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Leveraging Wearable Technology to Enhance STEM Education: Benefits, and Challenges

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ABSTRACT
This study adopted a descriptive survey research, designed to leveraging wearable technology to enhance Science Technology, Engineering and Mathematics education: Benefits and Challenges. The study was carried out at Glory Bond Montessori School, Rumuolumeni, Port Harcourt and Golden citadel school, Rumuolumeni, Port Harcourt. The population of the study is 52 teachers from the two schools selected for the study. A sample of 26 teachers was used for the study. Simple random sampling techniques were used for the study. A structured questionnaire titled leveraging wearable technology to enhance STEM education: Benefits and Challenges (LWTSTEMEBC) with 20 items. Face and content validity was used for the study. Reliability coefficient of 0.72 was obtained. Mean and z-test was used for the study. The study found that STEM disciplines can be made more engaging by combining wearable technology with gamified learning platforms and also students can find studying more fun and inspiring when they receive points, badges, or rewards for finishing assignments or reaching objectives. Furthermore, it was found that adaptive learning platforms that modify the type and level of content according to a student's performance and preferences can be integrated with wearable technology. Based on the findings, the researchers recommended that the government should create programs and alliances to supply schools in underprivileged areas with wearable technology.

1. INTRODUCTION

Wearable technology can provide customized feedback based on each learner's unique requirements. According to research, these gadgets can monitor students' development and modify course materials to better fit their preferred methods of learning. Wearable technology facilitates the connection between theory and real-world implementation. Students can see how STEM ideas are used in practical settings, like when wearable technology is used to track environmental factors or physiological reactions. Students can instantly exchange data and insights thanks to wearables, which can improve collaborative learning. In a group context, this fosters collaboration and improves problem-solving abilities [1].

Teachers can learn more about students' academic performance and learning habits by using wearable data. This data aids in improving instructional techniques and pinpointing areas that need more assistance. One obstacle to the broad adoption of wearable technology in schools is its expensive cost. Preventing inequalities in educational possibilities requires ensuring equitable access. Wearable technology raises serious privacy and security concerns since it collects personal data. Schools must put policies in place to safeguard student information and adhere to applicable laws [2].

Careful preparation and assistance are needed to successfully incorporate wearable technology into current courses. To use these resources in line with learning goals, teachers need to have sufficient training. Technical concerns with wearables, such malfunctions or communication problems, can interfere with learning. To overcome these obstacles, ongoing maintenance and expert assistance are required. If wearables are not used properly, there is a chance that they could become distracting. It is essential to make sure that these technologies contribute to learning rather than hinder it [3]. Abstract ideas become more concrete and applicable when they are connected to the real world [4]. By enabling real-time data and insight

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sharing, wearable technology can support collaborative learning. As students collaborate to evaluate and understand data gathered from their wearables, this feature fosters teamwork and improves problem-solving abilities [5].

To avoid inequalities and guarantee that all students may profit from their use, it is imperative to guarantee fair access to these technologies [6].

To successfully integrate these resources into their courses and make sure they support learning goals, teachers require professional development. Technical concerns, such as communication problems and device malfunctions, can arise with wearable technology. These problems can interfere with education and require constant maintenance and professional assistance [7]. If wearables are not used properly, they run the risk of becoming a distraction. In order to prevent any abuse or misuse, it is crucial to make sure that these technologies improve rather than diminish the educational process. By offering more engaging and dynamic learning opportunities, these developments could further enhance STEM education [8].

Best practices and areas for development will be identified with the aid of ongoing research on wearable technology's efficacy in educational environments. To further the use of these technologies in STEM education, cooperation between researchers, educators, and technologists will be crucial. It is essential to create efficient plans for incorporating wearable technology into STEM courses. This entails developing thorough lesson plans that make use of wearable technology's special features and coordinating them with academic standards and goals [9]

Developing lesson plans that take advantage of wearable technology's special capabilities is one way to do this [10]. Maximizing the advantages of wearable technology will require addressing concerns about equity and accessibility. All students will be able to gain from efforts to lower expenses and provide fair access. The potential for STEM education will continue to grow as new wearable applications are investigated, such as enhanced field excursions or virtual simulations [11].

There are many chances to improve student engagement, customize learning, and relate abstract ideas to practical applications when wearable technology is used into STEM (Science, Technology, Engineering, and Mathematics) education. Notwithstanding these possible advantages, a number of problems prevent wearable technology from being implemented and used in educational contexts. First off, wearable technology's exorbitant price is a big deterrent to its broad use, especially in schools with little funding. All kids cannot equally benefit from these cutting-edge resources because of this discrepancy, which restricts access and equity. Second, significant preparation and assistance are needed to incorporate wearables into current courses. Suboptimal use and lower educational outcomes may result from teachers' lack of resources and training to integrate these technologies into their classes.

Strict safeguards are required to preserve student privacy since the administration and collecting of personal data through wearables raises significant concerns about how this data is used, stored, and safeguarded. Lastly, even though wearable technology has the potential to improve group learning and offer data-driven insights, further research is required to assess its efficacy and identify the best ways to use it into STEM education. Addressing these issues is crucial for realizing the full potential of wearable technology in enhancing STEM education and ensuring that its benefits are equitably distributed among all students.

The aim of the study is to examine leveraging wearable technology to enhance STEM education: Benefits, challenges, and future directions. Specifically the study intends to:

Assess how the integration of wearable technology influences student engagement and motivation in STEM subjects in Glory Bond Montessori School and Golden Citadel School

Examine how wearable technology can be used to provide personalized learning experiences in Glory Bond Montessori School and Golden Citadel School

Identify and analyze the challenges associated with integrating wearable technology into STEM curricula in Glory Bond Montessori School and Golden Citadel School

Investigate the privacy and security implications of using wearable technology in educational settings in Glory Bond Montessori School and Golden Citadel School

Based on the objectives, the following research questions were drawn:

In what ways does wearable technology impact students' motivation to learn STEM subjects in Glory Bond Montessori School and Golden Citadel School?

How can wearable technology be utilized to provide personalized learning experiences in STEM education in Glory Bond Montessori School and Golden Citadel School?

What is the primary challenges teachers face when integrating wearable technology into STEM curricula in Glory Bond Montessori School and Golden Citadel School?

What is the privacy concerns associated with using wearable technology in educational settings in Glory Bond Montessori School and Golden Citadel School?

Wearable technologies, such as smartwatches, fitness trackers, VR headsets, and augmented reality (AR) glasses, can greatly enhance student interest in STEM disciplines. These technologies deliver interactive and immersive experiences that make learning more engaging and hands-on. For example, AR and VR headsets can provide students with an interesting and dynamic way to examine complex STEM ideas, such virtual dissections in biology or viewing 3D chemical compounds. This can increase students' interest and enthusiasm to learn by bridging the gap between abstract ideas and practical applications [4].

Wearables gather data on students' performance, progress, and levels of interest in real time, allowing for more individualized learning experiences. Analysis of this data can be used to modify course content, give students personalized feedback, and pinpoint areas in which they might require further assistance. For instance, fitness trackers and smartwatches can detect physiological reactions during STEM activities, giving teachers insight into how students' excitement or stress levels connect to particular assignments [12].

A fundamental element of STEM education, experiential learning, is made possible by wearable technology. Students can perform virtual experiments and simulations in otherwise inaccessible environments by using gadgets like haptic feedback gloves or smart glasses. For instance, wearable sensors can be used in physics experiments to measure acceleration, force, or heart rates, allowing students to collect and analyze real-time data directly. According to[13], budgetary constraints prevent the widespread adoption of wearable technology in classrooms, and the requirement for supporting infrastructure, such as dependable internet connections and compatible software, exacerbates these problems. STEM education places a strong emphasis on the development of data literacy and analytical skills. Wearables can collect a wide range of data (e.g. physical activity, environmental conditions, physiological metrics), allowing students to participate in data-driven projects.

Because wearable technology makes learning more interactive, individualized, and data-driven, it has the potential to revolutionize STEM education. To optimize its influence, however, issues like exorbitant expenses, privacy issues, and the requirement for teacher preparation must be resolved. Future studies should concentrate on creating applications that are in line with the curriculum, combining wearables with cutting-edge technologies, and examining the tools' long-term impacts in learning environments. Wearable technology can significantly contribute to preparing students for the needs of the STEM workforce of the twenty-first century if the proper tactics and assistance are provided.

2. MATERIALS AND METHODS

This study adopted a descriptive survey research, designed to examine leveraging wearable technology to enhance STEM education: Benefits and Challenges. The study was carried out at Glory Bond Montessori School, Rumuolumeni, Port Harcourt and Golden citadel school, Rumuolumeni, Port Harcourt. The population of the study is 52 teachers from the two schools selected for the study. A sample of 26 teachers was used for the study. Simple random sampling techniques were used for the study. A structured questionnaire titled leveraging wearable technology to enhance STEM education: Benefits and Challenges (LWTSTEMEBC) with 20 items. Face and content validity was used for the study. Reliability coefficient of 0.72 was obtained. Mean was used to answer the research questions while z-test was used to test the hypotheses.

This study was conducted in accordance with ethical standards. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

3. RESULTS

Research Question 1

In what ways does wearable technology impact students' motivation to learn STEM subjects?

Table 1 showed that with the mean score of 3.83, the study found that STEM disciplines can be made more engaging by combining wearable technology with gamified learning platforms. Students can find studying more fun and inspiring when they receive points, badges, or rewards for finishing assignments or reaching objectives.

Table 1. Ways wearable technology impact students' motivation to learn STEM subjects

S/N	Items Ways wearable technology impact students' motivation to learn STEM subjects	SA	A	SD	D	M	SD	Total Respondents
1	Learning is made more dynamic and interesting by wearable technology, such as fitness trackers, smartwatches, and virtual reality headsets.	16	10	-	-	3.61	0.50	26
2	Students can stay motivated to stay involved and work toward improved outcomes by receiving immediate feedback on their performance from wearables, which can help them understand their progress and areas that need development.	21	5	-	-	3.80	0.24	26
3	Personalized learning experiences are made possible by wearable technology's ability to gather information about students' learning preferences and habits.	17	9	-	-	3.65	0.48	26
4	STEM disciplines can be made more engaging by combining wearable technology with gamified learning platforms. Students can find studying more fun and inspiring when they receive points, badges, or rewards for finishing assignments or reaching objectives.	24	2	-	-	3.92	0.31	26
5	Wearable technology makes experiential and hands-on learning easier.	22	4	-	-	3.84	0.37	26
	Average Mean					**3.76**	**0.38**	

Mean (M); Standard deviation (SD)

Research Question 2

How can wearable technology be utilized to provide personalized learning experiences in STEM education?

Table 2. How wearable technology can be utilized to provide personalized learning experiences in STEM education

S/N	Items How wearable technology can be utilized to provide personalized learning experiences in STEM education	SA	A	SD	D	M	SD	Total Respondents
1	Real-time tracking of students' actions, development, and engagement levels is possible with wearable technology; trends can be found in the data and learning experiences can be tailored to meet the needs of each individual.	13	13	-	-	3.50	0.52	26
2	Smartwatches and other devices can track physiological indicators, such as heart rate and stress levels, to determine how well pupils are responding to various learning tasks.	15	11	-	-	3.57	0.49	26
3	Adaptive learning platforms that modify the type and level of content according to	25	1	-	-	3.96	0.36	26

	a student's performance and preferences can be integrated with wearable technology.							
4	A student's progress can be continuously tracked by wearable technology, which can also offer resources and personalized feedback.	14	12	-	-	3.53	0.51	26
5	Students can perform experiments in a regulated, customized setting by using wearable technology to enable virtual labs and simulations. This practical method accommodates varying learning styles and rates.	18	8	-	-	3.69	0.46	26
	Average Mean					**3.65**	**0.46**	

Mean (M); Standard deviation (SD)

Table 2 showed that with the mean score of 3.82, the study found that adaptive learning platforms that modify the type and level of content according to a student's performance and preferences can be integrated with wearable technology.

Research Question 3

What is the primary challenges educators face when integrating wearable technology into STEM curricula?

Table 3. Primary challenges educators face when integrating wearable technology into STEM curricula

S/N	Items Primary challenges educators face when integrating wearable technology into STEM curricula	SA	A	SD	D	M	SD	Total Respondents
1	It can be difficult to guarantee that every student has equal access to wearable technology; pupils from various socioeconomic backgrounds may have varied levels of access, which could exacerbate the digital divide.	20	6	-	-	3.76	0.43	26
2	Strong technological infrastructure, such as dependable internet connectivity, sufficient bandwidth, and compatible devices, is frequently needed to integrate wearable technology.	18	6	2	-	3.61	0.62	26
3	Concerns over student privacy are raised by the massive volumes of personal data that wearable technology gathers.	19	7	-	-	3.73	0.44	26
4	In order to prevent unauthorized access and data breaches, schools must implement strong cybersecurity measures to safeguard wearable technology and the data they gather from online threats.	15	10	1	-	3.53	0.56	26
5	Some students could be reluctant to embrace new technology because they are uncomfortable or unfamiliar with it. It can be challenging to guarantee that every student is at ease and actively using wearable technology.	21	4	1	-	3.76	0.51	26
	Average Mean							

Mean (M); Standard deviation (SD)

Table 3 showed that with the mean score of 3.66, the study showed that some students could be reluctant to embrace new technology because they are uncomfortable or unfamiliar with it. It can be challenging to guarantee that every student is at ease and actively using wearable technology.

Research Question 4

What is the privacy concerns associated with using wearable technology in educational settings?

Table 4. Privacy concerns associated while using wearable technology

S/N	Items Privacy concerns associated while using wearable technology	SA	A	SD	D	M	SD	Total Respondents
1	Sensitive personal information is frequently gathered via wearable technology, including location data, usage patterns, and physiological data (such as heart rate and activity levels).	14	10	2	-	3.46	0.66	26
2	Large volumes of personal data storage raise the possibility of data breaches; abuse, identity theft, and other negative outcomes might result from unauthorized access to this data.	12	14	-	-	3.46	0.53	26
3	It can be difficult to get students' and their guardians' informed consent, but it is vital to make sure that everyone is aware of the dangers involved, the nature of the data being gathered, and how it will be used.	25	1	-	-	3.96	0.35	26
4	Transparency regarding data collection procedures is essential for both schools and technology providers. This includes outlining data policies, the reason for data collection, and the ways in which the data will be used, shared, or sold.	19	6	1	-	3.69	0.53	26
5	Concerns have been raised over the ownership of the data gathered by wearable technology; parents, students, and educational institutions need to know if the data is the property of the school or the student and what rights they have over it.	20	6	-	-	3.76	0.43	26
	Average Mean					**3.66**	**0.50**	

Mean (M); Standard deviation (SD)

Table 4 showed that with the mean score of 3.74, the study found that it can be difficult to get students' and their guardians' informed consent, but it is vital to make sure that everyone is aware of the dangers involved, the nature of the data being gathered, and how it will be used.

Hypotheses

HO1

There is no significant difference between teachers in Glory Bond Montessori School and Golden Citadel School's ways that wearable technology impact student's motivation to learn Science, technology, engineering and Mathematics subjects (STEM)

Table 5. Table of analysis to determine the significant difference between teachers in Glory Bond Montessori School and Golden Citadel School's ways that wearable technology impact student's motivation to learn Science, technology, engineering and Mathematics subjects (STEM)

Group	M	SD	N	Df	SE	Z (Cal)	Z (Tab)	Decision
Glory Bond Montessori School	5.4	49.08	13	24	0.69	0.72	2.10	Accepted
Golden Citadel School	4.9	32.93	13					

Standard Error (SE), Mean (M); Standard deviation (SD)

If the absolute value of the calculated T-statistic (tcal) is greater than the critical T-value (tab), we reject the null hypothesis. Therefore, there is no statistically significant difference between the mean scores of students from Glory Bond Montessori School and Golden Citadel School. This suggests that any observed difference in the sample means is likely due to random chance rather than a true difference in performance between the two groups.

HO2

There is no significant difference between Glory Bond Montessori School and Golden Citadel School's teachers use wearable technology to provide personalized learning experiences in STEM Education.

Table 6. Table of analysis to determine the significant difference between Glory Bond Montessori School and Golden Citadel School's teachers use wearable technology to provide personalized learning experiences in STEM Education

Group	M	SD	N	Df	SE	Z (Cal)	Z (Tab)	Decision
Glory Bond Montessori School	4.23	44.31	13	24	0.67	0.70	2.10	Accepted
Golden Citadel School	3.76	26.44	13					

Standard Error (SE), Mean (M); Standard deviation (SD)

If the absolute value of the calculated T-statistic (tcal) is greater than the critical T-value (tab), we reject the null hypothesis. Therefore, there is no statistically significant difference between the mean scores of students from Glory Bond Montessori School and Golden Citadel School. This suggests that any observed difference in the sample means is likely due to random chance rather than a true difference in performance between the two groups.

HO3

There is no significant difference between Glory Bond Montessori School and Golden Citadel School's teachers challenges faced when integrating wearable technology into STEM curriculum

Table 7. Table of analysis to determine the significant difference between Glory Bond Montessori School and Golden Citadel School's teachers' challenges faced when integrating wearable technology into STEM curriculum

Group	M	SD	N	Df	SE	Z (Cal)	Z (Tab)	Decision
Glory Bond Montessori School	5.23	36.30	13	24	0.68	1.02	2.10	Accepted
Golden Citadel School	4.53	37.23	13					

Standard Error (SE), Mean (M); Standard deviation (SD)

If the absolute value of the calculated T-statistic (tcal) is greater than the critical T-value (tab), we reject the null hypothesis. Therefore, there is no statistically significant difference between the mean scores of students from Glory Bond Montessori School and Golden Citadel School. This suggests that any observed difference in the sample means is likely due to random chance rather than a true difference in performance between the two groups.

HO4

There is no significant difference between Glory Bond Montessori School and Golden Citadel School's privacy concerns associated with using wearable technology in educational settings

Table 8. Table of analysis to determine the significant difference between Glory Bond Montessori School and Golden Citadel School's privacy concerns associated with using wearable technology in educational settings

Group	M	SD	N	Df	SE	Z (Cal)	Z (Tab)	Decision
Glory Bond Montessori School	5.15	17.68	13	24	0.52	3.11	2.10	Rejected
Golden Citadel School	3.53	25.23	13					

Standard Error (SE), Mean (M); Standard deviation (SD)

Since the calculated Z-value (3.11) exceeds the critical Z-value (2.10), the null hypothesis is rejected. This implies that there is a significant difference between the privacy concerns of students from Glory Bond Montessori School and Golden Citadel School associated with the use of wearable technology in educational settings. The rejection of H_{04} suggests that students at the two schools experience privacy concerns at different levels when it comes to wearable technology, with Glory Bond Montessori School having a higher mean privacy concern score compared to Golden

Citadel School. This result could indicate differences in school culture, technology policies, or student familiarity with wearable technology, leading to varying levels of concern about privacy.

4. DISCUSSION

According to the current study, students who used wearable technology for interactive physics instruction demonstrated higher levels of engagement than those who used more conventional approaches [14]. The hands-on experience and real-time feedback that wearables like smartwatches and virtual reality headsets offered boosted motivation and interest in the topic. [15] discovered that teachers may modify classes in real time to fit each student's learning style by using wearable technology, such as fitness trackers and smart glasses, to assess students' cognitive load and physical activity. A more individualized educational experience and better academic achievement were the results of this customisation.

According to [16] major obstacles include the high expense of gadgets, the requirement for teacher preparation, and technical challenges. The survey also revealed opposition from certain educators who doubt wearable technology's ability to improve learning results. According to [17], wearable technology frequently gathers private information, including biometric data, which may be exposed to security breaches if improperly safeguarded. To protect student information, the study underlined the necessity of strong data protection regulations and the deployment of safe data management systems.

According to [18], students who used augmented reality (AR) glasses for group assignments revealed better communication and teamwork abilities. Real-time data sharing and visualization were made possible by the AR glasses, which improved teamwork and comprehension of challenging STEM subjects. Wearable technologies, such smart gloves and virtual reality headsets, greatly enhanced students' practical skills in lab settings, according to [19]. According to the study, these gadgets offered kids engaging and dynamic experiences that allowed them to hone their abilities in a safe, virtual setting. Their practical skills and self-assurance in conducting tests significantly improved as a result [20].

Discovered that students may gather data in real time during field experiments by employing smartwatches and wearable sensors. Through the use of specialist software, this data was subsequently examined, giving students the opportunity to learn more about scientific phenomena and hone their critical thinking abilities [21]. While many teachers acknowledged the potential advantages of wearable technology for student engagement and individualized learning, [22,23] discovered that others were worried about the implementation's viability. Significant difficulties were identified, including the necessity of professional development, equipment upkeep, and the alignment of technology with educational objectives.

5. Conclusion

Students' interest and engagement in STEM subjects can be improved by combining wearable technology with gamified learning systems. Wearable technology can accommodate a range of learning styles and speeds by offering an engaging, dynamic, and flexible learning environment, increasing the accessibility and appeal of STEM education. To fully reap the benefits of this technology, however, issues like guaranteeing fair access, getting informed consent, and resolving significant socioeconomic inequities must be resolved.

Recommendations

The government should create programs and alliances to supply schools in underprivileged areas with wearable technology. Draft thorough and intelligible permission forms that outline the types of data being gathered, their intended use, and any risks involved. To safeguard students' private information, implement stringent data privacy and security procedures. To provide individualized learning experiences, spend money on adaptive learning platforms that work in unison with wearable technology.

Conflict of Interest

No conflict of interest is declared by tehe authors. In addition, no financial support was received.

Ethics Committee

This study was conducted in accordance with ethical standards. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures.

Author Contributions

Study Design, KRY; Data Collection, KRY; Statistical Analysis, KRY; Data Interpretation, KRY; Manuscript Preparation, KRY; Literature Search, KRY.

REFERENCES

1. Almusawi, H. A., Durugbo, C.M., & Bugawa, A.M., (**2021**). Innovation in physical education: teachers' perspectives on readiness for wearable technology integration. *Comuter Education journal.* 167: 104185. [CrossRef]
2. Almusawi, H. A., Durugbo, C.M., & Bugawa, A.M., (**2021**). Innovation in physical education: teachers' perspectives on readiness for wearable technology integration. *Comuter Education journal.* 167: 104185. [CrossRef]
3. Barbosa, A., Whiting, S., Simmonds, P., Scotini, M., Mendes, R., & Breda, J., (**2020**). Physical activity and academic achievement: an umbrella review. *International journal of environmental research public health.* 17:5972. Doi: 10.3390/ijerph 1765972. [PubMed]
4. Matteucci, I., (**2021**). Wearable technologies as learning engines: Evaluations and perspectives. *Italian journal of sociology of education.* 13(1), 161-179. [CrossRef]
5. Shin, G. D., Wookyoung, J., & Hye-Eun, L., (**2023**). Factors affecting female college students' intention to use digital technology in wearable devices to stimulate health monitoring. Hellyon 9 (2023) e18118. [PubMed]
6. Shadiev, R., Hwang, W.Y., & Liu, T.Y., (**2018**). A study of the use of wearable devices for healthy and enjoyable English as a foreign language learning in authentic contexts. *Educational technology & society,* 21(4), 217-231.
7. Di Mitri, D., Schneider, J., Specht, M., & Drachsler, H., (**2018**). From signals to knowledge; A conceptual model for multimodal learning analytics. *Journal of computer assisted learning,* 34(4), 338-249. [CrossRef]
8. Qu, X.M., Wang, J. H., & Miao, R., (**2021**). Application of wearable technology in education. *Open access library journal,* 8:e7630. [CrossRef]
9. Stephen, R. K., Ng, N., Athanasios, T., Kenneth, M., Claudia, P., & Ewen, M. H., (**2021**). Mobile devices and wearable technology for measuring patient outcomes after surgery: a systematic review. *NPJ Digit Med.* 12, 4:157. [PubMed]
10. Wort, G. K., Gareth, W., Oliver, P., Simon, S., Daly-Smith, A., & Dylan, T., (**2021**). Teachers' perspectives on the acceptability and feasibility of wearable technology to inform school-based physical activity practices. *Front. Sports act. living,* 3:777105. [PubMed]
11. Chang, W., Hsu, C., Chen, L., Su, J., & Cheng, M., (**2020**). A wearable devices-based home sports recording system for health management. IEEE International conference on consumer electronics-Taiwan (ICCE-Taiwan), 1-2. [CrossRef]
12. Cheng, H., Bao, S., Lu, C., Wang, L., Ma, J., Wang, P., Lu, H., Shu, F., Oetomo, S.B., & Chen, W., (**2020**). Design of an integrated wearable multi-sensor platform based on flexible materials. *IEEE Access,* (8): 23732-23746. [CrossRef]
13. Godfrey, A., Hetherington, V., Shum, H., Bonato, P., Lovell, N. H., & Stuart, S., (**2018**). From A to Z: Wearable technology explained. *Journal of maturitas,* 113 (2018), 40-47. [CrossRef]
14. Philip, J., & Robin, H. K., (**2021**). Examining the use of wearable technologies for k-12 students: A systematic review of the literature. *Journal of digital life and learning.* 1(1), 56-67. [CrossRef]
15. Ng, K., & Ryba, T., (2**018**). The quantified athlete: Associations of wearable for high school athletes. Advances in human-computer interaction, 2018, [CrossRef]
16. Khosravi, S., Bailey, S.G., Parvizi, H., & Ghannam, R., (2022). Wearable sensors for learning enhancement in higher education. *Sensors journal.* [PubMed]
17. Engen, B. K., Giaever, T. H., & Mifsud, L., (**2018**). Wearable technologies in the K-12 classroom-Cross-disciplinary possibilities and privacy pitfalls. *Journal of interactive learning research,* 29(3), 323-341.
18. Dian, F., Vahidnia, R., & Rahmati, A., (**2020**). Wearables and the internet of things (IoT), applications, opportunities, and challenges: A survey. *IEEE Access,* 8, 69200-69211. [CrossRef]
19. Dehghani, M., Abubakar, A. M., & Pashna, M., (**2020**). Market-driven management of start-ups: The case of wearable technology. *Applied computing and informatics.* 18(1/2), 47-
20. Ciolacu, M.I., Binder, L., & Popp, H., (**2019**). Enabling IoT in education 4.0 with biosensors from wearables and artificial intelligence in 2019 IEEE 25th International symposium for design and technology in electronic packaging (SIITME) (Cluj-Napoca: IEEE0, 17-24. [CrossRef]
21. Cheng, K. H., & Tsai, C.C., (**2019**). A case study of immersive virtual field trips in an elementary classroom: students learning experience and teacher-student interaction behaviors. *Comput. Educ.* 140, 103600. [CrossRef]
22. Chu, S.L., Garcia, B. M., & Rani, N., (**2023**). Research on wearable technologies for learning: a systematic review. *Front. Educ.* 8:1270389. [CrossRef]
23. Siering, L., Ludden, G.D.S., Mader, A., & Van Rees, H., (**2019**). A theoretical framework and conceptual design for engaging children in therapy at home: The design of a wearable breathing trainer. *Journal of personalized medicine,* 9(2), 27-32. [PubMed]