The Effectiveness of Playful Augmented Reality Media for Teaching Early-Primary Students

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Abstract: Hybrid learning has become the only solution to ensure the learning process still occurs in place of traditional classroom activities during the Covid-19 pandemic. Following this condition, the phenomenon of "Zoom Fatigue" has emerged. Some of the symptoms reported are decreased learning motivation, low attention, and reduced responses. Thus, a refresher process, including the use of new playful and frugal learning media is necessary for varying children's learning activities. A learning intervention was designed to teach anatomy playfully as part of a biology curriculum. The Augmented Reality technology used in this research is a Humanoid 4D+ mobile application with flashcards, developed by Octagon Studio. This media displays information virtually on a smartphone screen when the application uses the camera to scan flashcards containing visual markers. A hybrid learning space is formed as students can see information virtually. But, physically, they are in control because they run applications and choose the type of flashcard they want to scan. The research was undertaken in several learning parks in Solo City, Central Java Province, Indonesia, with a total of 43 volunteer teachers and 132 early primary students participating. Previously, the ACES team (part of a UKRI funded project) had provided online training on the use of this media with teachers. Each teacher would then implement the media for all students in each learning park. The teachers demonstrate the media and each student takes turns running the application to view information virtually, therefore experiencing interactive learning. The qualitative approach was conducted for capturing teachers' perceptions of Augmented Reality media. A survey using the JISC online platform was distributed to capture participants' reflections on the activities and media used. Based on findings, the media appears beneficial, effective, and efficient for teaching anatomy concepts. Its virtual features can attract the children's attention and teachers do not need to bring a lot of physical teaching aids, just one application to explain all organ system concepts. Students can learn playfully on their own and feel new learning experiences. The results indicated that the intervention could create playful and frugal activities which build student engagement as a potential solution to address issues of Zoom Fatigue. The next stage of the project will involve volunteer teachers implementing the technology more widely in their classes.

Keywords: ACES, Playful, Frugal, Zoom Fatigue, Augmented Reality, Early-Primary Students

1. Background

The arrival of Covid-19 in Indonesia marked the sudden and simultaneous occurrence of the highest peak in the implementation of online learning in all schools in Indonesia. The learning process is carried out remotely, communication is carried out using video conferences, and the presentation of learning materials and evaluation of learning is carried out online with a home-based activity format. Video conferencing as a communication medium has subtly led to *Zoom Fatigue* due to the long duration of time allocated for video conferences (Fauville, 2021; Salim & Tandy, 2022). *Zoom fatigue* is a condition that describes the fatigue associated with the excessive use of virtual communication platforms (Wolf, 2020). *Zoom fatigue* symptoms are marked by forgetfulness and difficulty concentrating, frustration and irritability with co-workers, and physical symptoms like muscle tension, pain, fatigue, and insomnia (White, 2021). During observations by Peper, Wilson, & Martin (2021), approximately 80% of 350 participants indicated it was harder to focus their attention and stay present while taking online classes. There is more isolation, anxiety, and depression compared to face-to-face classes, although much of this may be due to COVID-19 social isolation. Students often appear unresponsive when attending synchronously online, which negatively impacts student-instructor interactions and nonverbal dynamics. Therefore, it is necessary to modify media, design, and learning methods with various applications that do not require high concentration so that fatigue during online learning does not occur (Pustikasari &

Fitriyanti, 2021). There are still few studies that publish the creativity and innovation of educators to modify learning into playful online learning to make it more fun for students. Meanwhile, an understanding of fun learning design is an indispensable element in maintaining the motivation and quality of children's learning. According to Broadhead, P. (2010), high-quality play experiences are essential for good early years education. Rice (2009) presented findings that playful learning can effectively motivate and improve student engagement, promote creative thinking towards learning, and develop approaches toward multidisciplinary learning. The authors propose to optimize the fun online learning process for students by modifying the learning design using an Augmented Reality media mobile application, equipped with flashcards, by adapting the principles, aspects, and indicators of playful learning (Arnab, Morini, and Clarke, 2018) and frugal education (Masters, 2021).

2. Literature Review

2.1 2.1 Augmented Reality Humanoid 4D+ Mobile Apps

Augmented Reality (AR) is a technology that enables virtual content to be seamlessly merged with the real world. Historically, the earliest AR systems discovered in the early 1990s were developed at the U.S. Air Force's Armstrong Laboratory (Rosenberg, 1992). AR experiences have become widely available on mobile and handheld devices in the last few years due to the emergence of smartphones that combine fast CPUs with displays, cameras, graphics acceleration, compass, GPS sensors, and even gyroscopes (Azuma, 2011). For educational purposes, Augmented Reality (AR) information content can be accessed by scanning or viewing images through applications on mobile devices. Displays can be videos, images, 3D animations, games, QR codes, or whatever you want (Brown, 2015). Korenova's research results (2019) confirmed that using visualization with Augmented Reality results in a deeper understanding, greater motivation, and strongly supported student creativity. The new method motivated students, those students cooperated very well, and learning was constructive.

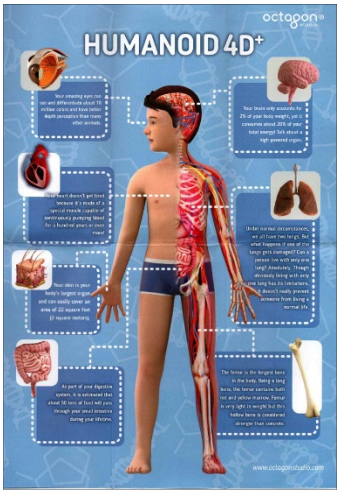

Figure 1: Screenshot of Humanoid 4D+ Interface.

The Humanoid 4D+ application developed by Octagon Studio is a mobile AR app designed to teach anatomy. This application is equipped with a physical card containing visual markers linked to information on various body organ systems. The app presents 3D visualizations of organ systems inside the human body, allowing users to explore human body parts in detail. Users can experience the anatomy exploration in Augmented Reality using the markers provided (App screenshot with AR label). When pointing the app at the markers, users can start exploring parts of the Skeletal System, Muscular System, Respiratory System, Digestive System, and Skin. The Humanoid 4D+ application was chosen in this study to measure its effectiveness for teachers in teaching early-primary students.

Figure 2: Humanoid 4D+ Interface application in use with students

(Participants were given consent forms and agreed to photographs being taken of them participating in activities with Humanoid 4D+)

As shown in Figure 2, Humanoid 4D+ can be played by children anywhere at any time. In addition, the principles of creativity and innovation are clearly used by educators to modify learning into a playful experience, making it more fun and engaging for students. An understanding of fun learning design is an indispensable element in maintaining motivation and quality within the children's learning.

2.2 ACES Project Research

This research is part of the ACES project, funded by the UKRI. ACES (A Community-Centred Educational Model for Developing Social Resilience) is investigating and seeking transformative educational models for young people toward a more inclusive, safe, and resilient society. One of the ACES principles is using Playful Learning and Frugal Education during the intervention for children in Indonesia.

2.2.1 Playful Learning Principles

Play is one of the most critical ways young children gain essential knowledge and skills (UNICEF, 2018). For this reason, play opportunities and environments that promote play, exploration, and hands-on learning are at the core of effective pre-primary programmes. According to Roberts, Arth, and Bush (1959), play is a model or theatrical simulation, such as a game. Games provide the necessary skills that may be needed later in life. Even the simplest games contain a complex set of properties. Children usually understand the basic concepts of a game depending on their development level. Higgins (2000) also proposed that the nature of play involves a trial and error process to overcome the challenges and obstacles it poses, thus promoting the development of logical thinking and problem-solving skills (Higgins, 2000). Similarly, Lieberman (1965) found that using play in learning can favor the cultivation of divergent thinking. Students discover the importance of elements such as empathy, purpose, meaning, art, creativity, and teamwork in their learning regardless of the specific disciplines they are pursuing (Arnab, Morini, and Clarke, 2018).

Playful learning is an educational approach in which a state of being is facilitated that is creative, explorative, experimental, active, and immersive. It stimulates intrinsic motivations and the flow state of the learner. The learning activities are focused on constructing knowledge or skills in a fun and experimental manner. Playful learning aims to stimulate the construction of new knowledge and skills by letting students wonder, experiment, fail, take a risk, construct, and reflect critically on the content and their learning experience (Witton,Toft-Nielson, Norgard, 2017). The focus is more on dynamics, the spontaneous, creative experience, and less on game mechanics. Playful learning can be found in humor in the classroom, roaming around in a virtual environment, or weekly reflection challenges. Playful learning has six overarching categories: Autonomy, Fun, Agency, Curiosity, Iteration, and Social (Arnab et al., 2020). The following will explain each aspect of the Playful Learning principles that is predicted to be found in the Augmented Reality media used in this study.

Table 1: Playful Learning Aspects and Indicators (Arnab et al., 2020)

Autonomy	**Fun**	**Agency**	**Curiosity**	**Iteration**	**Social**
Sense of Control	Easy	Capability	Perceptual	Repetition	Associative
Freedom of expression	Hard	Responsibility	Empathic	Experimentation	Competitive
Meaning	People	Accountability	Epistemic	Reflection	Collaborative

The Autonomy aspect suggests that learning designs created should be able to train children to make decisions and participate without pressure (sense of control), facilitate them to express feelings (freedom of expression), and help children find meaning in their activities (meaning). The Fun aspect recommends that interventions should be able to make children feel happy, curious, feel adventurous and fantasize (easy-fun), finish the challenge based on their abilities (hard-fun), and collaborate with others (relationship). The Agency aspect will be met if children can develop their capability through the activity (capability), can respond actively and encourage their commitment (responsibility), and can give the ownership of their performance (accountability). The Curiosity aspect will be shown if learning design can provide sensory stimulations, children start to explore, ask questions, and take risks (perceptual), become aware and understand other people (emphatic), and motivate children's desire for knowledge (epistemic). The Iteration aspect reflects activities for different skills when completing a task multiple times (repetition), exploring different ways to solve a problem by testing their strategy, finding alternatives (experimentation), and helping track the way they address/solve a problem (reflection). The Social aspect is the last part of the playful learning principles. The learning design indicated that children start to learn from other people by asking questions, talking, negotiating about the activities at hand, connecting actions and choices (associative), developing and discovering shared goals (collaborative), and comparing their progress with others (competitive).

2.2.2 Frugal Education Principles

The concept of Frugal Education is described as "harnessing the power of design thinking, leveraging available resources, and embracing sustainability to develop creative, practical, and sustainable education for all." (Masters, 2021). Over the course of the ACES project, further research into frugal education has been undertaken to refine the guiding principles and to develop a set of nine associated aspects for consideration when designing and adapting educational practice (Arnab, Mahon, Masters, et al., 2021). These aspects were informed by (1) the development of a 'learning, playful, and frugal mapping framework' for developing 21st century competencies and resilience, and (2) the design of playful and frugal interventions in collaboration with ACES partners for delivery within case studies across Malaysia, Vietnam, and Indonesia.

Table 2: Frugal Education Principles and Aspects (Masters, 2021)

Design with an Open Mind	**Leverage Available Resources**	**Build at the Speed of Need**
Creativity	Resourcefulness	Minimalism
Collaboration	Practicality	Sustainability
Openness	Resilience	Iteration

When applying frugal education practices for designing hybrid learning through interventions using Augmented Reality media, we need to consider the frugal education principles, and their respective aspects, and how they might be applied to the intervention to deliver frugal and sustainable learning designs toward varying early-primary learning activities and addressing *Zoom Fatigue*. First, learning intervention should be designed with an open mind which can be achieved by fulfilling the respective aspects. As an example, the activity should be more creative by combining ideas and creating innovative ways to foster experimentation (creativity), it should include the role of children to participate (collaboration) and be accessible by allowing others to apply, adapt, and build through clear and detailed guidance (openness). Second, the learning intervention should be able to inspire children through the use of available materials in the local environment and wider community that can be recycled to create new resources and materials (resourcefulness). The design needs to be practical and flexible

to engage more participants, especially those living in rural areas where the use of technology is limited (practicality) and it needs the flexibility to adapt gracefully to unforeseen circumstances (resilience). Lastly, the learning intervention design should be made more economical by reducing administrative processes and minimizing resource costs (minimalism), considering the environmental impact of the design on the wider community (sustainability), and creating simple designs and iterating on them through a continuous cycle of improvement and refinement (iteration), enabling educators to more effectively design, resource, build, and deliver quality education with limited resources.

2.3 Early Primary Students of Solo Mengajar

This project focused on the role of community stakeholders and young people in understanding, engaging and integrating playful approaches into informal education spaces in Indonesia. In this study, we collaborated with the Solo Mengajar NGO community. “Solo” is the name of the city the NGO community originates from, and “Mengajar” is the term to explain a learning mentoring activity carried out by volunteers to children in the area. Solo Mengajar NGO is a moral movement community in education for young volunteers in Solo City, Central Java Province, Indonesia, established independently on May 25, 2012, and is not affiliated with any political party or organization in Indonesia. Solo Mengajar uses a social assistance strategy through socialization, mediation, and facilitation in increasing citizens' awareness of the fulfillment of children's education rights (Pamungkas, 2018). One flagship program is Playful Activities, which participates in learning activities and play in several villages and nine learning parks. The main activity of Solo Mengajar is to strengthen the understanding of basic concepts within subject matter, instill, and teach a good attitude while helping children develop their interests and talents. The local community mentions the presence of Solo Mengajar as a Free Private Learning Service for their children who have learning difficulties (Susanti, A., 2021). We involved 43 volunteer teachers and 132 assisted students from the NGO Solo Mengajar for participation in this study. Currently, most children come from rural areas.

3. Method

A qualitative approach using the Participatory Action Research (PAR) method was conducted for this research. PAR is a research activity carried out in a participatory manner among citizens in a community or broader social sphere to encourage transformative actions (changes in better living conditions). Thus, according to the term, PAR has three main pillars: the research methodology, the action dimension, and the participation dimension. This means that PAR is carried out by referring to specific research methodologies, it must aim to encourage transformative action, and must involve as many citizens or community members as possible as PAR implementers themselves.

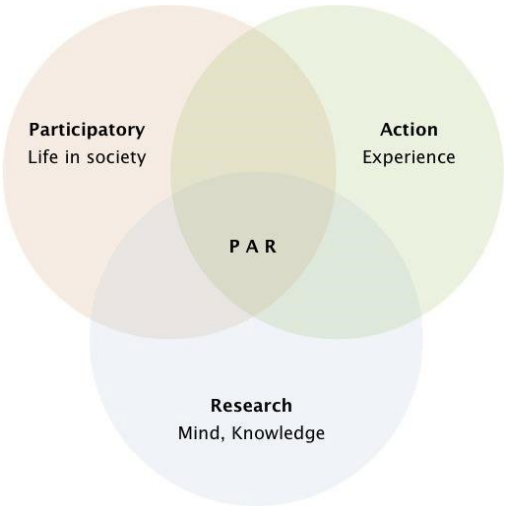

Figure 3: Participatory Action Research Diagram (Chevalier, J.M. and Buckles, D.J., 2013)

PAR offers an opportunity to deconstruct and reconstruct professional knowledge in the light of participants’ stances and theories in use, including their experiential and practical knowledge. It can support a group of practitioners to: consider a particular aspect of practice and its effectiveness collectively; examine how it is informed by knowledge and best practice (e.g. research, theory, policy, and practical knowledge); and explore where improvement may be required and implemented. As a collaborative research methodology, it offers significant benefits because it can contribute to the discovery and development of conditions and actions required for sustainable change. PAR aims to increase participant awareness of external forces affecting

decisions in their lives, including promoting self-confidence and the capacity to develop decisions that enable a new level of awareness and competence. PAR's effectiveness in enhancing the understanding of the inter-relationship between personal agency, professional competence, and knowledge translation has been examined with the use of case study material from a professional development research project (Wimpenny, K., 2010).

3.1 Plan: Planning Online Training for Participants

After analyzing the community's goals, needs, and initial conditions through a series of meetings, a plan was made to provide training on the use of various types of playful learning media to teach the community using the Gamification Webinar series format. The webinar materials presented many kinds of child-friendly playful learning media including the Augmented Reality Humanoid 4D+ media. 43 Solo Mengajar teachers were appointed as participants of this study. Due to restrictions on offline activities during the Covid-19 pandemic, 'Training of Teachers' was presented online in the format of the ACES Gamification Webinar Series.

3.2 Action: Distributing Learning Media to Participants

After finishing 'Training of Teachers', we distributed 20 flashcard packages and serial numbers for the Humanoid 4D+ mobile application. One serial number can be used to activate the Humanoid 4D+ application on three different smartphones. One flashcard package consists of 10 cards containing different information about all human body organ systems. Technically, the teacher alternated the use of applications and flashcards between 132 early primary students. Each teacher then implemented the media for all students in each learning park. The teacher demonstrated the media and each student took their turn running the application to view the information virtually and therefore experiencing interactive learning. This was achieved by pointing the app at markers on the flashcards to virtually explore the human organ systems.

3.3 Observe: Conducting an Online Survey To Measure The Effectiveness of Learning Media

When the implementation process was completed, the next step was to input the questionnaire in the form of open essay questions into the JISC Online Survey tool. The tool is designed to support Academic Research, Education, and Public Sector organisations in carrying out data collection and is accessible at https://www.onlinesurveys.ac.uk. The JISC Online Survey was used to collect, process, and display data for this research. Once the research instrument was prepared, a link to the questionnaire was shared directly with the participants. The use of questionnaires aimed to determine the effectiveness of media in explaining the human organ system concept to early primary students. The teacher guided the children in answering the reflection questions given while accompanying the children during the media implementation process and then uploading data as documentary evidence of their participation into the cloud storage system. From this data, participant statements regarding the use of media can be analyzed based on their responses in each question then the advantages and barriers could be identified in order to produce a recommendation. Data was collected from 19 March 2021 to 21 April 2021.

3.4 Reflect: Analyzing Data and Findings

After collection, the data were analyzed thematically.

4. Results Section

The paper is organized to respond to the problem of Zoom Fatigue faced by children. The study found that the Humanoid 4D+ application used in learning intervention provides new learning experiences. The app is very beneficial, effective, and efficient for building early-primary student engagement and increasing children's responses to teacher instruction, so is therefore a good potential playful solution for preventing *Zoom Fatigue* symptoms during the learning process due to the excessive use of virtual communication platforms (Wolf, 2020).

4.1 New Learning Experiences

When participants were asked about what they gained from this intervention. Each gave a positive response. Participant 1 noted, "I learned about the human body using a new method in the learning process." Participant 2 commented, "I got new lessons and experiences regarding the use of human organ recognition applications." Participant 3 said, "It turns out that learning the basic concepts of biology regarding anatomy can actually be done through advanced 4D technology," and some of them mentioned in similar statements that they felt very enthusiastic, were not sleepy anymore, felt interested, and quickly understood the concepts being taught during the learning process.

This suggests that the app may have a positive impact on student engagement as the children start to engage in a new learning experience through virtual interactivity. This finding follows Azuma's opinion (2011) that Mobile

Augmented Reality is one of the fastest-growing research areas partially due to the emergence of smartphones that provide powerful and ubiquitous platforms.

4.2 Usefulness

When they were asked about the benefits of the Humanoid 4D+ application in supporting the learning process, all participants gave the same answer, stating that the application was beneficial.
A majority of participants agreed that the app was useful. One participant noted that the app *"was very useful",* another stated it was "*extremely useful and easy to use*", and others stated that the app was useful to be used in the learning process.
Participant 2 commented, *"Learning human organs no longer needs to use physical teaching aids".*
Others mentioned that it was v*ery u*seful because it could attract attention*.* One participant went on to explain that teaching *"through gadgets which are of course more interesting".*

The ease of this app to use and to attract children's learning attention can be a solution to prevent and to reduce difficulty concentrating, frustration, and fatigue in children during the learning process as the symptoms of Zoom Fatigue mentioned by White (2021).

4.3 Effectiveness and Efficiency

When they were asked about the effectiveness and efficiency of the app in the learning process, the majority of participants answered that it was very effective and efficient. Some participants answered for various reasons.

> *The majority of them said that the app can be used anytime and anywhere without the need to bring physical props. Two participants commented that this Humanoid 4D+ app is effective for children. Others said that the app is very effective because it is playable, has much knowledge and is suitable for facilitating learning while playing. Two more participants noted that the app is effective and efficient, can save time, cost, and is easy to understand.*

These statements indicate that the app is effective because of its practicality and suitability for teaching the concepts to early-primary students whenever and wherever it is required. It is efficient in terms of time, money, and effort. The app does not necessitate complicated devices, nor does it necessitate prolonged periods of intense study, as is the case with online learning. Learning apps can be accessed repeatedly without worrying about missing the teacher's ongoing lesson or online presentation. As a result, it may be a viable option for reducing learning fatigue in children, both mentally and physically, and keeping children away from long periods of video conferencing attendance that could potentially cause *Zoom Fatigue* (Salim & Tandy, 2022).

The next stage of the project will involve more teachers implementing the technology more widely in their classes. Some participants complained of poor responsiveness when their smartphone internal memory was full, which could prove to be a potential limiting factor for the app's use. Providing an adequate number of smartphones to facilitate a larger number of students could make the learning activity more time-efficient, however, it would also increase the overall resource cost. If the school cannot provide enough smartphones for all students, an alternative solution would be to utilise an LCD projector to display the app contents on a whiteboard and the children could freely choose the type of flashcards they want to virtualize in turn. Also, the strength and the availability of internet access provided can be a limiting factor as AR technology requires internet connectivity to visualize objects on markers. Thus, the internet signal strength can significantly affect the application's performance. It is recommended to provide training, not only for volunteers but also for students, before starting learning experiences due to some children not having experience with using applications and therefore needing volunteer guidance in order to participate.

5. Conclusions

In conclusion, the use of playful augmented reality media is very beneficial, effective, and efficient at preventing *Zoom Fatigue*, and has been especially effective during the pandemic for teaching anatomy concepts to early-primary students. The study used a qualitative approach involving the thematic analysis of data collected through an online survey. The app can reduce the *Zoom Fatigue* symptoms as students are engaged and interested in a new learning experience. Students are actively involved in using this application accompanied by interesting flashcards so they can scan and get the information. In the learning process, students carry out image identification activities that require them to move, use physical objects, and communicate with their friends, further limiting the potential for *Zoom Fatigue*.

The playful and frugal aspects helped to identify and inform how the learning design and learning environment can be made. Several playful learning aspects were identified in AR Humanoid 4D+ app, such as: easy-fun, experimentation, perception and capability due to the apps ability to build involvement and interaction between children; through raising children's curiosity to discover more and become fully immersed in the activity context, and enable the sense of adventure, fantasy and make-believe; providing sensory stimulations (touch, auditory, and visual) to inspire and stimulate children's imagination and/or discovery; facilitating children in mastering new digital and contextual literacy skills.

We also found that these interventions align well with the frugal principles. When using Humanoid 4D+ app, teachers can create learning designs that foster creative thinking and problem solving by proposing tasks to identify potential causes of several diseases in the human body. In addition, collaboration involving participation among students is necessary to collectively identify parts of the body by working together and sharing ideas. Through this activity, teachers can listen to the participants, encourage participation, understand student needs, and identify areas of improvement. Teachers can recycle available materials such as used cardboard and paper to print new flashcards for use with the AR mobile apps. Through this practice, teachers and participants motivate one another to be resourceful by creating something new using what is available in the local environment. The design needs to be practical and flexible to engage more participants, especially those living in rural areas where the use of technology is limited. Teachers can create simple designs to be easier to create and manage. For as little as £2.76 in English pounds, or around IDR 50,000, parents or teachers in rural locations can purchase one Humanoid 4D+ application with flashcards that can be used simultaneously on three different smartphones to facilitate virtual learning. The cost is significantly lower than purchasing a single physical organ educational toy, which is five times more expensive (£13.66 or IDR 252,000), therefore making the app a more viable alternative, provided there are sufficient smartphones available to use the software, which in this case there are. Children can access the application for free at several learning parks managed by Solo Mengajar. This provides educators in rural locations with the ability to deliver engaging education practice with minimal resource cost, whilst also limiting online interactions as a way to mitigate against the potential for *Zoom Fatigue*.

5.1 Limitations

The authors wish to acknowledge that the participation in this study was limited to only several learning parks with a small number of participants. Further research would significantly increase the number of sample distributions through which to measure the effectiveness of the intervention.

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