
Gamification of Primary Education

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ABSTRACT

Young minds learn and explore through play. In an increasingly digitised world, 'play' has shifted its base to digital and virtual worlds, even for the youngest minds with basic cognitive skills. The relevance of sustainable education practices for early learners becomes paramount, especially in the wake of recent pandemic of COVID -19 which catapulted the education system into the digital domain.

The paper elucidates the core problem of adapting traditional education systems to the digital era. Evolving definitions of sustainable education, learning, retention, educator and learner are fructified and shifting dynamics between them, through primary data from providers of gadgets or technology and secondary research on changes in child psychology due to prolonged exposure to digital and virtual worlds. The research takes into account the disparities prevalent in different regions of India and shares insights into the challenges and opportunities unique to this demographic with a specific focus on the rural-urban divide. The research delves into the significance and effectiveness of gamification in e-learning to bridge these gaps and enhance learning outcomes, offering a fresh perspective on sustainable education practices. However, cautions against the plausible negative impacts on child psychology from excessive screen time and gamification-induced addiction are discussed.

Sustainable education can harness the power of gamification to engage and inspire young learners and there is a great scope for growth in this dynamic field while remaining vigilant of the negative repercussions. Ultimately, the paper provides a valuable framework for educators and policymakers navigating the ever-evolving landscape of digital education.

Keywords - Alternate Pedagogy, Child Psychology, Gamification, Technology, Early Learner.

1. Introduction

In an era marked by rapid technological advancements and unprecedented global challenges, education undergoes profound transformation. The COVID-19 pandemic, a global crisis, catalysed a shift in education perception and delivery. Traditional learning paradigms were disrupted overnight, making digital education the new norm (for and The United Nations Educational, Scientific and Cultural Organization (UNESCO), 2022).

The COVID-19 pandemic's impact on education is undeniable. School closures and lockdowns forced institutions to pivot to digital platforms and e-learning, changing education for young and adult learners. Early learners, in particular, are increasingly engaged in digital play and learning (Pattnaik and Jalongo, 2022).

The importance of sustainable education practices is evident in this digital age (Gray et al., 2011). These practices encompass more than environmental concerns; they address cultural, social, and systemic

dimensions (Sterling, 2001). Harnessing digital tools to educate the future generation necessitates exploring how these tools align with sustainable education principles.

Pedagogy is evolving into multifaceted dimensions, adapting traditional education for the digital era. New definitions of sustainable education, learning, retention, educator, and learner emerge within this digital transformation (Veresov and Veraksa, 2022). Analyzing the changing dynamics between educators and learners in the digital realm and examining potential impacts on child psychology due to prolonged digital exposure shifts understanding and education practices.

2. Review of Literature

Secondary research has been collated to form a comprehensive understanding of education goals, child psychology, and the impact of digital environments, along with studies on gamified learning. Pre- and post-COVID statistical data from various sources underscores the effects on educational disparities across diverse socio-economic demographics of children.

2.1. Sustainable Education

Table 1. Literature review - Sustainable Education.

Name	Authors	Research Methodology	Findings
Efficacy of Social Networking Sites for Sustainable Education in the Era of COVID-19: A Systematic Review	Cavus, N.et al. (2021)	Systematic Review	This review highlights SNS as a valuable platform for remote learning, fostering communication and resource sharing among students and educators. It emphasises digital tools' significance for sustainable education, particularly during the pandemic.
Homework: APA educational psychology handbook, Vol. 3. Application to learning and teaching	Cooper, H.et al. (2012)	Literature Review	The literature review explores homework's multifaceted role in education, offering a comprehensive overview of its effects on holistic learning.

Teacher development with mobiles: Comparative critical factors	Royle, K et al. (2014)	Critical Analysis	The paper explores factors impacting teacher development via mobile technology, emphasising the need to address unique challenges and opportunities in evolving pedagogical landscapes.
Sustainable Education: Re-visiting learning and change	Sterling, S. (2001)	Theoretical Framework	Sterling's work lays the theoretical foundation for sustainable education, focusing on ecological, social, and pedagogical sustainability. It stresses adaptability, inclusivity, and lifelong learning in a rapidly evolving digital landscape.
Trends in Educational Research about e-Learning: A Systematic Literature Review (2009–2018)	Valverde-Berrocso, J.et al. (2020)	Systematic Literature Review	This systematic literature review summarises the trends in e-learning research from 2009 to 2018. It highlights significant areas of research growth and change, providing valuable insights into the evolution of e-learning practices.
The relationship between homework time and achievement is not universal: evidence from multilevel analyses in 40 countries	Dettmers, S.et al. (2009)	Multilevel Analyses	This study highlights the complex, country-dependent relationship between homework time and achievement, influenced by socio-economic background and school track. Excessive homework can negatively impact other aspects of learning.

The collective insights from the literature on sustainable education underscore its dynamic nature and the diverse factors influencing its effectiveness, emphasising the pivotal role of digital tools, particularly Social Networking Sites (SNS) and e-learning platforms, in fostering sustainable education. We reviewed the evolving pedagogical landscape and the unique challenges and opportunities posed by mobile technology for teacher development. Sterling's theoretical framework lays the groundwork, emphasising the importance of adaptability, inclusivity, and lifelong learning in sustainable education, emphasising the need for adaptive approaches, leveraging digital tools, and considering socio-cultural contexts for effective educational practices.

2.2. Gamification

Table 2. Literature review - Gamification

Name	Authors	Research Methodology	Findings
The school as a playground: HCI in the full-scale living lab	Cajander, Å. et al. (2018)	Living Lab Study	The study explores schools as HCI research living labs, showcasing the potential of innovative educational environments, including apps and games.
Cybertext redux: using digital game-based learning to teach L2 vocabulary, reading, and culture	Neville, D.O et al. (2020)	Experimental research with digital game-based learning interventions	The study shows that digital game-based learning effectively improves L2 vocabulary, reading, and cultural understanding, enhancing language learning.
Digital games and digital play in early childhood: a cultural-historical approach	Veresov, N., Veraksa, N. (2022)	Qualitative research, cultural-historical analysis	This paper offers a cultural-historical view of digital games in early childhood, emphasising play's importance in learning. It advocates for diverse, inclusive game environments for young learners.
Is Gamification a Magic Tool?: Illusion, Remedy, and Future Opportunities in Enhancing Learning Outcomes during and beyond the COVID-19	Oe, H., Takemoto, T., and Ridwan, M. (2020)	Qualitative research, cultural analysis	This journal article explores gamification's potential to enhance learning outcomes during and beyond the COVID-19 pandemic, providing insights into its opportunities and challenges in education during crises.
Don't make the player, make the game: exploring the potential of gamification in IS education	Kenny, G.et al. (2017)	Qualitative research, literature review, case studies	The paper explores gamification's potential in IS education, highlighting its importance in engaging and motivating learners. It emphasises making learning enjoyable by game-like approaches.

The literature on gamification collectively illuminates its multifaceted impact on education. Gamification proves to be a powerful tool in engaging and motivating learners, as highlighted by Kenny et al. Through qualitative research, literature reviews, and case studies, the literature emphasises the importance of designing educational experiences that are inherently enjoyable and game-like. Oe et al.'s exploration of gamification during the COVID-19 pandemic provides valuable insights into its potential as a remedy for enhancing learning outcomes in crisis situations. Additionally, the studies by Cajander et al. and Neville et al. showcase the effectiveness of digital game-based learning interventions, not only in improving language skills but also in creating innovative educational environments within living labs. Veresov and Veraksa bring a cultural-historical perspective, advocating for diverse and inclusive game environments, particularly in early childhood education. The collective findings underscore gamification's potential as a transformative force in education, enhancing engagement, motivation, and the overall learning experience.

2.3. Other Technologies

Table 3. Literature review - Other Technologies.

Name	Authors	Research Methodology	Findings
Teacher development with mobiles: Comparative critical factors	Royle, K et al. (2014)	Systematic literature review	This systematic review delves into augmented reality in education, offering a comprehensive overview of existing literature. It highlights its potential benefits in enhancing learning but also addresses challenges and areas needing further research.
Advantages and challenges associated with augmented reality for education: A systematic review of the literature	Akçayır, M., & Akçayır, G. (2017)	Experimental research with digital game-based learning interventions	This systematic review comprehensively explores the pros and cons of using augmented reality in education. It highlights potential benefits in enhancing learning but also addresses challenges and areas for further research.
Cyber-physical systems: AI and COVID-19	Ramesh Poonia (2022)	Qualitative research, literature review, case studies	This book offers insights into the interplay between cyber-physical systems, artificial intelligence, and the COVID-19 pandemic, relevant to technology's role in education during the pandemic.

The literature on other technologies, including augmented reality and cyber-physical systems, provides valuable insights into their potential in education. The systematic reviews by Royle et al. and Akçayır and Akçayır highlight the advantages and challenges associated with augmented reality, emphasising its potential to enhance learning experiences. They also acknowledge the need for further research to address existing challenges. Additionally, Ramesh Poonia's work on cyber-physical systems and AI during the COVID-19 pandemic offers a broader perspective on the interplay between technology and education, particularly in the context of the global health crisis. The qualitative research and case studies contribute to understanding the dynamic role of technology in shaping educational practices. Collectively, these sources underscore the evolving landscape of educational technology, emphasising both opportunities and challenges that warrant exploration and consideration in the broader discourse on technology in education.

2.4. COVID and its Effects

Table 4. Literature review - COVID and its effects.

Name	Authors	Research Methodology	Findings
The impact of COVID-19 on early childhood education and care: International perspectives, challenges, and responses	Pattnaik, J., and Jalongo, M.R. (2022)	Qualitative primary research	This publication offers an in-depth analysis of the COVID-19 pandemic's impact on education, providing a broad overview of its challenges and transformations, particularly in relation to technology's role during and beyond the pandemic.
From Learning Recovery to Education Transformation	OECD, UNESCO, UNICEF, and Bank, W. (2022)	Qualitative primary research	This publication highlights the shift from learning recovery to education transformation, involving multiple organisations. It offers a comprehensive overview of the post-COVID-19 educational landscape.
Children's Eating Habits, Physical Activity, Sleep, and Media Usage before and during COVID-19 Pandemic in Poland	Łuszczki, E. Et al. (2021)	Survey and analysis	This study examines children's eating habits, physical activity, sleep, and media usage in Poland before and during the COVID-19 pandemic. It offers data and insights into how the pandemic has impacted children's lives, including technology use.

The Impact of the COVID-19 Pandemic on Education	for, A. and UNESCO (2022)	Qualitative research, literature review, case studies	This book offers insights into the interplay between cyber-physical systems, artificial intelligence, and the COVID-19 pandemic, relevant for understanding technology's role in pandemic education.
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The literature on COVID-19 and its effects on education provides a multifaceted understanding of the challenges and transformations within the educational landscape. Pattnaik and Jalongo's qualitative research delves into the international perspectives, challenges, and responses to the pandemic's impact on early childhood education and care, emphasising the role of technology in this context. The Organisation for Economic Co-operation and Development (OECD), UNESCO, United Nations Children's Fund (UNICEF), and World Bank collaboration offers a comprehensive qualitative exploration, shifting from learning recovery to broader education transformation post-COVID-19. This highlights the need for systemic changes in education. Łuszczki et al.'s survey and analysis on children's habits in Poland shed light on the pandemic's broader impact on children's lives, including changes in media usage. Additionally, the collective insights from various sources, such as UNESCO's book, provide a comprehensive overview of the broader effects of the pandemic on education, offering valuable perspectives for understanding the role of technology in shaping educational responses during and beyond the crisis.

2.5. Psychology

Table 5. Literature review -Psychology.

Name	Authors	Research Methodology	Findings
Processes and pathways in development via digital media: Examples from word learning	Kucker, (2021)	Experimental	This study explores digital media's role in early word learning for infants and suggests its significant role in facilitating early childhood word learning.
The Role of Play in Human Development	A.D. Pellegrini, (2009)	Literature Review and Observational	Pellegrini emphasises play's vital role in human development, contributing to various aspects of child development and psychology.

Television and video game exposure and the development of attention problems	E.L. Swing et al. (2010)	Observational & Longitudinal	This study explores the link between television, video games, and the development of attention problems in children, showing a connection.
Associations between screen time and lower psychological well-being among children and adolescents: Evidence from a population - based study	J.M. Twenge & W.K. Campbell, (2018)	Population Based Study	This research examines associations between screen time and lower psychological well-being in youth, providing evidence of a relationship between the two.

The literature on psychology reveals valuable insights into the impact of digital media on early childhood development, emphasising the significant role of digital media, particularly in word learning for infants. Pellegrini's work underscores the importance of play in human development, contributing to diverse aspects of child development and psychology. Swing et al.'s observational and longitudinal study explores the association between television, video game exposure, and the development of attention problems in children, shedding light on potential connections. Twenge and Campbell's population-based study further contributes by revealing associations between screen time and lower psychological well-being in children and adolescents. These collective findings emphasise the need for a nuanced understanding of the psychological effects of various media exposures on young individuals, providing valuable insights for crafting a comprehensive discussion on the psychological aspects of technology use in education.

3. Methodology

In this study, a mixed-method research approach was employed to gain comprehensive insights into the research topic. The research methodology encompassed both primary and secondary data collection methods to provide a well-rounded perspective.

This section outlines the primary and secondary data collection strategies utilised in the study. First, a qualitative observational study was conducted in public spaces and educational centres, focusing on toddlers' activities and their responses to technology. This observational study sought to provide firsthand insights into the behaviours and interactions of toddlers in various settings and their engagement with technology. This in-depth interview aimed to gather expert insights and firsthand information from a key figure in the field of educational technology and STEM learning. Mr. Gandhi's

perspective was sought to understand the vision and practices of Stemious, as well as its implications for addressing the research objectives. In addition to primary data collection, the study included a comprehensive secondary research component.

A literature review was conducted, encompassing various types of literature relevant to the study's focus. These sources were critically reviewed to provide a theoretical foundation for the study. Sources like online repositories, educational platforms, and relevant websites were also explored.

This mixed-method approach allowed for a holistic examination of the research topic, offering a multi-faceted perspective on the effects of educational technology in the context of COVID-19 and broader educational practices.

4. Findings and Discussions

The research collates all aspects of the primary and secondary data analysis to form a comprehensive path of pedagogy in the digital era for the new generations of early learners. This begins with the reassessment of basic blocks of learning within the parameters of the current scenario and re-establish relationships between them.

4.1. Re-definitions of core principles discussed in paper

For the purpose of this research paper, the following terms will be used as per renewed understanding of the concepts, as explained below:

- A. **Learner:** An active, curious individual engaged in acquiring knowledge, skills, and competencies, often through digital means, shaping their educational journey (Royle, Stager, Traxler, 2014).
- B. **Educator:** Includes traditional teachers, facilitators, and mentors guiding and inspiring learners in digital settings, promoting critical thinking, problem-solving, and a passion for continuous learning (Royle, Stager, Traxler, 2014).
- C. **Sustainable Education:** Beyond ecological sustainability, it encompasses "cultural, social, and pedagogical sustainability," endorsing adaptability, inclusivity, and lifelong learning in the evolving digital landscape (Sterling, 2001).
- D. **Learning:** Encompasses diverse knowledge acquisition modes, from classrooms to self-directed digital exploration. Learners actively engage, fostering creativity and essential skills (Pellegrini, 2009).
- E. **Assessment:** Adopts a multi-faceted approach, including formative and summative assessments, peer evaluations, and self-assessments. It provides constructive feedback, guides individual progress, and measures comprehensive understanding (Sterling, 2001).
- F. **Gamification:** Encompasses a spectrum of engagement strategies, like game-based mechanics, simulations, interactive challenges, and incentives. Designed to enhance the learning experience, stimulate curiosity, and foster a sense of accomplishment in digital education (OECD et al., 2022).

4.2. Trends in Education Systems in the Digital Era

In the digital age, where technology dominates, there is a need for a balanced pedagogical approach that incorporates digital tools while remaining rooted in sustainable education practices.

4.2.1. Trends in Educational Research about e-Learning

The field of educational research has been significantly influenced by the rapid proliferation of e-learning. The nature of education is evolving, emphasising the shift towards online and digital platforms. There is an increasing prevalence of Massive Open Online Courses (MOOCs), which have democratised education by providing accessible, online courses to learners worldwide.

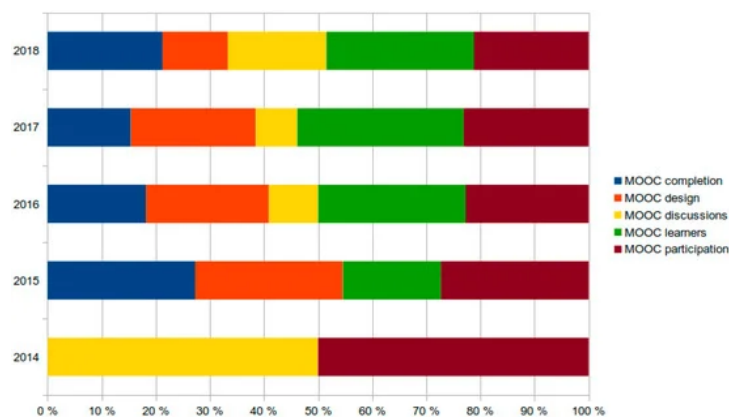


Fig. 1. Evolution of the nodes of massive online open courses in the period of 2009–2018, Valverde-Berrocoso et al. (2020)

Additionally, the integration of Artificial Intelligence (AI) and Machine Learning (ML) into e-learning platforms has opened new horizons for personalised and adaptive learning experiences (Poonia, 2022). These trends underscore the need for educators and policymakers to harness digital tools effectively.

In the digital era, traditional definitions of education, learning, retention, educator, and learner have evolved significantly. Sterling's work on sustainable education (2001) has contributed to reshaping our perception of education, emphasising the importance of holistic and environmentally conscious approaches to learning (Sterling, 2001). Furthermore, the digital landscape has blurred the lines between educators and learners, with students often adopting roles as both consumers and creators of knowledge. The research conducted by Royle, Stager, and Traxler (2014) emphasised factors related to teacher development in mobile learning environments. Their findings highlighted the evolving pedagogical landscape and the need for educators to adapt to digital platforms (Royle, Stager, Traxler, 2014). Additionally, Spires, Oliver, and Corn (2011) delved into the new learning ecology of one-to-one computing environments, underscoring the transformative impact of technology on the relationship between educators and learners (Spires, Oliver, Corn, 2011).

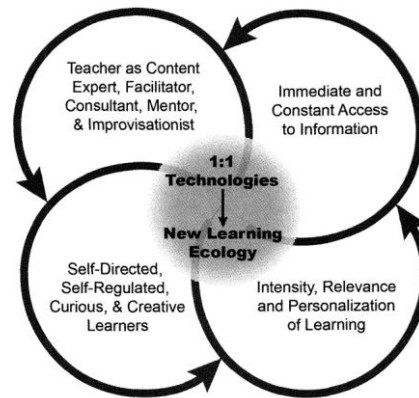


Fig. 2. The four conditions of the new learning ecology in one-to-one settings. (Spires, Oliver, Corn, 2011).

4.2.2. Impact of Tech-exposure on Child Psychology

The COVID-19 pandemic significantly increased children's screen time, raising concerns about its impact on child psychology, particularly attention spans. Extended screen time during the pandemic affects their ability to concentrate on learning, potentially impacting cognitive development. Parents worry about academic (73%), social (82%), and daily living (33%) skills if distance learning continues (Pattnaik and Jalongo, 2022).

Digital games' impact on cognitive skills varies based on content and exposure duration. There's a need for tools to quantifiably measure digital play effects on children. Widespread digital communication tools adoption necessitates adjustments in children's social interactions, impacting their social and emotional development (Núñez-Canal, de Obesso, Pérez-Rivero, 2022).

A case study on children's media usage before and during COVID-19 revealed significant variations in time spent on Internet/TV. Screen time and gaming activity notably increased.

Variable		\bar{x}	SD	NAA(%)	<30 min (%)	30 min–2 h (%)	≈2–3 h(%)	≈3–6 h(%)	>6 h (%)	p	
Time of watching movies or programs on the Internet (on an iPad, tablet, computer, smartphone) or TV per day [h]	pre Weekdays	2.12	1.00	11.7	0.0	61.1	20.5	5.3	1.3	0.0319	
	peri Weekdays	2.34	1.12	4.4	14.0	44.0	23.4	9.0	5.1		
	pre Weekend	2.81	1.04	4.3	0.0	34.4	37.6	18.9	4.8	0.0276	
	peri Weekend	2.70	1.10	2.3	8.0	35.9	31.5	16.2	6.1		
Time of playing games (on your computer/game console/smartphone/iPad etc.) per day [h]	pre Weekdays	1.29	1.08	27.7	30.1	31.5	7.2	2.7	0.8	<0.0001	
	peri Weekdays	1.64	1.23	20.3	27.8	29.5	14.7	5.9	1.9		
	pre Weekend	1.94	1.23	13.3	21.3	37.6	16.0	9.1	2.7	0.0599	
	peri Weekend	2.11	1.29	11.4	20.4	34.2	18.6	11.1	4.4		
Variable		\bar{x}	SD	I Don't Have Access (%)	<5Times a Day (%)	6–10 Times aDay (%)	11–20 Timesa Day (%)	21–50 Timesa Day (%)	51–100 Timesa Day (%)	>100 TimesPer Day (%)	p
Using a smartphone on a regular day	pre	3.14	1.65	18.4	22.1	22.1	14.7	13.1	6.1	3.5	0.0016
	peri	2.81	1.58	23.6	26.8	20.0	13.3	9.5	4.4	2.5	

NAA—not at all, \bar{x} —arithmetic mean, SD—standard deviation, p — p value, indicate significant values ($p < 0.05$). Bold values denote statistical significance at the $p < 0.05$ level.

Fig. 3. The media usage characteristics in the groups pre- and peri COVID-19. (Łuszczki et al., 2021)

In response to these changes, an opportunity arises to harness evolving child psychology positively. Tailoring learning experiences to accommodate shifting attention spans and cognitive abilities can be a powerful tool for personalised learning (Kucker, 2021).

Promoting digital literacy and critical thinking skills becomes essential as children engage more with digital media. Collaboration between educators and parents can integrate these skills into the curriculum, empowering children to navigate the digital world safely (Núñez-Canal, de Obesso, Pérez-Rivero, 2022).

Balanced screen time is critical to mitigate potential negative effects. Guidelines from educators and parents should ensure that digital exposure complements traditional learning and plays for a healthy balance (Pattnaik and Jalongo, 2022). Additionally, leveraging digital games and play-based learning enhances engagement and cognitive development, making education enjoyable and effective.

4.3. Gamification in E-Learning

This section discusses the potential for gamification in e-learning to enhance learning outcomes and offers a fresh perspective on the interplay between technology and sustainable education practices.

4.3.1. Understanding Gamification's Potential

Education faces challenges like low retention, motivation, and engagement. Gamification enhances learning outcomes, with 53% of variation in gamification self-efficacy promoting student-led gamification initiatives (Kenny, Lyons, Lynn, 2017).

Interview with Gaurang Gandhi, CEO of Stemious, reveals using research-backed pedagogical principles, like active/experiential learning and digital technology, enhances engagement and understanding. The relationship between play, homework, and learning is complex and context-dependent. Play fosters exploration, skill development (Pellegrini, 2009), while homework reinforces classroom learning and independent study skills (Cooper et al., 2006). Balancing these aspects, especially in primary school, is crucial. Poorly designed homework can cause stress and disengagement, undermining play-based learning benefits (Dettmers, Trautwein, Lüdtke, 2009).

Gamification encourages curiosity and a growth mindset, fostering students' resilience in the face of challenges and failures (Mr. Gandhi). As technology shapes education, digital resources and games bridge the gap between play and homework, offering interactive, engaging learning experiences (Shelton et al., 2016).

Educators and parents should adopt a balanced approach, leveraging play and homework's educational potential while considering learners' individual needs and developmental stages.

4.3.2. Industry leaders

Education faces challenges like low retention, motivation, and engagement. Gamification enhances learning outcomes, with 53% of variation in gamification self-efficacy promoting student-led gamification initiatives (Kenny, Lyons, Lynn, 2017).

Vernier, a standout leader in gamification and e-learning, provides science tools and educational solutions. Their Graphical Analysis app transforms science experiments into immersive experiences. Students use Vernier sensors for real-time data collection and analysis, turning science learning into an exciting adventure.

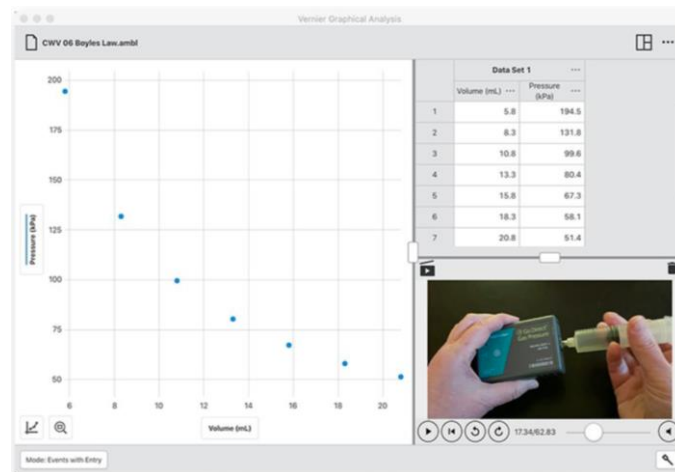


Fig 4. Vernier Graphical Analysis® tool, being used with their gas pressure sensor

Stemious partnered with Vernier, incorporating gamification elements like game-based challenges, interactive simulations, rewards, and leaderboards. Collaborations with brands like Snap Circuits Jr. 100 and Vernier Graphical Analysis® combine physical and digital learning spaces for an immersive learning experience. Users tackle real-world STEM problems, engage in virtual experiments, and collaborate with peers on STEM projects within Stemious.

Minecraft Education Edition, building on its immersive sandbox gameplay, ventures into education. It offers a digital learning ecosystem where students explore and build in educational worlds. By integrating gamification elements, it combines entertainment and education, making learning dynamic and interactive.



Fig 5. Coding with Minecraft: Education Edition

4.4 Funding and Support for Digital Learning

Securing digital education funding is vital, with options like public-private partnerships, grants, and crowdfunding. Public-private partnerships, exemplified in the World Bank's "Public-Private Partnerships for Education" report (World Bank, 2021), involve government and private sector collaboration. Grant programs, like those from the Bill & Melinda Gates Foundation (Bill & Melinda Gates Foundation, n.d.), support educational technology. Crowdfunding on platforms like Kickstarter and DonorsChoose engages a broader community (Kickstarter, n.d.; DonorsChoose, n.d.).

- a) **Identifying Potential Stakeholders and Interested Parties:** Identifying and engaging key stakeholders is crucial. These include government agencies, educational institutions, technology companies, and nonprofits. Government agencies shape policy and funding. Educational institutions partner with tech companies, while nonprofits like UNESCO and Education International promote global education quality (OECD et al., 2022). Collaborative efforts among these stakeholders are essential.
- b) **Role of Public and Private Sectors in Supporting Sustainable Digital Education:** Both public and private sectors have pivotal roles in sustaining digital education. The public sector creates an enabling environment with policies and investments, exemplified in India's Digital India campaign (Government of India, 2015). The private sector contributes through innovative educational technologies and partnerships, such as Google for Education and Microsoft Education (Google for Education, n.d.; Microsoft Education, n.d.). Balancing these contributions ensures equitable access and quality in digital education.

These considerations on funding, stakeholders, and the roles of the public and private sectors shed light on the multifaceted nature of sustainable digital education initiatives and highlight the need for collaboration and strategic planning.

4.5 Cautionary Notes on Negative Impacts

While digital education and gamification offer benefits, it's crucial to consider potential negative impacts on child psychology. Excessive screen time may lead to sedentary behaviour and health issues like

childhood obesity (Biddle et al., 2019). Educators and policymakers should integrate breaks, physical activity, and healthy lifestyle education into digital learning programs.

Excessive screen time and gamification can trigger addiction-like behaviours, affecting children's mental health. Research shows it can lead to sleep disturbances, reduced social interaction, and increased anxiety (Twenge & Campbell, 2018). Implementing screen time guidelines and raising awareness among parents and educators is essential.

Psychological research offers insights into technology's impact on children's development. Prolonged screen exposure may reduce a child's focus (Swing et al., 2010). Research on play therapy in digitised contexts can illuminate technology's effects on children's play and cognitive development (Veresov & Veraksa, 2022). Integrating these findings into digital education strategies balances the benefits and potential drawbacks of technology-based learning.

By addressing these concerns and drawing on psychological research, educators and policymakers can prioritise children's well-being and cognitive development in digital education programs while leveraging gamification and technology's advantages.

4.6 Addressing Disparities and Stereotypes

While digital education and gamification offer benefits, it's crucial to consider potential negative impacts on child psychology. Excessive screen time may lead to sedentary behaviour and health issues like childhood obesity (Biddle et al., 2019). Educators and policymakers should integrate breaks, physical activity, and healthy lifestyle education into digital learning programs.

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4.7 Insights into Gamification as a Model

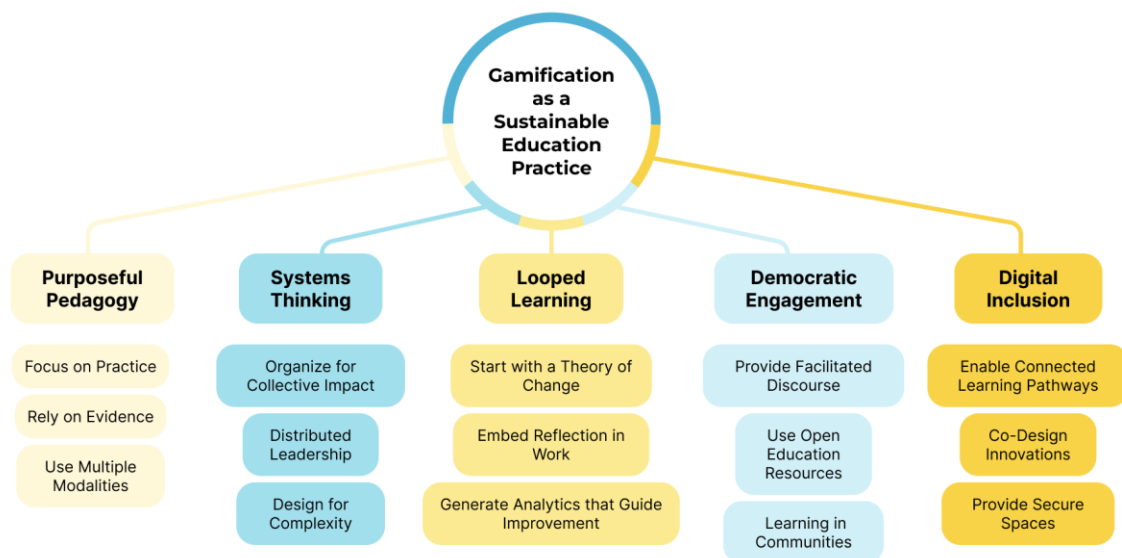


Fig. 6. Gamification as a Sustainable Education Practice

In our exploration of sustainable education practices for primary education, we draw inspiration from key principles in pedagogy, systems thinking, looped learning, democratic engagement, and digital inclusion. Our approach is rooted in purposeful pedagogy, emphasising a student-centred methodology where hands-on problem-solving is central to the learning process. Evidence-informed pedagogy guides our teaching practices, ensuring they are backed by reliable research and applicable across diverse contexts.

Co-creating content is fundamental in utilising digital resources to foster community building, critical inquiry, and the development of digital literacies. By embracing multiple modalities, one can leverage varied forms of communication – text, images, motion, and audio – to enhance the learning experience.

By applying systems thinking, we can organise for collective impact, encouraging collaboration across disciplines to solve complex problems. Distributed leadership structures, such as communities of practice, promote innovative solutions and the sharing of valuable insights. Designing for complexity allows one to dynamically adapt instructional elements to suit the unique contexts, abilities, and preferences of learners and educators.

Looped learning is integral to starting with a theory of change and embedding reflection into work. Analytics generated throughout the process guide continuous improvement, ensuring our practices are responsive and effective.

In fostering democratic engagement, we facilitate meaningful discourse through purposeful online discussions and leverage open education resources to enhance accessibility and adaptability. Structured learning communities, inspired by communities of practice and communities of inquiry, play a crucial role in developing teaching presence, social presence, and cognitive presence.

By embracing digital inclusion, we can aim to enable connected learning pathways, co-design innovations, and provide secure spaces that adhere to established standards for privacy and security. We

must seek to weave these sustainable gamification practices into the fabric of education, creating a holistic and adaptable framework for primary education. By aligning gamification with these principles, we envision a powerful and sustainable educational practice that caters to the evolving needs of primary learners.

5. Conclusion

In conclusion, this paper has delved into the transformative power of gamification in e-learning, exploring how it enhances sustainable education practices for the digital generation. In a post-COVID scenario marked by changes in attention spans, shifts in authority, and increased digital dependency, the need to adapt traditional education systems to the digital era has become paramount. The research has underscored the evolving definitions of sustainable education, learning, retention, educator, and learner, highlighting the changing dynamics between educators and learners in the digital context.

Throughout this paper, we've emphasised the potential of gamification to significantly enhance learning outcomes, particularly in the primary school context. The interplay between technology and sustainable education practices has been explored, shedding light on the implications of dynamic e-learning experiences in primary education. We've also highlighted the scope for further growth and innovation in this segment, especially by harnessing co-creation and peer learning methodologies.

While recognizing the promise of gamification, we've also issued cautionary notes regarding negative impacts on child psychology, such as excessive screen time and gamification-induced addiction. Drawing insights from psychological research, including studies on attention span and play therapy in digitised contexts, we've stressed the importance of a balanced approach that considers both the benefits and potential drawbacks of technology-based learning.

In this rapidly evolving landscape of digital education, this paper provides a comprehensive framework for educators and policymakers. It encourages the incorporation of sustainable education practices to engage and inspire young learners while safeguarding their overall well-being. As we continue to explore the possibilities of gamification, we must remain vigilant, prioritise children's holistic development, and ensure that technology serves as a valuable tool in shaping the future of education.

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References

- Akçayır, M., & Akçayır, G. (2017). Advantages and challenges associated with augmented reality for education: A systematic review of the literature. *Educational Research Review*, 20, 1-11. (Akçayır & Akçayır, 2017)
- Biddle, S. J. H., García Bengoechea, E., & Pedisic, Z. (2019). Screen time, other sedentary behaviours, and obesity risk in adults: A review of reviews. *Current Obesity Reports*, 8(4), 382-390.
- Bill & Melinda Gates Foundation. (n.d.). K-12 Education. <https://www.gatesfoundation.org/what-we-do/k-12-education>
- Cajander, Å., Daniels, M., McDermott, R., Moll, J., & Mozelius, P. (2018). The school as a playground: HCI in the full-scale living lab. *International Journal of Child-Computer Interaction*, 18, 43-51. (Cajander et al., 2018)
- Cavus, N., Sani, A.S., Haruna, Y. and Lawan, A.A. (2021). Efficacy of Social Networking Sites for Sustainable Education in the Era of COVID-19: A Systematic Review. *Sustainability*, 13(2), p.808. doi:<https://doi.org/10.3390/su13020808>.
- Cooper, H., Steenbergen-Hu, S., & Dent, A. L. (2012). Homework. In K. R. Harris, S. Graham, T. Urdan, A. G. Bus, S. Major, & H. L. Swanson (Eds.), *APA educational psychology handbook*, Vol. 3. Application to learning and teaching (pp. 475–495). American Psychological Association. <https://doi.org/10.1037/13275-019>
- Dettmers, S., Trautwein, U. and Lüdtke, O. (2009). The relationship between homework time and achievement is not universal: evidence from multilevel analyses in 40 countries. *School Effectiveness and School Improvement*, 20(4),. doi:<https://doi.org/10.1080/09243450902904601>
- DonorsChoose. (n.d.). DonorsChoose: Support a classroom. Build a future. <https://www.donorschoose.org/>
- Doyle, E. and Buckley, P. (2020). The impact of co-creation: an analysis of the effectiveness of student authored multiple choice questions on achievement of learning outcomes. *Interactive Learning Environments*, pp.1–10. doi:<https://doi.org/10.1080/10494820.2020.1777166>.
- Education International. (n.d.). Education International. <https://www.ei-ie.org/>
- For, A. and UNESCO (2022). *The Impact of the COVID-19 Pandemic on Education*. UNESCO Publishing.
- Google for Education. (n.d.). Google for Education. <https://edu.google.com/>
- Government of India. (2015). *Digital India: A transformative initiative for empowerment*. <https://www.digitalindia.gov.in/content/about-programme>

-
- Inclusion in Education A Manual for School Management Committee. (n.d.). Available at: [https://ncert.nic.in/pdf/announcement/Inclusion in Eduction.pdf](https://ncert.nic.in/pdf/announcement/Inclusion_in_Education.pdf).
- Kenny, G., Lyons, R. and Lynn, T., 2017. Don't make the player, make the game: exploring the potential of gamification in is education.
- Kickstarter. (n.d.). Kickstarter for Education. <https://www.kickstarter.com/education>
- Kucker, S.C. (2021). Processes and pathways in development via digital media: Examples from word learning. *Infant Behavior and Development*, 63, p.101559. doi:<https://doi.org/10.1016/j.infbeh.2021.101559>.
- Łuszczki, E., Bartosiewicz, A., Pezdan-Śliż, I., Kuchciak, M., Jagielski, P., Oleksy, Ł., Stolarczyk, A. and Dereń, K. (2021). Children's Eating Habits, Physical Activity, Sleep, and Media Usage before and during COVID-19 Pandemic in Poland. *Nutrients*, 13(7), p.2447. doi:<https://doi.org/10.3390/nu13072447>.
- Microdata.gov.in. (n.d.). India - Household Social Consumption: Education, NSS 75th Round Schedule-25.2 :July 2017-June 2018 - Overview. [online] Available at: <https://microdata.gov.in/nada43/index.php/catalog/151/study-description>
- Microsoft Education. (n.d.). Microsoft Education. <https://www.microsoft.com/en-us/education>
- Ministry of Human Resource Development (2020). National Education Policy 2020 Ministry of Human Resource Development Government of India. [online] Available at: https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf.
- Neville, D.O., Shelton, B.E. and McInnis, B. (2009). Cybertext redux: using digital game-based learning to teach L2 vocabulary, reading, and culture. *Computer Assisted Language Learning*, 22(5), pp.409–424. doi:<https://doi.org/10.1080/09588220903345168>
- Núñez-Canal, M., de Obesso, M. de las M. and Pérez-Rivero, C.A. (2022). New challenges in higher education: A study of the digital competence of educators in Covid times. *Technological Forecasting and Social Change*, 174, p.121270. doi:<https://doi.org/10.1016/j.techfore.2021.121270>.
- Oe, H., Takemoto, T. and Ridwan, M. (2020). Is Gamification a Magic Tool?: Illusion, Remedy, and Future Opportunities in Enhancing Learning Outcomes during and beyond the COVID-19. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, [online] 3(3), pp.1401–1414. doi:<https://doi.org/10.33258/birle.v3i3.1198>.
- OECD, UNESCO, UNICEF and Bank, W. (2022). From Learning Recovery to Education Transformation.
- Pattnaik, J. and Jalongo, M.R. (2022). The impact of COVID-19 on early childhood education and care : international perspectives, challenges, and responses. Cham: Springer.
-

-
- Pellegrini, A.D. (2009). *The Role of Play in Human Development*. [online] Google Books. Oxford University Press. Available at:
[https://books.google.co.in/books?hl=en&lr=&id=yO3zr_0iFYIC&oi=fnd&pg=PR9&dq=\(Pellegrini](https://books.google.co.in/books?hl=en&lr=&id=yO3zr_0iFYIC&oi=fnd&pg=PR9&dq=(Pellegrini) [Accessed 5 Oct. 2023].
- Ramesh Poonia (2022). *Cyber-physical systems : AI and COVID-19*. London, United Kingdom ; San Diego, Ca, United States: Academic Press.
- Royle, K., Stager, S. and Traxler, J. (2014). Teacher development with mobiles: Comparative critical factors. *Prospects* (00331538), [online] 44(1), pp.29–42. doi:<https://doi.org/10.1007/s11125-013-9292-8>.
- Spires, H.A., Oliver, K. and Corn, J. (2011). The New Learning Ecology of One-to-One Computing Environments. *Journal of Digital Learning in Teacher Education*, 28(2), pp.63–72. doi:<https://doi.org/10.1080/21532974.2011.10784682>.
- Sterling, S. (2001). *Sustainable education : re-visiting learning and change*. Devon: Green Books.
- Swing, E. L., Gentile, D. A., Anderson, C. A., & Walsh, D. A. (2010). Television and video game exposure and the development of attention problems. *Pediatrics*, 126(2), 214-221.
- Twenge, J. M., & Campbell, W. K. (2018). Associations between screen time and lower psychological well-being among children and adolescents: Evidence from a population-based study. *Preventive Medicine Reports*, 12, 271-283.
- UNESCO (2020). *Education: from school closure to recovery* | UNESCO. [online] www.unesco.org. Available at: <https://www.unesco.org/en/covid-19/education-response>.
In-text citation: (UNESCO, 2020)
- UNESCO. (n.d.). UNESCO Education. <https://en.unesco.org/themes/education>
- Valverde-Berrocoso, J., Garrido-Arroyo, M. del C., Burgos-Videla, C. and Morales-Cevallos, M.B. (2020). Trends in Educational Research about e-Learning: A Systematic Literature Review (2009–2018). *Sustainability*, 12(12), p.5153. doi:<https://doi.org/10.3390/su12125153>.
- Veresov, N. and Veraksa, N. (2022). Digital games and digital play in early childhood: a cultural-historical approach. *Early Years*, pp.1–13. doi:<https://doi.org/10.1080/09575146.2022.2056880>.
- Vernier (2019). Vernier Software & Technology | Vernier. [online] Vernier.com. Available at: <https://www.vernier.com/>.
- World Bank. (2021). *Public-Private Partnerships for Education*. [Report]. World Bank. <https://www.worldbank.org/en/topic/publicprivatepartnerships/brief/ppp-education>
- www.pratham.org. (n.d.). The sixteenth Annual Status of Education Report (Rural) 2021 released – Pratham. [online] Available at: <https://www.pratham.org/2021/11/17/the-sixteenth-annual-status-of-education-report-rural-2021-released/>
-

www.unicef.org. (n.d.). Transforming education with equitable financing. [online] Available at:
<https://www.unicef.org/blog/transforming-education-equitable-financing>.

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