teaching Learning (JETL), 4(2), 94-104.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. Computers in entertainment (CIE), 1(1), 20-20.

Göksün, D. O., & Gürsoy, G. (2019). Comparing success and engagement in gamified learning experiences via Kahoot and Quizizz. Computers & Education, 135, 15-29.

Gupta, P. (2016). Tools, Tips & Resources Teachers Must Know to Learn about Gamification of Education. Tools, Tips & Resources Teachers Must Know to Learn About Gamification of Education.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). Does gamification work?--a literature review of empirical studies on gamification. In 2014 47th Hawaii international conference on system sciences (pp. 3025-3034). Ieee.

Hamid, M. K. A., Ambikapathy, M., & Zanuddin, H. (2022). Gamification and student engagement during COVID-19: An analysis of "Quizwhizzer" application in virtual classes. SEARCH Journal of Media and Communication Research (SEARCH), 113.

Kim, S. (2014). Decision support model for introduction of gamification solution using AHP. The Scientific World Journal, 2014.

Kusuma, G. P., Wigati, E. K., Utomo, Y., & Suryapranata, L. K. P. (2018). Analysis of gamification models in education using MDA framework. Procedia Computer Science, 135, 385-392.

Lim, T. M., & Yunus, M. M. (2021). Teachers' perception towards the use of Quizizz in the teaching and learning of English: A systematic review. Sustainability, 13(11), 6436.

Lim, W. N. (2017). Improving student engagement in higher education through mobile-based interactive teaching model using socrative. In 2017 IEEE Global Engineering Education Conference (EDUCON) (pp. 404-412). IEEE.

Lo, C. K., & Hew, K. F. (2020). A comparison of flipped learning with gamification, traditional learning, and online independent study: the effects on students' mathematics achievement and cognitive engagement. Interactive Learning Environments, 28(4), 464-481.

Loayza, J. (2019). The 10 Best Educational Apps that use Gamification for adults in 2019. Yu-kai Chou.

López, C., & Tucker, C. (2018). Toward personalized adaptive gamification: a machine learning model for predicting performance. IEEE transactions on Games, 12(2), 155-168.

Oliva, H. A. (2016). The gamification as a methodological strategy in the university educational context. Realidad y Reflexión, 44(19), 100-122.

Ozsahin, D. U., Denker, A., Kibarer, A. G., & Kaba, S. (2021). Evaluation of stage IV brain cancer treatment techniques. In Applications of Multi-Criteria Decision-Making Theories in Healthcare and Biomedical Engineering (pp. 59-69). Academic Press.

Oztaysi, B., Dogan, O., & Gul, H. (2019). Selection of gamification elements for demand side energy management: an application using hesitant fuzzy

AHP. R&D Management in the Knowledge Era: Challenges of Emerging Technologies, 299-322.

Ramanathan, R. (2004). Multicriteria analysis of energy. Encyclopedia of Energy, 77-88

Roslan, R., Ayub, A. F. M., Ghazali, N., & Zulkifli, N. N. (2021). The development of a collaborated gamified e-quiz and strategy game mobile application to increase students' motivation and continuance usage intention. ANP Journal of Social Science and Humanities, 2(2), 74-81.

Saaty, T.L. (1994). Fundamental of Decision Making and Priority Theory with the AHP; RWS Publications: Pittsburgh, PA, USA.

Torres-Toukoumidis, A., Romero Rodriguez, L. M., & Perez Rodriguez, A. (2018). Gamification and its possibilities in the blended learning environment: Literature review. RIED-REVISTA IBEROAMERICANA DE EDUCACION A DISTANCIA, 21(1), 95-111.

Wahyuningsih, F., Saksono, L., & Samsul, S. I. (2021, December). Utilization of QuizWhizzer Educational Game Applications as Learning Evaluation Media. In International Joint Conference on Science and Engineering 2021 (IJCSE 2021) (pp. 148-152). Atlantis Press.

Wang, A. I., & Tahir, R. (2020). The effect of using Kahoot! for learning–A literature review. Computers & Education, 149, 103818.

Zhang, Q., & Yu, Z. (2021). A literature review on the influence of Kahoot! On learning outcomes, interaction, and collaboration. Education and Information Technologies, 26(4), 4507-4535.