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Exploring the Impact of Unexpected Learning Outcomes Across Cultural and Architectural Differences: A Comparative Study of Japan and Ethiopia

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Abstract

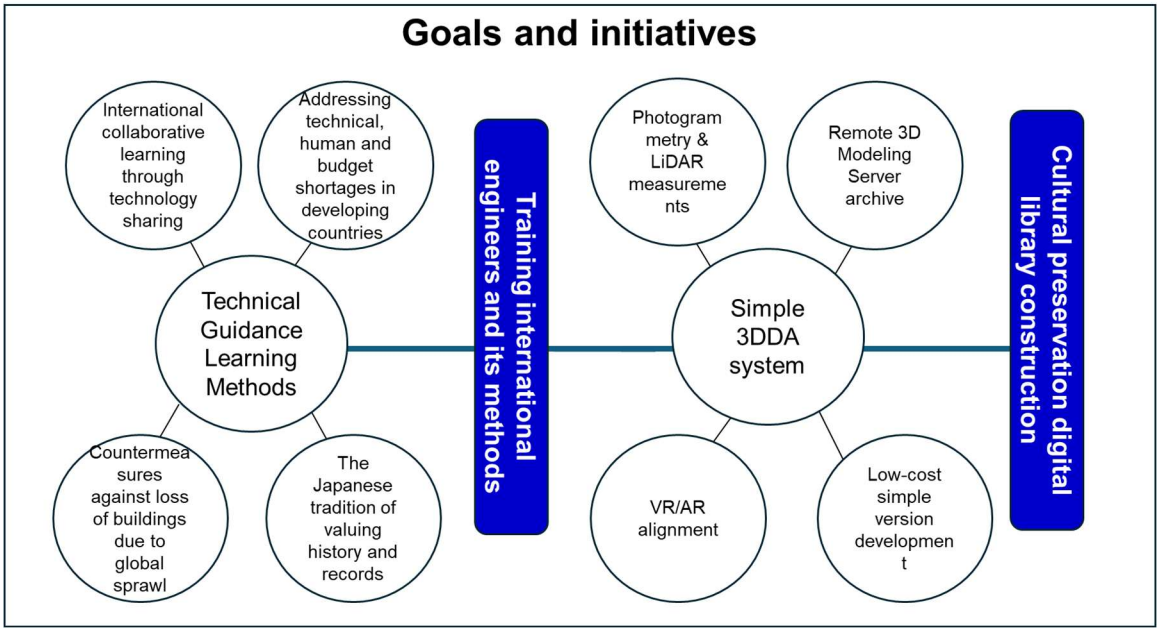
When students from diverse backgrounds collaborate, their learning outcomes often include unexpected insights. This research investigates the knowledge and skills acquired by Japanese and Ethiopian students through Problem-based Learning (PBL) programs and or focused on three-dimensional digital archiving (3DDA) via photogrammetry, an advanced technique for conserving architectural heritage. The PBLs follow a two-way exchange model: an initial phase in Japan introduces 3DDA basics in Tokyo, followed by a second phase in Addis Ababa, where students digitize Ethiopian cultural and historical structures threatened by rapid urbanization. Despite significant differences in geography, ethnicity, culture, history, communication styles, urbanization, and technology adoption, participants with limited prior knowledge of each other's contexts developed not only technical skills but also valuable global competencies. This study is framed within the Transformative Learning Theory and considers the Washington Accord's 11 Graduate Attribute Profiles, including non-engineering competencies.

1. Background

Mezirow's Transformative Learning Theory (TLT) (Mezirow, 2003) defined transformative learning as the process whereby adult learners critically examine their beliefs, values, and assumptions in light of acquiring new knowledge and begin a process of personal and social change called reframing in "perspective" (Kumi–Yeboah & James, 2014). He also suggests that greater cultural or ethnic divergence fosters the development of global competencies. Problem-based Learning (PBL) is a very effective approach to enhance knowledge application skill to real world issues through practical experiences (Barrows et al., 1980). The international PBL between Japanese and African students provides participants with life changing occasions for their perspective transformation due to multiple differences. Transformative learning causes a positive effect on the development of intercultural competencies (Stewart & Seauve, 2024). For Japanese, due to the socio-cultural aspects of passive style primary and secondary education, it is critical to have transformative approach in higher education (Goharimehr & Bysouth, 2017). On the other hand, traditional ethnic construction is facing deterioration or even demolition due in return for economic growth and commercial investments. For instance, the World Heritage Site of Lalibela, Ethiopia is affected by the rapid population growth and urban expansion (Sisay et al.,

2023). This issue is arising in happening other part of Ethiopia (Okazaki, 2011), and can be assumed commonly happening throughout African countries.
urban expansion that has been observed in the last four decades and above.
Since 2023, Shibaura Institute of Technology (SIT), a leading engineering university in Japan, and Addis Ababa University (AAU), a top-notch public university in Ethiopia, have conducted bilateral workshops to digitize Ethiopian historical buildings using 3DDA (Three-Dimensional Digital Archiving) technology. Currently, photogrammetry is widely used for heritage conservations around the world (Cabarcas Granados et al., 2023). Japanese and Ethiopian students participating in these workshops have explored how cross-cultural and technical differences influence their learning experiences and awareness of global competencies. The learning objectives of this fieldwork-driven PBL program encompass three key aspects: knowledge of 3DDA technology, practical application of such technology in the preservation of historical structures, and the acquisition of attributes essential for engineers to thrive in international settings. First, 3DDA involves remote 3D modeling and the utilization of state-of-the-art equipment and software, including LiDAR and Virtual Reality (VR)/Argumental Reality (AR) technologies. By applying these latest tools to the digital preservation of historically and culturally significant structures, students not only develop practical technical proficiency but also cultivate an awareness of societal issues such as destruction and loss of cultural heritage due to rapid urbanization. Furthermore, to become globally competent engineers, students must acquire a diverse set of skills as defined by the Washington Accord, irrespective of their nationality. To achieve these learning objectives, a hands-on, active learning approach - characterized by iterative trial and error through both intellectual engagement and practical fieldwork - proves highly effective. PBL is an innovative learning approach that is based on constructivism learning theory where the learning process is driven by the students(Noordin et al., 2011). This makes the PBL framework particularly well-suited for fostering both technical expertise and problem-solving abilities in real-world contexts. Chart 1 displays the structure of the program contents.

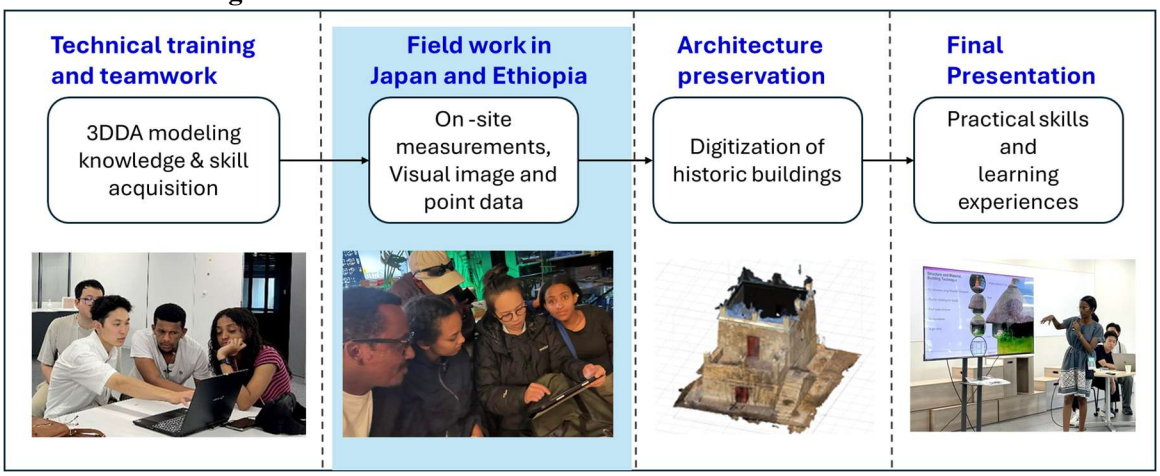
Chart 1: Program structure



This program consists of two reciprocal phases. In the first phase, Ethiopian students visit Japan for the Tokyo Digital Heritage Workshop, hosted by SIT and funded through the Sakura Science Exchange Program (SSP) (Japan Science and Technology Agency, 2025). Japan, known for its advanced adoption of digital technologies and its blend of modern architecture and historical structures, provides an ideal environment for introducing 3DDA techniques and demonstrating the significance of digital preservation. Students visit historical constructions and science museums in central Tokyo to experience cutting-edge VR exhibitions and technologies. These experiences encourage broad discussions about the challenges, possibilities, and importance of preserving architectural heritage in megacities like Tokyo and Addis Ababa.
Several months later, SIT students and faculty visit AAU for the fieldwork in Ethiopia, located in 1.5-mile-high plateau. They apply 3DDA photogrammetry to digitize residential and cultural structures in Addis Ababa, where rapid urbanization and large-scale development projects threaten traditional houses and communities. Through this second PBL, students and faculty from AAU lead field surveys and interviews to investigate and document historic districts. SIT students encounter completely different climates and circumstances from their norms.

Chart 2 describes the learning stream of this PBL. First, the participants study about the 3DDA technique and method in the classroom. Second, they go to field work for collecting data form by measuring physical construction by negotiating with the building owners through international teamwork. Third, data is compiled and transformed into 3D images. Lastly, each group makes a presentation about their output and their lessons learned through the entire program process from the perspectives of digital technologies and global competences. Global Competence is an essential attribute to live harmoniously in the multicultural communities (Ramos & Schleicher, 2018). Global competency comprises the knowledge and skills that help people understand the flat world in which they live, the skills to integrate across disciplinary domains to comprehend global affairs and events, and the intellect to create possibilities to address them(FERNANDO M. REIMERS, 2009). Therefore, it is critical for young generation to have exposures to multicultural settings during their study period, especially for those who are living in homogeneous country like Japan. PBL is suitable methodology for providing them with practical learning circumstances.

Chart 2: PBL Program Flow



The catalyst for realizing this bidirectional Japan-Ethiopia PBL initiative was the shared recognition of a critical social issue - the destruction and loss of local housing in Ethiopia - by faculty members from both countries. This awareness emerged as Japanese researchers specializing in African historical heritage and 3DDA technology collaborated with the architecture department of AAU, conducting on-site investigations.

During their respective university lectures and research activities, SIT faculty members instructed students about Ethiopia's social challenges, while AAU faculty members focused on the application of technology as a countermeasure against the social issues. In response, students frequently expressed a strong curiosity in exploring a country they had previously known little about, stating, "I want to see it for myself because it is an unfamiliar country." In response to this enthusiasm, the PBL program was launched in 2023. The number of students wishing to participate far exceeded the instructors' initial expectations, prompting a continuation of the program in 2024, during which data on learning outcomes was collected.

One of the primary challenges in implementing this PBL initiative was, unsurprisingly, the financial burden. Travel and accommodation costs were substantial, and the expenses associated with workshops in Japan, where the cost of living is significantly higher, posed a major challenge for Ethiopian students. To address this, Ethiopian students were invited to Japan using funding from the JST, ensuring that selected students, who had a strong desire to study abroad, could participate without financial burden.

Similarly, for Japanese students, undertaking a long-term project in Africa represented a considerable financial commitment. Of the total program cost of approximately USD 2,700 for a 10-day program, only USD 400 was subsidized by the university, leaving students to cover the remaining USD 2,300 on their own. Nevertheless, their enthusiasm for traveling to Africa was exceptionally high. Moreover, as the second session in Ethiopia was scheduled just three months after the first, many students proactively saved money through part-time work to finance their participation independently. The cost was comparable to PBL programs in Western countries and even lower for programs in Asia. Compared to these popular destinations, Ethiopia remains relatively unknown in Japan, with a level of recognition so low that it could be considered an unfamiliar country to most. However, more Japanese students than the initial expectation have participated in these PBLs regardless of the costs. Table 1 shows the number of participants in each program. Regarding SIT participants traveling to Ethiopia, they were willing to join this program regardless of high costs and huge differences. More students attended PBL 4 (13 participants) than previous year (10 participants) because of positive feedback from PBL2. Even some students joined both because of impactful experiences through the first experience through PBL2.

Table 1: Number of participating students from SIT and AAU

Program	PBL1	PBL2	PBL3	PBL4
Timing	August 2023	November 2023	September 2024	September 2024
Venue	Tokyo	Addis Ababa	Tokyo	Addis Ababa
Host/participants	SIT/21	AAU/10	SIT/7	AAU/8

Guest/participants	AAU/9	SIT/10	AAU/8	SIT/13

2. Research Objectives

Japan and Ethiopia present stark contrasts across multiple dimensions shown in Table 2:

Table 2: Comparison of difference between Japan and Ethiopia

	Japan	Ethiopia
Geography:	East Asia	East Africa
Ethnicity:	Homogeneous	Multi-ethnic
Major Religion:	Buddhism/Shinto	Christianity (Ethiopian Orthodoxy)
Language:	Japanese	English (common language) and many local languages
Urbanization:	Already developed	Rapid commercialization
3DDA Adoption:	Highly applicable	Beginning stage

Given these settings, students start the workshops with minimal prior knowledge about each other's countries and cultures. The workshop theme focuses on learning digital preservation techniques for historical structures and exploring challenges and solutions for technology transfer to developing countries like Ethiopia. Students experience both roles - as hosts introducing their country's culture and technology and as guests learning in a foreign environment.

A challenge to engineering educators is to determine how to incorporate real-world experiences into the engineering curriculum(Shuman et al., 2005). This interdisciplinary program integrates technical training and cultural anthropology, encouraging participants to gain skills in accordance with the Washington Accord's 11 Graduate Attribute Profiles (WA11GAP) (International Engineering Alliance, 2021). Graduate attributes are 'the skills, knowledge and abilities of university graduates, beyond disciplinary content knowledge, which are applicable to a range of contexts' (Barrie, 2004). The importance of teaching engineering students not only technical knowledge, but also the attitudes and skills required to perform as a professional engineer ()(Paul et al., 2015). Washington Accord has been playing a central role for education and training in the formation of a practising engineer (International Engineering Alliance, 2014).

1. Engineering Knowledge
2. Problem Analysis
3. Design and Development of Solutions
4. Investigation
5. Tool Usage
6. The Engineer and the World
7. Ethics
8. Individual and Collaborative Teamwork
9. Communication
10. Project Management and Finance
11. Lifelong Learning

This PBL program is also referring to the global competence as a 21st century imperatives (National Education Association (NEA), 2010) for nurturing mindset of global citizen.

It is easily expected that the major learning outcomes of this 3DDA workshop are related to Engineering Knowledge, Problem Analysis, Investigation, and Tool Usage. The question is how and how much extent other attributes could be acquired through the transformative learning experiences.

3. Theoretical framework

The program design integrates Transformative Learning Theory (TLT) and PBL characteristics, emphasizing social interactions and complex problem-solving in group activities. TLT process consists of (1) disorienting dilemma, (2) critical reflection, (3) rational discourse, and (4) perspective transformation. Japanese and Ethiopian students are (1) getting out of their ordinary circumstances and jumping into unknown environment, (2) recognizing both new world and redefining the own origin through the contrasts, (3) interacting each other through collaborative group engagements, and (4) continuing borderless research activities and personal relationships.

Students from vastly different backgrounds collaborate to address urgent preservation challenges. Observational learning plays a key role, with Japanese students initially hosting Ethiopian students and later gaining confidence as they prepare to visit Ethiopia. Ethiopian students, reciprocating the hospitality, foster mutual cultural understanding. Through 3DDA modeling, both Ethiopian and Japanese instructors demonstrate a role model for adapting to new environments and take initiative in unfamiliar environments. By experiencing problem-solving in highly contrasting cultural settings, participants build self-efficacy (Bandura, 1982), making future challenges in more familiar environments seem manageable. Reflection and feedback further reinforce learning outcomes.

In addition to the essential engineering (hard) and professional (soft) skills, engineering criteria must include global skills that will help engineering professional to work globally (Arun S. Patil, 2005). Global citizenship is described as “awareness, caring, and embracing cultural diversity, while promoting social justice and sustain-ability, coupled with a sense of responsibility to act”. (Robinson & Levac, 2018)

4. Research Questions (RQ)

The questions that arise from this are: "What motivated participants to willingly travel to Africa?" and "Did they gain satisfactory learning experiences that justified their decision? If so, what was the nature of these experiences?" Furthermore, after the conclusion of the PBL program, multiple students reported that their experiences had exceeded their expectations. Some of them even stated it was a life-changing moment. These outcomes are presumed to be influenced by qualitative factors that were not explicitly outlined in the syllabus. Such unexpected elements are typically not captured through standard surveys. Therefore, by conducting a follow-up investigation in this study, we anticipate uncovering new insights.

RQ1. What were the initial motivations of participants to explore an unfamiliar country? Given Japan's conservative, homogeneous society, Japanese students often remain in their comfort zones. Ethiopian students, typically more familiar with European and Chinese countries, have limited preliminary knowledge of Japan. During this what kind of disorienting dilemma have they encountered?
RQ2. What were the learning outcomes from these bilateral PBLs, particularly unexpected findings that have triggered perspective transformation?

4. Research Methodology

The study combines post-workshop surveys and semi-structured interviews with participants.

(1) Surveys: Google Form Likert scale (0–4) surveys conducted in Japan and Ethiopia (11 and 9 respondents, respectively).

Question 1 is "What are your initial objectives and expectations for attending this program?". This is to identify the factors to encourage students to attend the program for jumping into the new world with various gaps or almost no preliminary knowledge.
The question 2 is "Which competencies/awareness could you develop through this program?" related to WA11GAP. The design of this PBL aims to ensure a well-balanced acquisition of skills in using 3DDA equipment, its practical applications in addressing social issues, and the competencies required for international engineers. Accordingly, it seeks to understand what the participating students have consequentially learned.
(2) Interviews: Semi-structured interviews with selected participants to explore learning outcomes, reflections, and experiences as both hosts and guests. Students from both countries participating in these two PBL programs will experience both roles: as hosts, leading the learning process for guest students and supporting their daily lives during their stay, and as guests, visiting an unfamiliar country and challenging themselves in a new environment. Additionally, while both projects utilize the same 3DDA technology, there are significant differences between the contexts - such as Japan, where urban development is well-established, and Ethiopia, where existing housing is being demolished and removed. To capture qualitative factors that cannot be measured using a Likert scale, direct interviews will be conducted with participants to extract detailed insights.

The hearing method was structured to elicit participants' opinions in a sequential manner, covering the following aspects:

1) Their initial motivation and reasons for participation, including why they particularly chose Africa over more familiar regions like USA, Europe or Asia.
2) Their consequential learning experiences throughout the PBL.
3) What perspective transformation they have achieved.

For 2), the interviews explored both technical engineering knowledge and soft skills such as communication, teamwork, and ethics. Additionally, if participants encountered unexpected experiences that later influenced their personal direction, those aspects were examined in depth. Such unforeseen experiences, which were not originally included in the curriculum design, varied greatly among individuals and could only be fully captured through these interviews.

5. Data Analysis & Discussion

Table 2 displays the response to the survey question "What are your initial objectives and expectations for attending this program?".

Table 2: Participants' objectives and expectations for attending PBL

Question 1: Initial objectives and expectations	PBL3 (Japan)	PBL4 (Ethiopia)	PBL4-PBL3 difference
To understand new techniques and methodology	3.60	3.33	-0.27
To enhance engineering skills	3.30	3.33	0.03
To understand social problems	3.20	3.78	0.58
To improve commination and presentation skills	3.60	3.33	-0.27
To develop teamwork skills	3.60	3.56	-0.04
To make new and international friends	3.80	3.78	-0.02
To interact with international professors and industrial experts	3.80	3.67	-0.13
To practice English	3.60	3.44	-0.16
To prepare for future jobs	3.40	3.44	0.04
To receive a certificate and credits	3.10	3.22	0.12
To explore other countries' history and culture	3.80	3.78	-0.02
Interest in conservation of architectural heritages	3.80	3.67	-0.13
	highest 3		1st < 2nd

The high scores (3.80) in Japan's workshops were recorded for:
- "To make new international friends",
- "To explore other countries' history and culture",
- "Interest in conservation of architectural heritage", and
- "To interact with international professors and industrial experts".

It became clear that the primary motivation for students from both countries was building international friendships, engaging with foreign instructors, and developing an interest in culture and history. As secondary factors, practical aspects such as learning new techniques, improving communication and presentation skills, teamwork skills, and practicing English were highlighted. These motivations remained largely unchanged in the second PBL in Ethiopia. However, there was a significant increase in interest regarding social problems. This shift is likely a reflection of the direct engagement with the serious issue of housing demolition.

Table 3 is the response to the question "Which competencies/awareness could you develop through this program?".

Table 3: Which competencies/awareness could you develop through this program?

Question 2: WA11GAP	PBL3 (Japan)	PBL4 (Ethiopia)	PBL4-PBL3 difference
1. Engineering Knowledge	3.20	3.11	-0.09
2. Problem Analysis	3.50	3.22	-0.28

3. Design and Development of Solutions	3.30	3.22	-0.08
4. Investigation	3.60	3.78	0.18
5. Tool Usage	3.60	3.56	-0.04
6. The Engineer and the World	3.20	3.44	0.24
7. Ethics	3.30	3.67	0.37
8. Individual and Collaborative Teamwork	3.40	3.78	0.38
9. Communication	3.60	3.78	0.18
10. Project Management and Finance	3.40	3.22	-0.18
11. Lifelong Learning	3.30	3.56	0.26
	highest 3		1st < 2nd

In both PBL programs, Investigation and Communication consistently showed high scores. Tool Usage scored high in the 1st PBL but slightly dropped in the 2nd, probably because participants had already acquired foundational knowledge, making its relative importance decrease. On the other hand, Individual and Collaborative Teamwork (+0.38) saw a significant increase. This can be attributed to the more effective group work in the 2nd PBL, where students visited local housing, negotiated direct investigations, collaborated in capturing data, and divided roles to compile their findings into a 3DDA design. An especially notable finding is the significant improvement in Ethics (+0.37) , Lifelong Learning (+0.26), and The Engineering and the World (+0.24) during the 2nd PBL. Image 1 and 2 depict the field research activities in Ethiopia. This is likely due to the hands-on nature of the fieldwork, where students engaged with local communities while investigating the issue of housing demolition. As a result, there was an increased awareness of Lifelong Learning, which was further confirmed through semi-structured interviews.

Image 1 and 2: PBL 4 Field research in Ethiopia

It was an excentric experience for AAU students to travel to Tokyo, one of the most advanced metropolitan cities in the world, since most of them grew up in the small towns in Ethiopia. While they did preliminary studies through the Internet, physical trip gave them pragmatic exposure to Japanese living environment thanks to hospitality by SIT hosting students. Another interesting finding is that both Ethiopian and Japanese have introverted personalities. Ethiopians generally consider themselves rather shy, but they found Japanese students even shier. Nevertheless, they were aware that Japanese were trying to get out of their comfort zone and

become brave for taking initiatives to maximize AAU students' first exposure to foreign circumstances. Thus, AAU participants tried to reciprocate the hospitality when they host SIT students visiting Ethiopia for the first time.

In terms of social issues and solution part, traveling to Japan also provided useful insights about the cultural conservation using 3DDA technologies. In Ethiopia, many people are concerned about demolitions of traditional houses and buildings. While they welcome economic development and modernization, it is a matter of approach. General public believe in the harmonization of modernization and preservation of original cultures including heritages. However, demolition is ongoing without public discussions or interventions. This 3DDA workshop was effective as a best practice of symbiosis by balancing architectural heritages and modern life in Japan. They could also learn 3DDA as a solution of historic preservation.

Key Findings:

(1) Motivation for Participation

A common motivation was the desire to see an unfamiliar country with their own eyes precisely because they had never been there before. Their areas of interest included:

- Social issues such as urbanization, population growth, housing demolition, and cultural loss
- The application of 3DDA technology for historical preservation

(2) Interactions with Ethiopian Students

Although they initially perceived significant cultural and physical differences, they discovered many similarities at a deeper level due to being of the same generation. A notable realization was that, in Ethiopia, the demolition of traditional houses was not merely seen as modernization but rather as cultural loss. Both groups shared a common pride in their respective histories and a deep attachment to their architectural heritage. This mix of differences and similarities heightened mutual curiosity, leading to sustained connections even after the PBL through social media.

(3) Hosting Experience in Japan

When Japanese students are hosting Ethiopians in Japan, they learned to act with cultural and religious sensitivity to ensure their guests had a fulfilling experience. They also took on leadership roles, which they found to be a meaningful learning experience. A key takeaway was that engaging in Q&A sessions about religion and politics prompted them to research their own country in greater depth, leading to a reaffirmation of their own identity.

(4) Personal Growth & Future Aspirations

Through the interviews, three common conclusions emerged:

- Their initial mindset of “I’d like to go to completely unknown country rather than the US or Europe because of curiosities” evolved into a strong desire to visit Ethiopia, Africa, and other countries again. They wanted to get out of the status quo and face disorienting dilemma.
- Overcoming challenges helped build self-confidence. In hindsight, the entire process became a fond and enjoyable memory.
- This aligns with the idea that greater cultural and ethnic divergence fosters global competencies. Some continue to attend this workshop series both in 2023 and 2024. Others extend their horizon by actively traveling to other countries.

(5) Perspective Shift on 3DDA Technology

Previously, participants associated architecture primarily with creating new structures. However, this experience broadened their perspective, demonstrating how 3DDA technology can be applied to historical preservation and addressing social issues. This real-world application led to a major shift in their understanding of technology’s role in society.

(6) Unexpected Insights

A recurring theme was the impact of "seeing is believing" and "can’t connect the dots looking forward, only backward" (Jobs, 2005). Participants emphasized that conducting hands-on field investigations - engaging their five senses - was an experience that classroom lectures or internet research could never replicate. Another unexpected outcome was how their initial one-time curiosity stretched into a long-term interest in global experiences, reinforcing the transformative impact of real-world exposure.

By combining the results of the survey and interviews, an intriguing pattern emerges. Although the primary learning objective of this PBL was the acquisition and application of 3DDA technology, participants reported significant growth in investigation, communication, and teamwork skills. Additionally, they gained unexpected insights through non-curricular experiences such as cultural exchange. Notably, in Ethiopia -where participants directly confronted ongoing social issues - the second PBL phase shifted their awareness toward Ethics, The Engineering and the World, and Lifelong Learning. This transition highlights the effectiveness of active learning methods in fostering deeper, reflective engagement.

Another key takeaway is the development of self-efficacy. Participants recognized their own ability to achieve meaningful outcomes even in unfamiliar environments, which in turn fueled their motivation to pursue further learning abroad.

One crucial point to emphasize is the need to create opportunities for students with potential to take action. While PBL participants are naturally curious and unique individuals - making them somewhat of a niche group - it is not always the case that they are fully aware of their potential or know how to take initiative. In such cases, hands-on experiences in unknown environments serve as a catalyst, unlocking hidden abilities and perspectives. These experiences can act as transformative turning points, helping participants redefine their personal and professional aspirations.

6. Conclusion

This article examines the learning outcomes achieved in a unique environment where cutting-edge 3DDA technology is applied to the digital preservation of African traditional houses, and where Japanese and Ethiopian students - who initially have minimal knowledge of each other's backgrounds - engage in collaborative learning. Furthermore, it explores how students develop attributes required of international engineers in such settings. The findings indicate that curiosity overcomes the fear of the unknown, leading to skill acquisition through hands-on experiences, which in turn fosters self-efficacy. This self-confidence then drives a long-term motivation to seek out new experiences beyond the program itself. Additionally, it was observed that this process nurtures awareness in areas such as Ethics, Engineering and the World, and Lifelong Learning, which cannot be fully learned through textbooks alone, as outlined in the WA11GPA framework.

However, these learning outcomes are often recognized in hindsight and vary among individuals, making them difficult to explicitly define as curricular objectives in a syllabus. Given these insights, educators should recognize the potential learning outcomes that emerge through active learning and incorporate them into future curriculum design. By doing so, they can contribute to the development of globally competent engineers.

As this bilateral PBL program is set to continue over multiple years, future iterations will integrate further improvements while continuing research on its impact. One limitation of this study is the small sample size, with interviews conducted only with Japanese students. Future research should include interviews with Ethiopian students, as well as insights from Teaching Assistants who play a role in facilitating the program.

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