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Hands-On-Activity And Gamification For Developing Critical Thinking Skills In 21st Century Learners

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Abstract: Generation Alpha, born between 2010 to 2024, popularly known as the young ones who have faced a lot with the pandemic being a defining experience. Encouraging and teaching 21st-century skills to this generation is the need of the hour in such a fast-changing world. Innovative pedagogies can be an important tool that can challenge their intellect, and foster curiosity amongst them to learn more so that they can earn more. Innovative strategies like Hands-on-activity and Gamification and many more have contributed in many ways by stimulating their curiosity in day-to-day teaching-learning activities that challenge educators as well as students to strive for excellence in various disciplines. The researcher aims to see how innovative pedagogies like Hands-on-Activity and Gamification develop and encourage 21st-century skills like critical thinking among school students by enlisting the advantages and disadvantages of the abovementioned. For this the researchers reviewed 25 research papers and searched various databases like ERIC, Google Scholar, IEEE, ResearchGate, ScienceDirect, Springer, Taylor and Francis Online, and many more. Findings state that Hands-on-Activity and Gamification enhance critical thinking skills in students. This research will be beneficial for various stakeholders as it will encourage the inculcation of 21st-century skills in students and help them acquire life skills that would help them earn their livelihoods and contribute to the nation-building process.

Index Terms- Critical Thinking Skills, Gamification, Hands-on-Activity, School education, 21st-Century learners.

Introduction

Generation Alpha, born between 2010 to 2024, popularly known as the young ones who have faced a lot with the pandemic being a defining experience. Encouraging and teaching 21st-century skills to this generation is the need of the hour in such a fast-changing world. Innovative pedagogies can be an important tool that can challenge their intellect, and foster curiosity amongst them to learn more so that they can earn more. Innovative

strategies like Hands-on activity and Gamification and many more have contributed in many ways by stimulating their curiosity in day-to-day teaching-learning activities that challenge educators as well as students to strive for excellence in various disciplines. A significant focus of the National Education Policy (NEP) 2020 is educating students for the challenges of the twenty-first century. It acknowledges the necessity of moving away from conventional memorization and toward a more comprehensive strategy emphasizing abilities, creativity, and critical thinking. Critical thinking is the ability to sequence-wise and reflectively analyze, assess, and understand information. "Critical thinking is the process of applying logical and analytical thinking abilities to decide what to believe or do" (Purwoko et al., 2023). "Focus, justifications, inferences, context, circumstances, clarity, and overview are all components of critical thinking" (Marasabessy et al., 2021). A hands-on activity is an educational experience in which participants actively perform tasks that entail movement as opposed to merely listening or watching. Through active engagement, the objective is to promote problem-solving, enhance comprehension, and build skills. Active participation, practical application, skill development, engagement, and motivation are the key features of hands-on activity. Hands-on activity helps retain the concept of Mathematics (Kehinde et al., 2021). Ogbeba and Ajayi (2016) in their study revealed that students taught through Hands-on activity showed better retention than students taught through the demonstration method. Gamification is using game elements and mechanics in non-game contexts. Al-Azawi et al. (2016) in their paper indicate that gamification fosters a student mindset that promotes experimentation, reduces the fear of failure, and facilitates enjoyable learning experiences. Aliyu, H. & Mani, B.U. (2022) in their study suggest that skills and knowledge relevant to the 21st century can be acquired by understanding the interdisciplinary aspects of learning. Gamification encourages critical thinking by presenting challenges that require problem-solving, decision-making, and strategic planning to achieve goals or rewards. Nazneen, S.S. (2024) in a study indicates that Game elements encourage students to evaluate situations, critically think, and plan accordingly to accomplish their goals.

Significance of the study

21st-century skills are significant in today's world because they address the dynamic demands of modern society, where technology, globalization, and complex social dynamics are reshaping how we work, communicate, and learn. In order to stay updated, individuals must be equipped with digital literacy and the ability to navigate and utilize new technologies like coding, analyzing data, and understanding the implications of emerging technologies like Artificial Intelligence, robotics, and virtual reality. With upcoming changes in technology, work environments, and societal norms, the most important skill required these days is being able to adapt to new situations. People possessing excellent adaptability skills are able to handle uncertainty, make plans afloat when events do not work out as planned, and stay productive in the midst of adversity which is the urgent need of the hour. Critical thinking skills are essential because they enhance better comprehension, improve the problem-solving ability, contribute to independent thinking, prepare to face future challenges, improve communication, foster curiosity and lifelong learning, and facilitate collaborative work. Critical thinking is crucial because it helps children develop the intellectual abilities essential for success in school Hands-on activities have a significant effect on enhancing student interest, expanding knowledge, and developing important life skills. Critical thinking obtained by gamification is more and more essential in today's world since it not only promotes problem-solving and decision-making capacities but also prepares one with the skills required to manage the intricacies of contemporary life, technology, and the workplace. In the era of technology, where speed and precision are key, people need to be capable of making well-thought-out decisions in a short span of time. Critical thinking that has been achieved through gamification enables people to gain a strategic thinking ability, where they can think on their feet, analyze situations from different angles, and make decisions that are aligned with long-term objectives. Gamers learn to accommodate new challenges, re-strategize, and attempt again. Trial-and-error learning, the focus of gamification, enables these traits, allowing people to approach challenges with a solution-oriented mindset, not defeat. Critical thinking, if cultivated through cooperative games, educates people on how to analyze the strengths and weaknesses of teammates, problem-solve as a team, and communicate effectively to reach a common objective. Gamification not only increases critical thinking but also increases exposure to digital tools and platforms so that people become ready to deal with complicated technological realms with certainty. Gamification cultivates this

mentality, leading people to experiment more, learn from mistakes, and keep getting better—major characteristics for success in a rapidly changing world. From the discussion above, we can conclude that critical thinking cultivated through gamification is highly valuable since it gives people the cognitive tools they require to thrive in today's world. These abilities are not only useful but required for survival in a world where technology, globalization, and rapid change are the order of the day. Gamification encourages a way of thinking that is not only thoughtful and strategic but also resilient, innovative, and learning as a continuous process—qualities absolutely necessary for thriving in today's dynamic and demanding world. The researcher aims to see how innovative pedagogies like Hands-on-Activity and Gamification develop and encourage 21st-century skills like critical thinking among school students by enlisting the advantages and disadvantages of the abovementioned.

Review of Related Studies

Holstermann, N., Grue, D., & Bogeholz, S. (2010) in their study states that Hands-on activities can positively influence students' interests differently. **Walan, S. (2019)** in the study concluded that a combination of storytelling, combined with Hands-on-Activity is important in teaching science to students. **Kartini., Nursyamsiah., & Mualimah. (2022)** in their study found that the performance of students taught through Hands-on activity is better than other methods. **Usman, U. K., Dauda, M. O., & Zayum, S. D. (2023)** in the study highlights that the Hands-on Activity teaching technique enhanced students' academic achievement. Hands-on activity is gender-neutral since no significant difference was recorded. **Ibrahim, L., Azhari, B., & Rosalina (2023)** in the study revealed that students' mathematical critical thinking skills taught by Multimedia-assisted Habits of Mind learning strategies are better than those taught by conventional learning strategies. **Maghfiroh, F., & Dasari, D. (2023)** in the study found a change in students' critical thinking skills in mathematics who were taught using the conceptual change approach than conventional learning. Findings reveal that students' critical thinking skills in mathematics acquired with a conceptual change approach were higher than a scientific approach. **Vidyastuti, A.N., Baiduri., Inganah, S., & Hagenimana, E. (2023)** in the study indicates a drastic improvement in students' critical thinking abilities, that is evident from their confidence in probing, providing solutions, and collaborating with peers during the teaching-learning process. It was found that the Anchored Instruction assisted by Edpuzzle proved effective in developing students' communication skills and thereby enhancing their critical thinking skills. **Pradana, C.K., & Noer Hastuti. (2023)** in the study highlights that Blended Learning significantly impacts critical thinking and problem-solving skills. **Pramasdyahsari, A. S., Setyawati, R. D., Aini, S. N., Nusuki, U., Arum, I. P., Astutik, I.D., Widodo, W., Zulian, N., & Salmah, U. (2023)** in the study shows that the digital book STEMPjBL is vital in stimulating students' critical thinking skills and also impacts 21st-century learning skills. **Mellawaty., Sukestiyarno, YL., Zaenuri., & Isnarto. (2023)** in the study reveals the weakness of students in understanding the problem is the huddle faced by students in dealing with mathematical critical thinking problems. **Surayaningsih, P., Widodo, A., Agustito, D., & Perbowo, K. S. (2024)** in the study shows that learning Mathematical equations, linear equations in one variable using Tri-N-based worksheets has no impact on students' ability to think critically and creatively. **Luqyana, N. A., & Fakhriyana. (2024)** in the study found that Team Game Tournament and Means-End Analysis cooperative learning models develop students' critical thinking skills in mathematics. **Arofal, I., Alingsi, B. A., & Sensci, A. (2024)** in the study highlights that Mathematical intelligence significantly influences the critical thinking skills as well as instills anxiety in students about mathematics. **Srinivasa, K.G., Singh, A., & Chauhan, K.K.S (2024)** in their article state positive correlations between Overall Satisfaction, engagement, and Motivation with Knowledge Improvement were noticed with the use of statistical analyses. **Tzelepi, M et al. (2020)** in their study found that students who were awarded individual gamification elements attained higher levels of critical thinking than community gamification elements. **Claudia, V. A. et al. (2023)** in their study reveal that game-based methodology can be effective across different disadvantaged communities. **Bourke, B. (2021)** in their study states that many researches show connections between engagement in a game-based course and a depth of cognitive processing and positive impacts on student engagement. **Dwyer, S. (2018)** in a study found that gamification can facilitate the critical thinking skills that are key elements of transfer from FYC to writing in the disciplines by encouraging the formation of student identity. **Huang, L-Yi & Yeh, Yu-Chu (2017)** in a study indicated that the students significantly increased their critical thinking skills and dispositions through the gamified platform

with the experimental intervention in a blended learning environment. **Kota, J. et al. (2021)** in their study show that an effective Critical Thinking app can be developed using existing question banks but that the effect of gamification needs further research. **Christian, D. & Rudiger, T. (2021)** in their study suggest that the game is very motivating to the experts and the implemented first three problem-solving phases as well as many of the critical thinking skills are addressed by the game. **Abbassyakhrin, A., Setyosari, P., & Sulton. S. (2014)** in their study recommended that Gamification needs to be applied in the classroom focusing on the student's academic abilities. **Koten, G. J. L., & Utama, C. (2023)** in their study proved that introducing game features and challenges as part of the gamification approach also made learning much more enjoyable, and enhanced student engagement in the learning process thereby encouraging students' motivation. **Ahmed, A.A. et al. (2025)** in their study reveal that gamification, particularly reflection tasks and progress-tracking, significantly aids critical thinking by promoting self-assessment and engagement. **Shavab, O.A. et al. (2022)** in their study show that the gamification application prototype was successfully developed by validating the material through experts.

Findings of the study

The findings concerning the use of the Hands-on-activity and gamification to enhance critical thinking skills , which have been drawn from the review, have been culled out, keeping in mind the relative advantages and disadvantages of the Hands-on-activity and Gamification in the enhancement of critical thinking skills that forms a part of 21st-century skills making the teaching-learning experience more engaging and meaningful.

Advantages of Hands-on Activity:

1. Active Participation: Students must actively participate in hands-on activities, which keeps them attentive and involved.

2. Increased Content Retention: Students are more likely to retain the ideas being taught when they engage with the materials in a hands-on way. Neural connections are strengthened and learning becomes more memorable when "doing" is involved.

3. Learning by Doing: Learning by Doing is how some individuals learn best. Kinesthetic learners, who like to engage with the subject through hands-on experiences, are catered to.

4. Development of Critical thinking skills: Problems or puzzles that call for analysis and judgment are frequently a part of hands-on activities. Thus, students are encouraged to consider their decisions and the effects of their actions critically.

5. Better Cooperation and Collaboration: Collaboration is a common component of Hands-on Activities, which promotes communication, sharing of ideas, and teamwork with students. This fosters the growth of social abilities like leadership, cooperation, and dispute resolution.

Disadvantages of Hands-on Activity:

1. Time-consuming preparation and setup: The amount of material that can be addressed in one lesson may be restricted by the time it takes to prepare and set up practical exercises.

2. Highly Resource-Intensive Equipment and Materials: Some materials, equipment, or technology are often required for practical activities, and these may be expensive or difficult to obtain.

3. Resources-intensive Materials and Equipment: Frequently needed for hands-on activities, certain materials, equipment, or technology may be costly or hard to obtain.

4. Physical and Safety Issues: There are potential safety hazards involved with certain hands-on activities, like experiments or science workshops involving tools and machinery. Students can be at risk for accidents or injuries if proper supervision and safety measures are not implemented.

Advantages of Critical Thinking Developed Through Gamification:

1. Engagement and Motivation: Gamification provides more fun and engaging learning, thus enhancing motivation. The participatory nature of games, reward systems, challenges, and the tracking of progress ensure that the person remains actively engaged in learning.
2. Development of Problem-Solving Skills: Games tend to involve intricate problems that need students to apply analytical and strategic thinking to calculate them. Users make decisions, manage resources, and analyze systems—abilities essential in daily life and the workplace.
3. Encouraging Creativity and Innovation: Most games promote unconventional thinking, presenting various methods to solve problems. This encourages creative problem-solving and innovation, which can be applied across industries.
4. Learning from Errors: Games tend to employ a trial-and-error strategy, where error is a significant part of the learning process. Players learn to examine errors, modify strategies, and attempt again, which fosters resilience and adaptability.
5. Better collaboration and communication: Multiple users games and cooperative ones promote collaboration where players have to communicate and coordinate with each other to attain unified objectives.

Disadvantages of Critical Thinking Developed Through Gamification:

1. Risk of Overemphasis on Rewards: Though rewards such as points, badges, and levels can be incentive, they tend to foster extrinsic motivation as opposed to inherent interest in creating critical thinking competencies.
2. Lack of Real-Life Context: Certain gamified spaces will not necessarily mimic the complexity or uncertainty of actual circumstances. The controlled environment of most games tends to oversimplify issues or omit real-world limitations such as time constraints, moral conflicts, and extraneous influences.
3. Over-Reliance on Digital Tools: Gamification usually depends on digital tools, which are not universally available, especially to those without access to necessary technology or the internet.
4. Time-Consuming: Critical thinking games are time-consuming, particularly when they are made to be engaging and immersive.
5. Potential for Frustration: Gamification that involves extremely challenging tasks or repetitive tasks may cause frustration, disengagement, or burnout. Not all players are equally adept at solving difficult problems, and difficulty spikes can make progress slow.
6. Restricted Emphasis on Soft Skills: Though gamification may encourage critical thinking in problem-solving and strategic planning, it is not always focused on other soft skills such as emotional intelligence, ethical decision-making, or communication in depth.

Educational implications

Hands-on activities can be used to develop critical thinking skills has far-reaching educational implications that touch multiple contributors within the education system, including students, teachers, parents, school principals, and policymakers.

1. For Students:

- Improved Problem-Solving Ability: Hands-on activities frequently challenge students to navigate problems, debug, and modify their approach, leading to improved problem-solving and analytical skills.
- Concept Learning and Content Retention: Hands-on activities enable students to progress beyond rote memorization, interacting with content on a more meaningful level. By practicing theories in real-life

situations, students are able to retain information more effectively and comprehend the material on a holistic basis, which is essential to critical thinking.

2. For Teachers

- Teaching Flexibility: Hands-on activities prompt teachers to move away from the traditional lecturing and take on a more facilitative role. Teachers must be flexible, receptive to new approaches, and at ease with facilitating inquiry-based learning.
- Accommodation of Multiple Learning Styles: Hands-on activities accommodate a multitude of learning styles and instructors can capitalize on this by developing more encompassing classrooms where every student has the chance to participate in meaningful learning experiences.

3. For Parents:

- Encouraging Independence: Hands-on activities tend to necessitate students to struggle through difficulties and make decisions on their own. As students build these skills, parents might find that their children become more independent and confident in solving academic issues, which can also be applied to life skills.
- Increased Student Motivation: Students are usually more motivated and enthusiastic about school when they are involved in hands-on learning. Parents will probably see an improvement in their child's enthusiasm for learning, especially in areas that are normally perceived as difficult, such as math or science.

4. For School Administrators

- Curriculum Innovation: School administrators who favor experiential learning are promoting a shift towards more experiential and student-centered curricula. This innovation has the potential to lead to a more active curriculum that focuses on critical thinking, problem-solving, and creative skills, which are vital for 21st-century success.
- Teacher Professional Development: Administrators may design professional development programs for teachers with an emphasis on incorporating hands-on learning in the classroom.
- Resource Allocation: To effectively conduct hands-on activities, schools can be required to invest in physical resources (such as lab equipment, project materials, technology tools) and teachers' planning time and collaboration.

5. For Policymakers:

- Curriculum Standards and Assessments: Policymakers can be required to update curriculum standards so they stress critical thinking and problem-solving.
- Support for Educational Equity: To be effective, hands-on learning requires policies that support equitable access to resources.
- Research and Evaluation: Policymakers can facilitate the research into the effectiveness of experiential activities for developing critical thinking abilities. Policies based on evidence that encourage experiential learning will enable ongoing improvement in teaching practices and ensure that the methods mirror desired outcomes.

Gamification can be applied to build critical thinking and has extensive educational repercussions that impact various contributors in the education system, such as students, teachers, parents, school principals, and policymakers.

1. For Students:

- Increased Engagement and Motivation: Gamification enhances the learning experience, making it more engaging and fun, thus boosting students' engagement. Through solving puzzles, overcoming obstacles, and earning rewards, students become more interested in the subject matter.
- Development of Problem-Solving Skills: By Gamification, students are usually provided with intricate situations that allow them to dissect, weigh, and critically judge the solutions. Such skills are essential for driving real-world issues and academic assignments.
- Greater Collaboration and Communication: Much learning through gaming entails collaboration with others, building teamwork and communication abilities. Collaborative work on multifaceted tasks or challenges promotes thinking critically as learners learn to evaluate alternate points of view, negotiate, and integrate information.

2. For Teachers

- Enabling Active Learning: Gamification can change the educator's role from that of a typical "lecturer" to one of a "guide" or "facilitator" enabling students to sail through challenges. This enables active learning, whereby students own the learning process and hence it becomes simple to come up with solutions.
- Personalized Learning Experience: Most gamified systems enable personalization, making it possible for educators to adapt content to students' various needs. Students learn at their own pace facilitating differentiated instruction thus aiding educators in catering to students' various needs.

3. For Parents:

- Fosters Critical Thinking Ability: Parents can see their children learn critical thinking, problem-solving, and strategic thinking skills from gamified learning exercises.
- Fostering Healthy Learning Habits: Gamification can render learning fun and less stressful, providing an idealized outlook on education. This can translate into greater academic achievement as well as the development of a lifelong passion for learning.

4. For Policymakers

- Fosters 21st-Century Skills: Gamification can serve as a valuable method of promoting important 21st-century skills. Policymakers endorsing gamification can ensure that students are well-equipped to deal with the challenges of an increasingly complex and digital world.
- Scalable and Accessible Learning: Gamified systems can be designed to support massive numbers of students, and some platforms are free or low-cost. This can assist policymakers in encouraging fair access to high-quality education, especially in underserved or remote communities.

Conclusion

This research aims to find how innovative pedagogies like hands-on activity and gamification develop and encourage 21st-century skills like critical thinking among school students. From the above, it can be inferred innovative pedagogies like Hands-on activity and Gamification had a significant impact on critical thinking. Hands-on activity involves puzzles, problems, and analysis and judgement is a part of it which helps in the development of critical thinking. Gamification involves games where problem-solving ability, motivation, creativity, innovations, and engagement are required and which further help in increasing critical thinking skills. Similarly, Hands-on activity and gamification have some disadvantages like time-consuming, resources, equipment, and material. Hence it can be inferred that when implemented thoughtfully, hands-on activity and gamification can significantly enrich the educational experience and promote the critical thinking skills necessary for success in the 21st century.

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