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Promoting Water Environment Education through Digital Technology: A Case Study of Liuchuan Canalin Taichung City

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Abstract: Liuchuan Canal in Taichung City is a key water environment area. The "Endless Flow" research project aims to enhance water quality and highlight the watershed's historical and cultural aspects through the core concepts of safety, environment, and culture. The project established the "Endless Liuchuan Canal" digital tour platform, integrating local water environment information with engineering guides and mobile applications. It uses data analysis to assess effectiveness and attracts public engagement through gamified knowledge, intelligent services, and multifunctional robots. By May 2024, the platform had over 410,000 users. The project reached 2.55 million people through integrated marketing, including a launch event and parent-child activities, which garnered significant media attention. A May 2024 event saw high participation and satisfaction, promoting intergenerational learning through guided tours and AR games.

Keywords: Sustainable Development Education, Smart Technology, Water Environment Education

I. INTRODUCTION

Liuchuan Canal is an important water environment in Taichung City, flowing through densely populated and prime areas. To provide citizens with a safe and clean water environment, the core concepts of safety, environment and culture are emphasized. This includes strengthening connections with surrounding attractions and historical sites to enhance the safety of public facilities and optimize the benefits of the water and surrounding environment, showcasing the results and technologies of hydraulic engineering. Through navigation, knowledge transfer, and the expansion and diversification of water environment education applications, the aim is to continuously promote and diversify water environment education (Balbuena-Hernandez et al., 2023) [3], which is also the goal of this study in promoting water environment education.

In the process of promoting water environment education, efforts are made to enhance the understanding of the importance of water resources and encourage actions to protect the water environment. Through educational activities, advocacy measures, and technological innovations, community awareness is cultivated, promoting respect for and preservation of water culture. At the same time, schools are actively encouraged to participate in water environment protection efforts to facilitate the involvement of social learning processes in achieving the goal of ensuring water supply (Mott Lacroix, Xiu, & Megdal, 2016) [27]. Through these efforts, this study aims to integrate information about the water environment near Liuchuan Canal, improve water environment quality, showcase the historical and cultural aspects of the watershed, and attract the public to visit and enhance their understanding and recognition of the water environment through digital tours, mobile applications, and gamified river knowledge.

To fully leverage the promotional benefits of river and surrounding environment improvements, the "Endless Liuchuan Canal" mobile tour platform integrates scenic spot guides and historical information about Liuchuan Canal. Using positioning technology, a water-oriented smart mobile database has been developed to introduce the achievements and technologies of hydraulic engineering, serving as an extension of guided tours to promote knowledge transfer and enhance the function of water environment education. This includes the construction and expansion of a river mobile knowledge base. Additionally, participation in various virtual and physical integrated water environment and promotional activities aims to effectively enhance the best synergistic effects of river environment improvement and cultural promotion. This study uses system data analysis to assess overall effectiveness and applies curriculum design planning as material for workshop teaching plans. The curriculum design can be based on the natural landscape and historical culture around Liuchuan Canal, highlighting its development background and features. It provides curriculum design and plans for gamified carbon emission designs in response to the United Nations Sustainable Development Goals, net-zero emission policies, and carbon footprint-related issues. Examples of carbon emissions in daily life scenarios are explained, providing various quantifiable emissions. According to the research by Miller, Davis, Boyd, and

Danby (2014) [26], children's water-saving behaviors at home and in the community have a profound impact on their adulthood. Many teachers recognize the results of this study and therefore emphasize sustainable development education, ensuring that the concept of water resource protection is valued in early childhood education.

II. LITERATURE REVIEW

1. Key Learning Points of Water Environment Education

Water environment education aims to raise awareness of water resources and promote sustainable practices. It involves educating individuals about the importance of water conservation, the impact of human activities on water quality, and the importance of protecting aquatic ecosystems (da Silva & de Oliveira Costa, 2021; de Carvalho & de Barcellos, 2017) [6] [7]. Water resources and the water environment play crucial roles in ecosystems, human life, and the economy. Educating students about the importance of water resources is essential for fostering a sense of responsibility and awareness in water resource management. Studies have shown that students tend to have low knowledge and responsibility regarding water resource issues, water environment, and water pollution (Balbuena-Hernandez et al., 2023; Liu & Liang, 2023) [3] [24]. Therefore, enhancing water environment education and deepening students' understanding of water resource issues, including the impact of industrial discharge, agricultural fertilizers, and urban sewage treatment on water quality, is crucial for the safety of ecosystems and human drinking water (Lisetskii & Buryak, 2023) [23].

The United Nations Sustainable Development Goals (SDGs) Goal 6 emphasizes the importance of water resources for life and society. Focusing on ensuring the availability of clean drinking water and sanitation facilities. Implementing sustainable water management, maintaining water quality, promoting integrated water resources management, and creating an environment conducive to addressing water-related issues (Jaafar et al., 2023) [15]. Education plays a significant role in achieving sustainable water environment management by designing multidisciplinary teaching tools. Students can understand water resources from physical and biological perspectives and explore them from social, cultural, and ethical angles. Interactive learning connects knowledge with real-world problems, enriching students' learning experiences and providing necessary applications for global water resource challenges (Khiri et al., 2023; Mathur et al., 2023) [21].

Implementing sustainable development education programs focused on the New Culture of Water (NCW) enhances four competencies related to water management: Knowledge, Attitude, Perception, and Practices (KAPP). Such educational programs can have significant positive impacts and help cultivate students' awareness of water environment protection and management(Balbuena-Hernandez et al., 2023) [3]. Therefore, multidimensional and interdisciplinary water environment education can integrate diverse perspectives such as geography, ecology, and economics. Through interdisciplinary teaching methods, students can think about and understand water resource protection issues from different angles (Karyanto et al., 2023) [20], thereby comprehensively mastering relevant knowledge. Achieving carbon emissions reduction and promoting sustainable education are essential for addressing climate change. Higher education institutions (HEIs) play a crucial role in reducing carbon footprints and standardizing practices to set examples for other institutions (Lai, Wang, & Hsieh, 2023) [22]. Community-based carbon emission strategies are seen as key issues in environmental education and social responsibility, actively implementing effective governance and operations to address increasingly severe climate change and environmental pollution issues. Gamified education programs have proven effective in enhancing prosocial behaviors, particularly students' water-saving practices (Álvarez, Austin, Rodríguez, Mora, & De León, 2022) [1].

This study, based on a literature review of key learning points in water environment education, aims to enhance students' sense of responsibility and awareness in water resource management through interdisciplinary water environment education. It also responds to educational institutions' efforts to address carbon footprints by using educational programs, gamified education, and smart technology applications to raise students' awareness of water environment protection and management. This aligns with the core competencies of the Ministry of Education's 108 Curriculum Guidelines, conveying clean, safe, and sustainable hydrological knowledge.

2. Community Participation and Sustainable Development Education

Community participation and interaction are essential for sustainability initiatives, whether in the adaptive reuse of historical buildings or the promotion of sustainable recreation. Involving the community in decision-making processes, such as the adaptive reuse of historical buildings or the expansion of sustainable recreational development, can enhance the effectiveness and acceptance of sustainability measures (Iqbal, Ramachandran, Siow, Subramaniam, & Latiff, 2023) [14]. Additionally, community participation promotes empowerment, capacity building, and skill development, contributing to the long-term sustainability of project initiatives. This can be achieved by involving the community in development measures or local engineering

projects (Fadhil & Al-Zaidi, 2023) [11]. Community participation, through the promotion of sustainable development principles, knowledge sharing, and practical application, is closely related to enhancing sustainable development education.

Education for Sustainable Development (ESD) aims to cultivate individuals with sustainable living practices (Thakran, 2015) [30]. It focuses on the learning process, fostering qualities necessary for sustainable living, including mindfulness, empathy, critical thinking, and systemic understanding (Garbie, 2016) [13]. According to the United Nations Agenda 21, sustainable development education is a key tool for achieving sustainable development and has gained widespread recognition from the international community. Institutions such as engineering schools, universities, and manufacturing sectors play important roles in providing sustainable development education (Dunetz, Avissar, & Gan, 2017) [9]. By promoting collaboration between educational institutions and local communities, community members can participate in the educational process, identifying real-world problems and needs, thereby creating high-quality learning experiences (Siridhrungsri, 2018) [29]. This includes the relevance of inclusivity, transformation, and solidarity in community participation dimensions to sustainable development outcomes (Aung, Arunberkfa, Hague, Luxchaigul, & Vadevelu, 2019) [2].

Furthermore, research indicates that community participation and planning in sustainable community development, involving various stakeholders such as parents, community members, and teachers, contribute differently to student learning improvement and school development, highlighting the importance of their active involvement (Mia, Islam, Sakin, & Al-Hamadi, 2022) [25]. Therefore, sustainable community development relies on community participation and planning to enhance sustainable development education by creating holistic living patterns beneficial to individuals, schools, communities, and society.

This study integrates the Liuchuan Canal Canal tour, promoting inclusivity, transformation, and solidarity by combining schools, communities, non-profit organizations, and the public in experiential learning. By fostering collaboration between sustainable development education and local communities and organizing a series of activities, the study aims to achieve educational and recreational benefits, advocate for high-quality water-friendly environments, and emphasize continuous investment in water management and water-friendly environment creation. It also strives to convey the spirit of water conservation and uncover the precious local water culture.

3. Digital Technology and Water Environment Education

Digital technology is gaining traction in Outdoor and Environmental Education (OEE) (Jukes and Lynch, 2024) [16]. And the effective use of technology to achieve educational goals or support teaching and learning methods extends to the daily lives of outdoor environmental education participants, using digital games and software to stimulate students' knowledge and awareness of water-related issues, thereby increasing student engagement and learning outcomes. Digital technology and mobile navigation are elaborating on the role of water environment education, where students are invited to answer questionnaires in an interactive and collaborative way, which can be explained in the context of the teaching process about the use of mobile devices and fun play activities (Pereira, Dinis, and Gouveia, 2020) [28]; Such education through mobile devices can improve cognitive development, autonomy, creativity, and awareness of social and environmental issues. The use of mobile devices and QR codes by high school teachers in the field of environmental education is a notable example of this in sustainable education, as the effective integration of mobile learning technology into environmental education can add digital functionality to environmental education when attached to related objects, changing and expanding the way mobile device users access environmental information, and removing temporal and spatial constraints (Kalogiannakis and Papadakis, 2017) [18]. In addition, the development of interdisciplinary environmental mobile education applications focusing on water environment is an effective way to raise awareness and education about water management and sanitation (Kacoroski, Liddicoat, &Kerlin, 2016) [17]. Mobile navigation enhances the learning experience through innovative technologies, using mobile devices to navigate the water environment (Kamarainen et al., 2013) [19], using GPS support on smartphones to complete navigation tasks, and system design that combines verbal protocols and analysis of gaze behavior to improve environmental engagement and environmental learning impact. In addition, mobile navigation and augmented reality (AR) have improved the integration of mobile devices and AR applications with maps and geographic information systems (GIS) to improve navigation reliability and visualization, changes in students' attitudes towards science and content knowledge, including changes in civic responsibility, and augmented reality functions to increase students' knowledge and interest in science (Brenner, Hendrix, & Holford, 2021; Dönmez-Usta & Ültay, 2022) [4] ◦

Therefore, this study is based on the abundant scenic spots and sightseeing resources around Yanagawa River, and through AR guides, the scenic spots and trails in the Yanagawa area are designed and built through

GPS positioning, and when the user approaches the set location, the mobile phone screen can present the scenic spots in front of them in real time through augmented reality, just like the actual tour guide, which can quickly grasp the relevant information of the attractions around the user and bring the public an immersive travel experience.

4. Water Environment Education on the Endless Liuchuan Canal Canal Digital Tour Platform

Environmental education aims to achieve sustainable development by improving knowledge, skills, attitudes, and actions on environmental issues, and to cultivate an attitude of individuals and communities to be environmentally responsible (Dillon, 2014) [8]. In addition to sewage treatment and sustainable environment, it also provides a beautiful recreational attraction in the densely populated city, and has become a check-in hotspot on various social platforms, injecting a bit of atmosphere into the old city of Taichung. Through environmental education programs and direct contact with nature, children's awareness of urban river ecosystems can be significantly improved, and thus of the impact of biodiversity and human activities on ecosystems (Feio et al., 2022) [12]. In addition, the use of mobile navigation systems can improve independence, accuracy, and speed in unfamiliar environments (Yu, Chiu, Lee, and Chi, 2015) [31]. In addition, the integration of augmented reality technology into the ecological environment can assist navigation, provide special animal and plant information, create an eco-friendly navigation system, and support navigation tasks with audio spatialization services, through interactive auditory voice, maps to effectively transmit location information (El-Shimy, Grond, Olmos, & Cooperstock, 2012) [10].

Therefore, this study utilizes the Endless Liuchuan Canal digital tour platform in Taichung City, applying a hydraulic mobile knowledge base to plan and integrate tourism, recreation, cultural history, and interactive introductions to hydraulic engineering methods. The platform offers services such as “City Flow Chronicles,” “Old City Stories,” “River Walks,” and “Interactive Games.” The following is a brief introduction to the scenarios and system contexts developed in this study to provide participants with learning opportunities about water environment education concepts:

1.1 “Liuchuan Canal News” provides the latest updates and event calendar features, offering real-time information related to the seven major rivers in Taichung, including Hanxi Drainage, Huilai Creek, Chaoyang Creek, Fazih Creek, Dongda Creek, Green River, and Liuchuan Canal.

1.2 “City Flow Chronicles” introduces the seven major rivers mentioned above, showcasing local city events and nearby attractions through the perspective of the rivers.

1.3 “River Walks” offers diverse digital tour services, including customized tours and segmented tours, providing the public with more convenient and enjoyable ways to explore the rivers. The “Endless Liuchuan Canal Digital Tour Platform” offers various tour services to meet visitors’ needs in an interesting and practical manner, including “List Tour,” “Map Tour,” “Segmented Tour,” “AR Tour and Virtual Guide,” “Customized Tour,” and “QR Code Tour.” The “AR Tour and Virtual Guide” features the mascot designed for Liuchuan Canal, Liumei, who leads the public to explore interesting knowledge along the Liuchuan Canal trail. In the “Segmented Tour” design, the public can choose routes recommended for couples, cultural enthusiasts, and families as travel references.

1.4 Interactive Games: The “Water Management Cadet” game is designed to drag and drop low-impact development methods to the correct locations on Liuchuan Canal within a limited time. The game also introduces the descriptions and uses of each method, allowing the public to gain knowledge of hydraulic engineering while playing. To enable the public to learn more about river-related knowledge in a gamified way, the “Liuchuan Canal Knowledge King” digital worksheet is designed. After visiting the Liuchuan Canal trail and related tour platforms, the public can test their knowledge and understanding of Liuchuan Canal through the fun worksheet, adding small pieces of knowledge while being entertaining. Another game, “Gravel Water Quality Battle,” simulates the gravel water purification method, allowing children to understand how the rough pores of gravel and microorganisms purify sewage through interaction.

1.5 Multifunctional Intelligent Interactive Machine: At the Green River and Liuchuan Canal Water Culture and Environmental Education Center, AI multifunctional intelligent machines serve the public (as shown in Fig. 1). The virtual assistant image of Liuchuan Canal’s mascot, integrating AI technology to provide a lively and engaging interactive experience like a real person.

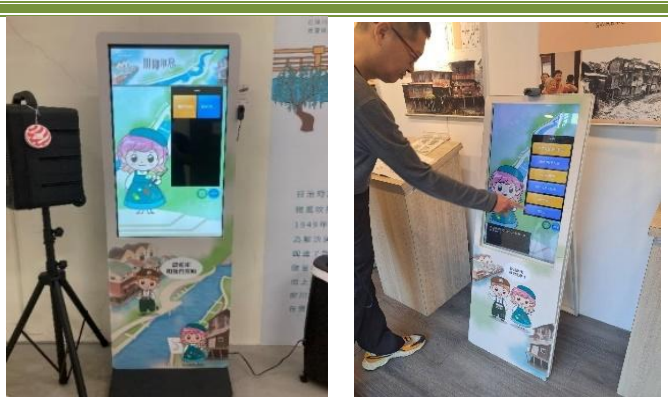

Fig.1Multifunctional Intelligent Interactive Machine

III. CONCLUSION

This study uses gamified river knowledge, intelligent services, and mobile multifunctional intelligent interactive machines to attract the public to visit and enhance their understanding and recognition of the water environment. The results show that the gamified river knowledge platform had 412,088 users by May 2024, with Taichung City residents accounting for the highest proportion at 70.97%, followed by Changhua County at 5.11% (as shown in Table 1).

1. Taichung City (70.97%)

Taichung City is the largest source of visitors to Liuchuan Canal, accounting for more than half of the total. This is likely due to the high awareness of the Liuchuan Canal riverside trail among Taichung residents and the convenient transportation within the city, making it easier for residents to visit.

2. Changhua County (5.11%)

Changhua County ranks second, likely because it is adjacent to Taichung City, attracting more nearby tourists. Continued promotion and publicity of the Liuchuan Canal riverside to Changhua residents, or providing transportation solutions, could make travel more convenient.

Table 1Questionnaire for the county or city where the visitor lives

County/City	Proportion
Taichung City	70.97%
Changhua County	5.11%
New Taipei City	4.9%
Taipei City	3.37%
Kaohsiung City	2.73%

3. Increasing Attention to Water Environment Issues

The design of the mobile multifunctional intelligent robots and virtual assistants in this study has increased public attention to water environment issues. Through diversified virtual and real integrated marketing, the project reached over 2.55 million people. This includes the launch event of the Endless Flow project and the Liuchuan Canal walking tour activities, which attracted more than 43 media reports with a total reach of over 2.3 million people. Digital marketing promotions reached 500,000 people. In May 2024, a parent-child Liuchuan Canal walking tour activity was held, with over 50 teachers, parents, and children participating. There were 46 valid questionnaires, with a high satisfaction score of over 4.9, combined with positive learning feedback from the digital platform. The guided tours and AR interactive games encouraged joint participation of parents and children, creating an intergenerational learning model.

IV. ACKNOWLEDGEMENTS

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