Teacher Beliefs about Wearables and Gaming

Qing Li
Professor, Department of Learning Technologies
Towson University
Towson, USA
li@towson.edu

Justin Patterson
Towson University
Towson, USA
jpatter3@students.towson.edu

***Abstract*— This study examines practicing teachers' thinking on wearable gaming for educational purposes. Specifically, it explores teachers' envisioned use of wearable gaming and their perceptions about the pros, cons, and challenges of wearable gaming in the context of education. Adopting a case study approach, data were collected from 31 teachers enrolled in a graduate course. The results showed that teachers considered conveniences, flexibility, social emotional development, etc. as pros, while over reliance on technology, hazards, and inequality, etc. were cons. Interestingly, several other aspects were articulated by teachers as both pros and cons. Specific ways to apply wearable gaming for educational purposes were also discussed.**

Keywords-component; wearable gaming; game-based learning; teacher perceptions; wearable design.

I. INTRODUCTION

This paper builds upon the original conference paper with substantial additions and deeper analysis to enhance the context, methodology, and findings of the research [1]. These extensions provide a more comprehensive and rigorous examination of the study.

The power of digital game-based learning is now widely accepted as reflected, for example, in well recognized publications including the Federation of American Scientists' (FAS) report [2] in which games are considered as a powerful tool with great educational potentials [3]. Various studies have demonstrated that games can enhance learners' conceptual understanding [4], motivate students [5], and positively influence players' attitudes [6]. On the other hand, wearable technology has increasingly attracted attention from researchers and developers for its power to enhance student learning anywhere and anytime.

Despite the growing interest and increased number of studies in the field, how to best design wearable technology for learning in general, and how wearable technology on game-based learning (GBL) can be optimally used remain underexplored [7]. The adaptation of wearable game-based learning in classrooms is scarce due to various reasons. For example, teachers often found it challenging to connect wearable games with existing curriculum [8]. The technical skills required to use wearable gaming can be another roadblock for teachers [9]. Using wearable tools can be too complicated for teachers [8].

This study, therefore, aims to bridge this gap by examining teachers' thinking and envisioned use of wearable gaming for educational purposes. Understanding what teachers concern the most as they consider wearable games for instructional purposes can help us not only better design instructional and training practices for teacher education, but also identify effective approaches for educational wearable game design that are aligned with existing curriculum and meet the needs of the teachers and their students.

II. RELATED LITERATURE

Wearable technologies, referred to digital devices that can be easily attached to our bodies as accessories or clothing, are gaining increased attention from educators, researchers and designers. Small and affordable wearables such as watches, glasses, rings, and other accessories allow users to monitor several biometric factors, control their smartphone apps via voice and gesture, play games unique to the technology, and much more. It has been argued that wearable technologies hold substantial educational potential for their ability to enhance interaction, collaboration, and immersive learning [10].

A. Wearables and Games

Still in their infancy, wearables that were initially planned only as medical devices have the potential to provide solutions beyond the healthcare and personal sectors [11]. Gains in data transfer and storage, energy efficiency, and connectivity as well as the capability to augment reality (AR) or provide virtual reality experience (VR) in off-the-shelf wearables have made them attractive for educational integration [12]. Additionally, wearables possess three qualities that make them compelling: wearables can collect data from the wearer on an ongoing basis, the wearable can have a direct relation to the wearer's public appearance, and wearables can monitor bodily systems to improve the wearer's quality of life [13].

User adoption of wearables can be influenced by factors such as age, trust of technology, data protection concerns, technology-related health concerns, technical skills, and the wearable's ability to interoperate with other technology-based infrastructure [11]. Additionally, there exists concern over the sustained integration of wearables, as individuals who adopt wearables – specifically fitness trackers – tend to abandon them within months after first use [14]. Designers have attempted to combat this phenomenon by adding

features that some users view as gimmicks versus valuable tools [15].

A survey study [16] of 70 participants examined public perception of wearables for every day, moment-to-moment learning opportunities were evaluated. Using nine scenarios based on task-oriented activities- that include assistance needs, health monitoring, and location-based use- they found there was a positive inclination to use wearables as a learning tool. Additionally, the survey seemed to perceive wearables to already support some form of learning with their current set of abilities. As an example, tracking one's heart rate was viewed as learning about oneself. Of the many types of wearables available, the study found smartwatches and smart glasses to be the most chosen devices amongst respondents for use in these fictional, everyday scenarios.

Video games or gamified experiences can present multidimensional combinations of the wearer's sensations [17][18]. Tied to wearable technology, gamification has the potential to utilize game design elements in non-game contexts with the anticipated outcome of affecting the wearer's behavior [19]. In a literature review study by Windasari and Lin [14], ten empirical studies were examined to identify ways to sustain the use of wearables with a focus on interactivity levels and the inclusion of game-design elements. They reported that the higher the level of activities built into the wearable, the higher the continued use. This is to say that wearables that collected data alone were not as useful to a user as those that collect data and share it with larger, integrated systems. Instead, implementing game mechanics, especially those that link to social elements, such as competition and collaboration, leads to a higher intention of use.

B. K-12 Education and Wearables

Wearable technology can afford educational experiences that are intrinsically motivating and relevant to school aged children [20]. Available off the shelf, they require minimal modifications to be incorporated into a curriculum [21] but may necessitate the development of additional hardware/software supports to be meaningful. Evidence also suggests that wearables can achieve certain positive outcomes in students with learning disorders and disabilities [22].

In a study [23], 808 elementary students were given an opportunity to engage with e-textiles powered by the LilyPad Arduino. The results showed that by making the wearables customizable and visible, students were more apt to use, dress, and show off their wearables to family and friends. Created through a combination of electronics and crafting materials that include a microcontroller, sensors, actuators, and conductive thread, this STEM activity allowed students the opportunity to engage with a personalized challenge through a relevant, authentic learning process. They concluded that wearable textiles that combine computer science with aesthetics can work as cognitive tools for problem solving, programming, design, and other STEM content.

An earlier work [24] compared outcomes such as student engagement, student motivation, and student excitement using the same pedagogical strategy on two distinct technological platforms: Palm hand-held devices and smart badges in two high schools and one middle school to play games based on complex systems: 188 high school students were randomly assigned and grouped to use either the Palm handheld devices or the smart badges – dubbed thinking tags - to play a simulation built on Mendelian genetics. An additional 82 middle school students played Virus - a game that explored the spread of a disease – using either the Palm or thinking tags. The results reported that both versions of the simulation were exciting and motivating, with students remaining engaged through interaction, investigation, collaboration, and testing. With little difference in the collected data and how the activities unfolded using the Palm or the think tags, the researchers concluded that using the inexpensive think tag technology in simulations holds great promise for integrating technology in authentic, collaborative learning opportunities that students will find engaging and motivating.

Ko and colleagues [25] adopted an experimental approach, connecting gaming experience with somatic exercises. A somatic game called We Wave was presented to children of 5-12 years old. Using a Wii Balance Board to map movement to music, they discovered that most children were able to enter in proper kinesthetic interactions with a cooperative player. In 2014, We Wave was adapted to the sensorimotor facility of autistic children, where it was found that the environment can help with anxiety through a blend of sounds being in time with body movement. Once relaxed, these players were involved in non-verbal interaction and shared emotions with cooperative players. In their follow up project, VR headsets were added with the intention to create an in-game body experience coupled with binaural spatialization sound synthesis for sensorimotor.

In a randomized clinical trial by Voss et al. [26], 71 school-aged children (six to 12 years old) with autism spectrum disorder (ASD) used Superpower Glass (SG), an artificial intelligence-driven intervention deployed via smart glasses and a smartphone app, to teach recognition and relevance of emotion. Amongst the children, 40 were randomly selected to be treated with the SG and applied behavioral analysis (ABA) therapy while 31 used ABA therapy alone as the control group. Families were asked to conduct 20-minute sessions at home four times a week for six weeks. Concluding the treatment, the children who used SG and their associated games showed significant improvements on the Vineland Adaptive Behavior Scale socialization subscale when compared to the control group. That is, using wearable technology to teach the recognition and relevance of emotion better improved student socialization as compared to receiving regular therapy.

In general, this body of literature suggests that accessible wearables and those that integrate gamified opportunities can produce positive learning outcomes for K-12 students. By providing relevant and engaging activities that increase student motivation, wearables allow for authentic problem solving and permit collaborative learning opportunities. Furthermore, these studies show encouraging support for

wearables and gaming support for students with disabilities in the classroom and at home.

C. Higher Education and Wearables

In the higher education setting, wearables can be used beyond the intrinsically motivating use of activity tracking, badging [27], receiving notifications, social communication [28], gaming, and recording features [20]. In an earlier study [29], students were asked to wear glasses during 15 standard medical simulation sessions to track their performance, including eye movement. The results included detailed information about each participant's practice style, allowing for personalized feedback and teachable moments.

Another study [30] utilized a head-mounted AR display worn by a lecturer and the 11 students to investigate the bidirectional communication of teacher-students. The results showed that using AR could improve student interaction and communication with the teacher and enhance engagement. Researchers found that feedback from students was more direct, that there was satisfaction in receiving visual cues regarding student affirmation of learning concepts, and that using AR goggles allowed the lecturer access to notes at all times while speaking.

Little research exists highlighting wearable technology and gaming being utilized in higher education. The two highlighted studies show evidence that wearables promote individualized learning opportunities, personalized and contextualized feedback, and opportunities for students' inquiry.

D. Higher Education and Wearables

Research exploring the interplay of wearable technology and teacher beliefs has gained little attention. In a study [31] of physical education (PE) teachers, researchers analyzed qualitative data focusing on teacher perceptions of incorporating wearable technologies in their practice. Data was collected from interviews of 26 teachers in the UK. Their results showed that teachers recognized the benefits of wearable tools in schools in helping with motivating, goal setting that would lead to increased physical activities. They viewed wearable tools designed for schools as acceptable. Though limited, current investigations suggested that the teacher's attitudes towards innovation determines the overall quality of integration [32].

In an initial iterative study [33] of 16 K-12 math teachers, AR smart glasses were used to support a personalized learning classroom. The system used real-time detectors found in advanced learning technologies (ALT) to simulate a learning environment that would allow the wearer to evaluate relationships with student learning gains. Teachers reported that they felt wearing smart glasses allowed them to more quickly respond to key events in the room. Interpretations of teachers' responses suggested that certain student-related information should be made simplistic, with related and more sensitive elements available on demand. As an example, viewing indicators of current student activity states would be more helpful if their pervious activity state were known – such as a student in a "not working" state due to being in a "struggling" state moments earlier. Teachers also suggested that if students were provided with a way to request help via the ALT, they would be more apt to ask for assistance.

Many review studies showed that the majority of research related to smart wearable were conducted in areas like medicine [34], sports or physical activity [35][36][37], neuroscience [38] and work environments [39]. In education, Schroeder and colleagues [40] conducted a scoping review of wrist-worn wearables (WW). Their analysis of 46 empirical studies indicated that a similar proportion of the studies focused on k-12 students and adult learners. While a wide range of subjects were explored, there is a lack of work focusing on teacher training and the use of such tools.

E. Summation

In sum, although there is research available on wearables in education, most tend to focus on awareness, features, level of comfort, and accessibility. Less attention pays to wearables and gaming in practical, K-16 classrooms. Of those that exist, most focus on student observation, interviews, and results with almost no perspective from an educator. In addition, few, if any, studies exist in the way of design research that might provide in-depth information about the optimal features of wearables and gaming [41] for educational purposes. This study thus attempts to bridge the gap by examining teacher perceptions related to wearable gaming.

III. Research Questions

This study explored practicing teachers' thinking and envisioned use of wearable gaming for educational purposes. Specifically, the following research questions guide the research:

1. What are teachers envisioning of using wearable gaming for educational purposes?
2. What do teachers believe about wearable gaming in terms of pros, cons, and challenges?

IV. Methods

This study was a case study framed in a qualitative, naturalistic research perspective [42]. Aiming to capture teachers' thinking, the focus was on investigating teachers' beliefs about wearable gaming and their envisioned educational use of wearable gaming. Complying with the case study design, this work used a range of data collection approaches to gather detailed information over extended time [43].

A. Participants and data sources

The participants were graduate students enrolled in a graduate course involving online learning. A total of 31 students participated, which constituted the sample of this study. The course was aimed at providing students with a foundational understanding of online education.

A majority of them were practicing or formal teachers in k-16 educational institutions with about 20% of them were active or previously worked as trainers in different organizations or businesses. These 31 participants (about

15% males) were referred to as teachers and pseudonyms were used in this paper. This study was part of a larger research project focused on teacher digital game design experiences. The initial data collection included class observations, assignments completed by teachers, instructor's reflective journal and learners' feedback after class. Other data sources were the teacher created digital artifacts. This paper focused on participants' reflections, although other data provided information for the context of the study and triangulation of the results.

V. ANALYSIS

A five-stage thematic analysis [43] was adopted for data analysis. First, open coding of the data was conducted where three researchers independently preliminarily identify the themes. Secondly, these initial codes were then compared, discussed and continued to be revised during the interaction with data until mutually agreed themes were developed. Third, the initial list of codes was re-examined, and the codes pertaining to the educator perceptions, as described in the relevant literature, were isolated. Fourth, data were grouped under different codes, allowing researchers to identify patterns and themes emerging. Lastly, through repeated scrutiny, the original contextualized descriptive codes were refined to answer the research questions. The different themes were interpreted within a broader social context. Various strategies were used to ensure reliability and accuracy. For example, different data sets were analyzed, including teacher reflections, and researchers' field diaries to triangulate the results. Also, three researchers independently analyzed data. Additionally, attention was paid to extreme cases, especially to negative evidence [43].

VI. RESULTS

A. Teacher beliefs

The first research question focused on teacher beliefs about wearable gaming in terms of benefits and drawbacks. Benefits described by the teachers included: conveniences, flexibility, "[wearable] provide people with convenient, on the go solutions to their everyday dilemmas." (ST). Many argued that wearable gaming would allow highly personalized learning to meet diverse learner needs. Helping with social emotional development was an advantage cited by many teachers. Some teachers, initially wary of wearable technology for various reasons like excessive screentime and potential distractions, later discovered potential benefits of wearable gaming on students' social-emotional development. LT's following comment exemplified this:

- So my first thought was, give the kids a break. We are inundated with technology as it is...But as I thought of my students with specific needs during stressful situations, it dawned on me how successful a wearable device would be vs. a timer or adult reminder. It would build personal capacity, independence and self-awareness way more than an adult reminder or cue would.

The teachers also identified a range of cons and challenges including becoming overly dependent on technology, the possibility of hazards, and inequality. The inequality-related challenges could be brought by a multitude of factors ranging from knowledge or language barriers to cost-associated issues. Students from with limited English proficiency or exposure to the technology might be hindered from effectively interacting with the systems. Students from low-income families, schools located in rural areas or under-resourced communities might get restricted access to or maintain wearable technologies due to their financial limitations. Since wearable technologies were attached to our bodies, potential risks, such as radiation or electric shock, or side effects like dizziness, existed. The following comments provided a nice summary:

- "In terms of cons, some include gradual complete reliance on technology, potential hazards and costs. Potential challenges include inability of some populations to navigate systems due to lack of technological knowledge or language barriers, as well as cost challenges related to obtaining and maintaining the wearable over time." (ST).

An interesting observation was that several themes were identified both as positive and negative. The first example was the health-related topic. From the positive side, teachers articulated how wearable gaming could be used for real time health monitoring, thus promoting healthy behaviors and encouraging a more active lifestyle. At the same time, some teachers also considered wearables as a con due to concerns about risks associated with them. For example, some cautioned that wearable gaming might cause "hypervigilance of targeted behaviors" (EF). Additional con included the unknown impact on health from using wearable gaming since "health effects of wearables are unclear" (TB). The engagement value was the second theme that teachers considered as both beneficial and detrimental. On the one hand, teachers believed wearable gaming would attract students' attention, thus leading to effective learning. On the other hand, concerns were raised about how wearable gaming "could be a distraction" (CP).

The concept of convenience and accessibility was a third topic discussed both as a pro and a con. The teachers repeatedly stated that a benefit of wearable gaming was "being able to be worn provides a sense of convenience" (SM). At the same time, several participants deliberated that a con of wearable gaming was students could suffer from too much exposed to technology, as exemplified by SM: "some parents may not want their children to be exposed to technology consistently."

The last theme that was taken up as both positive and negative related to equity. Wearable gaming was perceived as a tool that could level the playing field because it could allow anyone to access it any time and any place. In contrast, it might create inequality due to various factors such as cost, visually impaired users, social divide, etc.

B. Teacher envisioned use

How did teachers envision wearable gaming to be used for educational purposes? A high number of teachers discussed how they foresaw the use of wearable gaming in helping with daily life skill and functioning. Diverse ideas, ranging from calendar to alarm-type programs, to behavior reminders, were shared as meaningful application of wearable gaming.

One theme that emerged was the integration of wearable gaming with augmented and virtual reality (AR/VR). Examples included "glasses could integrate AR to run scavenger hunts. VR headset could be used for simulations" (TB), or "virtual reality for history (seeing events as they happened)" (MM).

Health related topics, including mental health, were discussed by many participants. How to use wearable gaming to encourage healthy lifestyle both in schools and other workplace settings were mentioned repeatedly.

- Reviewing logs for mood, etc. may allow users to gain insights into times of day or activities that are particularly challenging or health-promoting across their day. (EF).
- In a larger workplace setting, challenges between peers would be a great way to use [wearable gaming]. A fitness challenge between coworkers might provide opportunities for involvement in a healthy lifestyle. (SF)

A closely related theme identified related to social emotional development. The teachers articulated how wearable gaming could be a valuable tool to help students manage their emotions and improve their social-emotional wellbeing.

- I would love to see a wearable device that supports social emotional well-being by providing breathing techniques with visuals for students to follow. It could encourage who struggle with sharing their emotions to have private opportunity to work on and show those skills. (KP)
- In the context of social-emotional development, a built-in reminder to breathe or use a variety of calm down/sensory activities when heart rate increases due to stress, overstimulation, etc. tailored to specific students. (LT)

Content learning, of course, was discussed by some teachers. The teachers described various approaches to using wearables, ranging from short quiz games to teach STEM to interactive activities for developing social skills. Examples that were shared by the teachers included:

- Content-based games that are brief & fast paced (e.g., quick math games based on telling time, sight word games, etc.) (SC).
- As a math teacher, I would love to access wearable gaming for educational purposes. If the wearable gaming device allows students to track their speed and time, we could measure a multitude of different scenarios. Using this data...students could solve for equations in relation to their data tables. This type of learning activity would change the way students view algebra concepts (TK).
- In a formal setting I could see using it as a way to incorporate some games into the lesson, such as that one game where the person wears their identity on their head and other people give them clues about it to enhance their social and team building skills (SM).

Equity was another theme identified. Teachers explained how they could use wearable gaming to provide differentiated learning to help diverse learners such as those with special needs.

- In classrooms, students with attention challenges could be quietly prompted to monitor if they are on task or not. I could imagine building reward systems or a game-related component to earn points. (EF)
- Wearable gaming could be a great way to seamlessly bring differentiation into a lesson and level the playing field for all students. (SR).

Heightening social connection and collaboration to break the brick and mortal boundaries was another theme that emerged.

- Students could connect in group activities without having to physically sit next to each other. (BD)

VII. Discussion

Today's rapid growth of technology and its variety of interconnected devices that are small and affordable gave way to a new technology market – wearable technology. Although with great potential, how to harness the power of wearable technology and gaming, especially in K-12 classrooms, remains largely missing in the current body of literature. Aiming to address this gap, this study has explored practicing teachers' perceptions related to wearable gaming.

Several results from the analysis of data are worthy of further discussion. The most significant contribution of this study is the revelation that teachers identified some benefits of wearables, which they also perceived as drawbacks. Health related topics are the first to exhibit this ambivalent relationship. For example, teachers recognize great benefits of wearable gaming in promoting and encouraging healthy, active lifestyles. On the flip side, teachers are concerned about potential risks such as hypervigilance of targeted behaviors and unclear health effects associated with wearable gaming.

The second example of this contradictory belief relates to the engagement value of wearable gaming. Teachers view the huge benefits of wearable gaming for capturing students' attention, thus enhancing learning, while at the same time considering it detrimental due to potential distractions. Teachers perceived that wearable gaming can increase students' interest in learning, which aligns with the previous research [23] that students are excited to actively learn through wearable gaming.

A third example of such seemingly conflicting viewpoints is that teachers discuss the convenience of wearable gaming, while at the same time expressing concerns about excessive technology exposure. This is similar to the results of a previous study [31], which found that teachers acknowledge the potential of wearable technology in schools yet also present possible negative effects like health and safety issues. Equity is the fourth topic that elicited teacher divergent opinions. On the one hand, wearable gaming can promote equal access due to its

anytime, anywhere availability. On the other hand, cost, social divide, etc. can exacerbate inequality.

In this study, teachers have shared their diverse visions for using wearable gaming, from using wearables for different subjects, to promoting collaboration. It suggests the multitude of possibilities that teachers see in using wearable gaming in their classrooms. Yet, the opposing stances shared by the teachers highlight the importance of professional development to ensure all teachers gain a thorough understanding of the pros and cons, and best practices with wearable gaming. Such deepened understanding can help align teachers' perspectives and allow them to create a more effective approach. To ensure wearable gaming is not a fad, it needs to be integrated intentionally, with teacher awareness, alignment to broader systems, and the provision of unique kinesthetic learning opportunities.

Just like any educational research, there are limitations of this work. First, this is a qualitative study with no quantitative data analyzed. Future research is recommended to include quantitative data in order to gain a broader perspective. Secondly, the study focuses on in service educators only. We suggest additional research also explore preservice teacher perspectives.

VIII. CONCLUSION

The gaming market is still growing with an expected value of US $545.98 billion dollars by 2028, according to the 2022 Fortune Business Insights [44]. Further, gaming is becoming more and more diversified: being played pervasively (e.g., AR games), on new platforms (e.g., VR, mobile games), being played by different groups (e.g., different age levels, both male and females, etc.) [41]. Wearable gaming undoubtedly has its advantages including but not limited to, allowing our body to be used as a controller, enabling more flexible playing and promoting social connections. Yet, wearable game-based learning has little success in education, partly due to its recent emergence. This study addresses the gap in the literature related to wearable gaming and teacher perceptions, adding valuable information to help us understand the value and design considerations of wearables in the context of wearable gaming. Practically, the results of this study are readily understandable by practitioners, which can help guide game designers, developers and educators to best design and use of wearable gaming for educational purposes.

Note: An earlier version of this paper was presented at the 16th International Conference on Mobile, Hybrid, & Online Learning (eLML2024), Barcelona, Spain.

AI tools such as Google Gemini and Grammarly were used to help generate initial ideas and offer editing assistance. The tools were used in the same way as one might employ a writing tutor.

REFERENCES

[1] Li, Q. (2024). Wearable Technology and Gaming: A study of teacher perspectives. Proceedings of eLmL 2024: The Sixteenth International Conference on Mobile, Hybrid, and On-Line Learning

[2] Federation of American Scientists. (2006). Summit on educational games: Harnessing the power of video games for learning. In: Author Washington, DC.J. Clerk Maxwell, *A Treatise on Electricity and Magnetism*, 3rd ed., vol. 2. Oxford: Clarendon, pp.68–73, 1892.

[3] Clark, D. B., Tanner-Smith, E. E., & Killingsworth, S. S. (2016). Digital games, design, and learning: A systematic review and meta-analysis. *Review of Educational Research*, 86(1), 79-122.K. Elissa, "Title of paper if known," unpublished

[4] Klopfer, E., Osterweil, S., Groff, J., & Haas, J. (2009). The instructional power of digital games, social networking, simulations and how teachers can leverage them.Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," *IEEE Transl. J. Magn. Japan*, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[5] Li, Q. (2014). Learning Through Digital Game Design and Building in A Participatory Culture: An Enactivist Approach. Peter Lang.Electronic Publication: *Digital Object Identifiers* (DOIs):

[6] An, Y.-J., & Cao, L. (2017). The Effects of Game Design Experience on Teachers' Attitudes and Perceptions regarding the Use of Digital Games in the Classroom. TechTrends, 61(2), 162-170.European Space Agency. *ESA: Missions, Earth Observation: ENVISAT*. [Online]. Available from: http://envisat.esa.int/ 2008.06.25

[7] Motti, V. G. (2019). Wearable technologies in education: a design space. Learning and Collaboration Technologies. Ubiquitous and Virtual Environments for Learning and Collaboration: 6th International Conference, LCT 2019, Held as Part of the 21st HCI International Conference, HCII 2019, Orlando, FL, USA, July 26–31, 2019, Proceedings, Part II 21,H. Goto, Y. Hasegawa, and M. Tanaka, "Efficient Scheduling Focusing on the Duality of MPL Representatives," Proc. IEEE Symp. Computational Intelligence in Scheduling (SCIS 07), *IEEE Press*, Dec. 2007, pp. 57-64. doi:10.1109/SCIS.2007.357670

[8] Bower, M., Sturman, D., & Alvarez, V. (2016). Perceived utility and feasibility of wearable technologies in higher education. Mobile Learning Futures–Sustaining Quality Research and Practice in Mobile Learning, 49

[9] Antonioli, M., Blake, C., & Sparks, K. (2014). Augmented reality applications in education. *The Journal of technology studies*, 96-107

[10] Almusawi, H. A., & Durugbo, C. M. (2024). Determinants of teacher attitudes and innovative use of wearable technology. *IEEE Transactions on Learning Technologies*

[11] Ometov, A., Shubina, V., Klus, L., Skibińska, J., Saafi, S., Pascacio, P., Flueratoru, L., Gaibor, D. Q., Chukhno, N., & Chukhno, O. (2021). A survey on wearable technology: History, state-of-the-art and current challenges. *Computer Networks*, 193, 108074

[12] Almusawi, H. A., Durugbo, C. M., & Bugawa, A. M. (2021). Wearable technology in education: A systematic review. *IEEE Transactions on Learning Technologies*, 14(4), 540-554

[13] Lee, V. R., & Shapiro, R. B. (2019). A broad view of wearables as learning technologies: Current and emerging applications. Learning in a digital world: Perspective on interactive technologies for formal and informal education, 113-133

[14] Windasari, N. A., & Lin, F.-r. (2021). Why do people continue using fitness wearables? The effect of interactivity and gamification. *SAGE Open*, 11(4). https://doi.org/10.1177/21582440211056606

[15] Canhoto, A. I., & Arp, S. (2017). Exploring the factors that support adoption and sustained use of health and fitness wearables. *Journal of marketing management*, 33(1-2), 32-60

[16] Rani, N., & Chu, S. L. (2022). Wearables can help me learn: A survey of user perception of wearable technologies for learning in everyday life. *Education and Information Technologies*, 27(3), 3381-3401

[17] Ermi, L., & Mäyrä, F. (2005). Fundamental components of the gameplay experience: Analysing immersion. Proceedings of DiGRA 2005 Conference: Changing Views: Worlds in Play

[18] Högberg, J., Hamari, J., & Wästlund, E. (2019). Gameful experience questionnaire: Measuring the gamefulness of service use. *Frontiers in Service 2019*, National University of Singapore, 18-21 July 2019.

[19] Petkov, P., Köbler, F., Foth, M., Medland, R., & Krcmar, H. (2011). Engaging energy saving through motivation-specific social comparison. In CHI'11 Extended Abstracts on Human Factors in Computing Systems, 1945-1950.

[20] Al-Emran, M., Al-Nuaimi, M. N., Arpaci, I., Al-Sharafi, M. A., & Anthony Jnr, B. (2023). Towards a wearable education: Understanding the determinants affecting students' adoption of wearable technologies using machine learning algorithms. *Education and Information Technologies*, 28(3), 2727-2746

[21] Sharma, K., Pappas, I., Papavlasopoulou, S., & Giannakos, M. (2019). Towards automatic and pervasive physiological sensing of collaborative learning

[22] Daniels, J., Haber, N., Voss, C., Schwartz, J., Tamura, S., Fazel, A., Kline, A., Washington, P., Phillips, J., & Winograd, T. (2018). Feasibility testing of a wearable behavioral aid for social learning in children with autism. *Applied clinical informatics*, 9(01), 129-140

[23] Nugent, G., Barker, B., Lester, H., Grandgenett, N., & Valentine, D. (2019). Wearable textiles to support student STEM learning and attitudes. *Journal of Science Education and Technology*, 28, 470-479

[24] Klopfer, E., Yoon, S., & Rivas, L. (2004). Comparative analysis of Palm and wearable computers for Participatory Simulations. *Journal of Computer Assisted Learning*, 20(5), 347-359

[25] Ko, Y. C., & Hsieh, C.-W. (2016). We wave II, an interactive somatic game in an immersive and participative environment. Proceedings of the 2016 Virtual Reality International Conference

[26] Voss, C., Schwartz, J., Daniels, J., Kline, A., Haber, N., Washington, P., Tariq, Q., Robinson, T. N., Desai, M., & Phillips, J. M. (2019). Effect of wearable digital intervention for improving socialization in children with autism spectrum disorder: a randomized clinical trial. *JAMA Pediatrics*, 173(5), 446-454

[27] Elton, K. (2019). How smart watches could revolutionize the education industry. In: The Innovation Enterprise

[28] Krey, M. (2020). Wearable device technology in healthcare—Exploring constraining and enabling factors. Fourth International Congress on Information and Communication Technology: ICICT 2019, London, Volume 1

[29] Wu, T., Dameff, C., & Tully, J. (2014). Integrating Google Glass into simulation-based training: experiences and future directions. *Journal of Biomedical Graphics and Computing*, 4(2), 49

[30] Zarraonandia, T., Aedo, I., Díaz, P., & Montero, A. (2013). An augmented lecture feedback system to support learner and teacher communication. *British Journal of Educational Technology*, 44(4), 616-628.

[31] Wort, G. K., Wiltshire, G., Peacock, O., Sebire, S., Daly-Smith, A., & Thompson, D. (2021). Teachers' Perspectives on the Acceptability and Feasibility of Wearable Technology to Inform School-Based Physical Activity Practices. *Frontiers in Sports and Active Living*, 3, 777105. https://doi.org/https://doi.org/10.3389/fspor.2021.777105

[32] Sahin, N. T., Keshav, N. U., Salisbury, J. P., & Vahabzadeh, A. (2018). Second version of google glass as a wearable socio-affective aid: Positive school desirability, high usability, and theoretical framework in a sample of children with autism. *JMIR human factors*, 5(1), e8785

[33] Holstein, K., Hong, G., Tegene, M., McLaren, B. M., & Aleven, V. (2018). The classroom as a dashboard: Co-designing wearable cognitive augmentation for K-12 teachers. Proceedings of the 8th international conference on learning Analytics and knowledge

[34] Niknejad, N., Ismail, W. B., Mardani, A., Liao, H., & Ghani, I. (2020). A comprehensive overview of smart wearables: The state of the art literature, recent advances, and future challenges. *Engineering Applications of Artificial Intelligence*, 90. https://doi.org/10.1016/j.engappai.2020.103529

[35] Girginov, V., Moore, P., Olsen, N., Godfrey, T., & Cooke, F. (2020). Wearable technology-stimulated social interaction for promoting physical activity: A systematic review. *Cogent Social Sciences*, 6(1), 1742517

[36] Kirk, M. A., Amiri, M., Pirbaglou, M., & Ritvo, P. (2019). Wearable technology and physical activity behavior change in adults with chronic cardiometabolic disease: a systematic review and meta-analysis. *American Journal of Health Promotion*, 33(5), 778-791

[37] Santos-Gago, J. M., Ramos-Merino, M., Vallarades-Rodriguez, S., Álvarez-Sabucedo, L. M., Fernández-Iglesias, M. J., & García-Soidán, J. L. (2019). Innovative use of wrist-worn wearable devices in the sports domain: A systematic review. *Electronics*, 8(11), 1257. https://doi.org/10.3390/electronics8111257

[38] Ozanne, A., Johansson, D., Hällgren Graneheim, U., Malmgren, K., Bergquist, F., & Alt Murphy, M. (2018). Wearables in epilepsy and Parkinson's disease—a focus group study. *Acta Neurologica Scandinavica*, 137(2), 188-194

[39] Khakurel, J., Melkas, H., & Porras, J. (2018). Tapping into the wearable device revolution in the work environment: a systematic review. *Information Technology & People*, 31(3), 791-818

[40] Schroeder, N. L., Romine, W. L., & Kemp, S. E. (2023). A Scoping Review of Wrist-worn Wearables in Education. *Computers and Education Open*, https://doi.org/10.1016/j.caeo.2023.100154

[41] Xi, N., Chen, J., Jabari, S., & Hamari, J. (2024). Wearable gaming technology: A study on the relationships between wearable features and gameful experiences. *International Journal of Human-Computer Studies*, 181. https://doi.org/10.1016/j.ijhcs.2023.103157

[42] Creswell, J. (1998). Qualitative Inquiry and Research Design; Choosing Among Five Traditions. *Sage Publications*

[43] Creswell, J. W. (2014). Research design: Qualitative, quantitative, and mixed methods approaches (4th ed.). *Sage*

[44] Insights, F. B. (2021). Gaming Market Worth $545.98 Billion by [2021-2028] (Fortune Business Insights, Issue. https://www.globenewswire.com/news-release/2021/09/22/2301712/0/en/Gaming-Market-Worth-545-98-Billion-by-2021-2028-Fortune-Business-Insights.html