Impact of Technology Integration on Students' Knowledge, Attitudes, and Practices (KAP) Towards the Sustainable Development Goals (SDGs): A Structural Equation Modeling (SEM) Approach

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Abstract: This study examined the relationship between university students' knowledge, attitudes, and practices (KAP) regarding the SDGs and their local community engagement, with a particular focus on the role of technology integration in promoting sustainable education. Utilizing a quantitative, descriptive-correlational design, the research involved 205 students enrolled in Contemporary World classes for the 2024–2025 academic year, drawn from a total population of 430 through stratified random sampling. Data was collected using a validated and reliable adapted survey instrument and analyzed using Structural Equation Modeling (SEM). Findings revealed two distinct KAP-based student segments, with Cluster 1 students demonstrating strong awareness of the SDGs and active engagement. In contrast, Cluster 2 showed lower involvement, indicating the need for targeted intervention. SEM analysis confirmed that knowledge significantly predicts both attitude ($\beta = 0.918$) and practice ($\beta = 0.634$). Among technology integration strategies, interactive and project-based learning have emerged as the most effective in enhancing student engagement, while gamification has shown weaker outcomes, highlighting a gap in its pedagogical utility. This study contributes a validated model illustrating how technology integration supports SDG-related knowledge and behavior. It recommends enhancing KAP-based and technology-enhanced strategies, particularly project-based learning, in the curriculum to strengthen student participation in sustainability initiatives.

1 INTRODUCTION

The United Nations' Sustainable Development Goals (SDGs) were established in 2015, outlining ways and benchmarks to achieve a sustainable world by 2030. These objectives discuss global issues, including hunger, gender inequalities, injustices, social gaps, and pollution. Education is an integral aspect in achieving these goals as it empowers individuals with the knowledge, skills, and values necessary to foster sustainable development. The Contemporary World is a multidisciplinary course that integrates the United Nations SDGs using theoretical ideas and principles. With this curriculum, which utilizes embedded learning in conjunction with the UN-SDGs, there is an excellent opportunity to integrate technology. It is one of the key factors that the 21st-century education requires.

In responding to the SDGs, developments in educational technology have disrupted the ways many educators have achieved that goal through more inclusive, accessible, and impactful learning experiences. Developments in innovations such as interactive spaces and platforms, gamification, video-based learning, and project-based learning have proven to present opportunities that engage and positively impact students' learning experiences and outcomes, as well as their sustainability education. Furthermore, it is essential to note that these technologies are not simply pedagogical enhancements; they act as mediators that will determine the ways students construct their knowledge, develop their attitudes, and demonstrate behaviors related to the SDGs.

While the body of work at the intersection of technology and sustainability education is increasing,

research studies which have rigorously modeled and analyzed the structural relationships of students' KAP, and the role of technology integration, are becoming more limited. It is also necessitated that we segment and model those relationships from a rigorous analytical perspective so that we can start to respond to the evidence for targeted pedagogical practice with the purpose of improving students' KAP of the SDGs

Globalization arose from the realization that the world finds itself in a process, through which it will become a kind of "global state" or, at least, one single economic, socio-political and cultural system. This implies that social and environmental issues can have a ripple impact globally. This only proves how nations are interconnected with one another. As such, individuals must be made aware of the gravity one plays in the global village. In this context, education is a powerful tool for shaping individuals who are informed, responsible, and capable of addressing complex issues across national boundaries

In higher education institutions in the Philippines, The Contemporary World integrates SDGs which fosters critical understanding of global issues and emphasizes the roles of students as global citizens in achieving the SDGs. Furthermore, strengthening technology integration to cultivate 21st century learning is a great opportunity to make SDG learning more meaningful to students. Through technological advancement in education, students have access to critically examine global issues and recognize their role as global citizens.

Given the importance of technological innovation and its impact, this study explores students' engagement with all 17 Sustainable Development Goals. It seeks to explore how technological integration in education such as interactive learning, gamification, video-based instruction and project-based learning enhance awareness and cultivate positive attitudes and practical methods in achieving global goals. Examining how technology support students' engagement in sustainable education, it sought to provide meaningful insights into developing curricula and promoting learning experiences of all SDGs. The findings may be used help educators develop their learning curricula with effective technology integration that deepens students' understanding of global citizenship and prepares them to help achieve SDGs.

2 LITERATURE UNDERSTANDING ON THE SDGS

Enhanced perception of global issues and their impact on attaining Sustainable Development Goals is interrelated with The Contemporary World course. As in economy, the course discusses how trade, globalization, and ethical business practices affect balanced and equitable growth (SDG 8). Dialogues on improving inclusive policies and community-based solution to address issues on inequality, cultural diversity and human rights (SDG 10) are also part of what this course gives emphasis. The course encourages students to support environmental policy by examining sustainability, resource conservation, and climate change (SDG 13). By accepting a range of viewpoints, the course equips students to think critically, behave responsibly, and contribute to a more just and sustainable world.

The Commission on Higher Education (CHED) continues its effort to provide quality higher education with SDGs integration to curricula and research agendas with the hope of contributing meaningfully to the attainment of the 17 goals by 2030. The 2024 'The Impact' Rankings revealed that the PH Universities, Colleges and State Universities are into paradigm shifts of integrating SDGs to their core missions[1].

In the year 2015, the UN-SDGs aims to combat all the challenges which guarantee that no will be left behind [1]. The organizations' adaptation of "Transforming Our World: The 2030 Agenda for Sustainable Development" has been a good move to respond in the global pressing issues having the 167 aims compressed in the 17 goals [2]. Decentralized governance institutions are well placed to facilitate the achievement of the goals because of the nature of the services they provide and their relative proximity to local communities [3]. Education as one of the basic institutions will play a greater role in promoting awareness to achieve a more sustainable future by 2030. The significance of the SDGS could be amplified if integrated in the context of education. Addressing pressing issues and crafting solution acquire ideas and principles for a sustainable future [4]. The UNESCO Global Action Program (GAP) highlights the critical role of educational institutions in the intensifying environmental issues [5].

[1]Commission on Higher Education (CHED), Philippine universities included in Impact Rankings, Jun. 15, 2024. https://www.philstar.com/headlines/2024/06/15/2363022/ched-lauds-56-philippine-universities-included-impact-rankings

Recognizing students' knowledge, attitudes, and practices regarding the SDGs is essential in designing effective learning assistance that stimulates active participation and long-term commitment to sustainable development [6].

Although it is agreed that higher education is interested in Sustainable Development Program, the actual research indicated that most nursing students had low knowledge levels prior to the program, and this knowledge level significantly increased because of the program's implementation of the SDGs [7].

3 TECHNOLOGY INTEGRATION TO ADDRESS SDGS IN EDUCATION

The process of integrating technology integration in educational setup is vital and multifaceted given with diverse culture, teachers' and students' digital literacy, social status and economic background [8]. Likewise, numerous changes as result to the fast-changing society, economic expansion and technological advancements shifted how people live. These changes create gaps between countries and continually strive economically to achieve a sustainable nation[2].

In achieving the SDGs, digital technology is also considered as a critical enabler by enhancing transparency, efficiency and inclusivity across sectors including health, economy, environment and education. The potential it holds in accelerating the achievement of SDG targets lies from enhancing education opportunities to making impacts to other SDGs accordingly [9]. Since technology is continuously revolutionizing in many fields, its capacity to deliver change is considered vital in the attainment of effective and sustainable means of development. However, the success of leveraging its role in the achievement of SDGs can be fueled by the newly created technologies and innovations that are boosted by collaboration and strengthened knowledge-sharing in the local and global context [10].

Digital technologies pave the way to address challenges and barriers of academic opportunities, ensuring the continuity of learning despite geographical, economic, social and health issues. Therefore, understanding the role of technology integration to address SDGs in education is crucial. Such insights can help educators and policymakers to determine its potential role, and ways in which it can be utilized to achieve the SDGs by 2030 [11].

Different digital learning platforms link abstract concepts and hands-on learning experiences through practical applications. Those technology makes personalized learning that provides students with opportunities to pursue the interest on the chosen career or specialization. [7].

Moreover, gamification is a technique that ensembles active learning while honing students' abilities to be critical thinkers and problem solvers through the help of affective engagement and discovery learning as gamification improves project-based learning. Also, gamification tends to resonate with students who are familiar with the mechanics and approach [12].

A comprehensive review demonstrated gamification's capacity to increase user engagement, motivation, and cooperation in various sustainability situations [13]. The study found that gamification promotes long-term actions in education, community projects, and organizational tactics.

Employing video instructional methods, it is revealed that students' consciousness of global issues is amplified through video storytelling and virtual reality [14]. These technologies develop empathy or attitudes and motivate learners to undertake sustainable actions by enabling them to see real-world challenges.

In relation to project learning, SDG themed projects considerably enhance awareness, critical thinking, and social as well as environmental activism among university learners [15]. Voucher[3] endorses this by demonstrating how primary pupils develop sustainability knowledge, cognition, and practice through technology-enabled projects such as sustainable cities design.

4 RESEARCH OBJECTIVES

This study aims to examine the relationship between the students' awareness on the SDGs and the local engagement in the community which affects by the globalization that contributes to the achievement of the United Nations Sustainable Development Goals (SDGs).

More specifically, it seeks to:

1) Segment students based on their KAP (Knowledge, Attitudes, and Practices) profiles.
2) Analyze the relationship between the students' knowledge, attitude and practices on the SDGs.
3) Evaluate the roles of technology integration in the achievement of the SDGs in terms of interactive learning, gamification, video-based learning and project-based learning.

[2]UN ECOSOC, 2008. https://press.un.org/en/2008/ecosoc6354.doc.htm

[3]Educational Service Contracting (ESC) Voucher Program /DepEd https://www.deped.gov.ph/wp-content/uploads/FY-2024-Major-Projects-Program-and-Activities-Beneficiaries.pdf

4) Analyze the relationship between the roles of technology integration and the students' KAP (Knowledge, Attitudes, and Practices) on the SDGs.
5) Develop a model that explains how different KAP (Knowledge, Attitudes, and Practices) segments influence the advancement of SDGs through technology integration.
6) Identify key patterns and gaps in students' technology-related practices that could impact the achievement of SDGs.
7) Recommend targeted strategies for curriculum development and technology initiatives that are aligned with the needs of different student segments.

5 METHODOLOGY

5.1 Research Design

This study employed a quantitative descriptive-correlational research design to examine the relationship between university students' knowledge, attitudes, and practices regarding the SDGs and their local engagements in the community. This research design allows for the systematic measurement and analysis of students' knowledge, attitudes, practices and the roles of technology integration to achieve SDGs.

5.2 Respondents of the Study

The respondents of the study are the university students enrolled in the Contemporary World Classes for the current academic year 2024-2025, with a total population of 430 students. A stratified random sampling technique was used to represent equal participation among different programs within the university. Using the Raosoft sampling, considering the 95% confidence level and 5% marginal error, a total of 205 samples were selected.

5.3 Data Gathering Instrument

The study utilized an adapted survey questionnaire divided into two parts, with established validity and reliability from prior research.

There were 2 parts to the questionnaire. Part I focused on the knowledge, attitude, and practice towards the Sustainable Development Goals dapted from a study [16] published in the Journal of Indonesia Sustainable Development Planning, while Part II focused on the technology integration and its roles in achieving SDGS. A 4-point Likert Scale was used in assessing the students' knowledge, attitude, and practices (KAP) in the role of technology integration.

5.4 Data Collection

Experts in the social science field and research have validated survey instruments to guarantee the suitability and relevance of each question. Thirty (30) students who were used in the pilot testing were not included in the main study. Using Cronbach's Alpha, the results were examined to evaluate the instrument consistency and dependability. Cronbach's Alpha value for the students' knowledge obtained an alpha value of 0.93; students' knowledge obtained an alpha value of 0.92 and students' practices obtained an alpha value of 0.80. For the sub-variables pertaining on the roles of technology obtained alpha value as follows – interactive learning, 0.89; video-based learning, 0.70; and in project-based learning, 0.86. the obtained alpha value from the conducted pilot testing signify that the research tool is valid and reliable which the data to be collected can assess the targeted parameters. After the validation phase, the survey questionnaires were distributed via online platforms. Prior to the distribution set of instructions were given to the participants.

5.5 Data Analysis

In this study, descriptive statistics were used to provide an analysis on the collected data from the survey responses. Through K-means cluster analysis, two distinct student clusters were segmented based on Knowledge, Attitudes, and Practices (KAP) towards the Sustainable Development Goals (SDGs). The researchers used the Pearson correlation coefficient to describe the strength and direction of a linear relationship between two continuous variables. The analysis of variance (ANOVA) was being utilized to identify the relationship of the variables. Multivariate Analysis of Variance (MANOVA) which is a statistical technique used to examine whether there are differences between segmented or clustered students on two or more dependent variables at the same time was also used. Structural equation modeling (SEM) analysis was used to provide compelling evidence for the significant role of Knowledge in shaping both Attitudes and Practices related to sustainable development goals (SDGs).

5.5 Ethical Considerations and Limitations

The study was carried out at a single academic institution, which may restrict the representativeness of the results to other Higher Education Institutions (HEIs), especially those operating with different cultural contexts, environment, or institutional profiles. Furthermore, there is a limited number of respondents as the institution is relatively new. It reduces the extent on which the result can be applied in other settings.

Moreover, this study relied heavily on quantitative methods of data collection and analysis. This may have limited depth of qualitative insights, specifically in capturing students' personal experiences and perceptions related to the affective component of the questionnaire. As such the exclusive dependence on quantitative data presents a methodological constraint on other aspects of interpreting and analyzing the data.

The study adhered to established ethical standards to ensure the protection and identity of all the participants. Before the data collection, participants were informed about the purpose study. It was clearly explained that participation was voluntary an in times of confusion, the participants have the right to withdraw at any time without consequences. The confidentiality and anonymity of the respondents were strictly maintained ensuring participants' identities were not recorded. The data collected was secured, stored and used solely for the purpose of the study. Additionally, the instrument used was carefully designed to be non-invasive and respectful of individual opinions and experiences. More importantly, ethical clearance was obtained from the ethics committee, affirming that the study complied with the established guidelines for research involving the participants.

Figure 1 shows the segments of the students based on their KAP (Knowledge, Attitudes, Practices) profiles. As gleaned from the figure, Cluster 1 (Moderately High KAP) are the students who have slightly above average scores in Knowledge (+0.59), Attitude (+0.59), and Practice (+0.48) about SDGs. This group (n = 129, 62.93%) exhibited moderately higher levels of knowledge, positive attitudes, and active practices related to the SDGs – better than average.

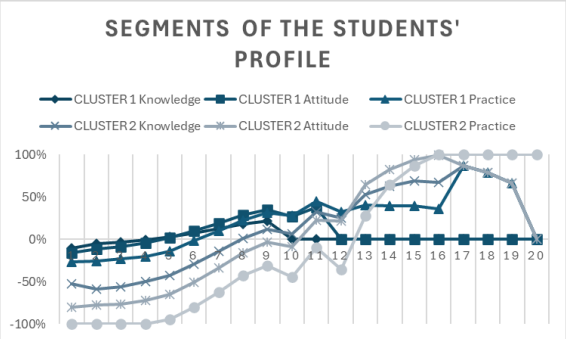

Figure 1: Segments of the students based on the KAP profile.

6 RESULTS AND DISCUSSION

Cluster 2 (Low KAP) are the students who have below average scores in Knowledge (-1.01), Attitude (-0.99), and Practice (-0.82) about SDGs. These segmented students are not aware, with negative attitude, and inactive toward SDGs. This group (n = 76, 37.07%) demonstrated lower levels of knowledge, less favorable attitudes, and fewer practices toward the SDGs.

The results suggest that a majority of students are relatively aware and engaged with SDG-related concepts and actions, while a notable minority requires additional support and intervention. The result supports the study of Filho, et. al. (2024) [6] which highlighted the comparison of the undergraduate students in Higher Education Institution (HEIs) to those who graduated already are more familiar in SDGs. In terms of students' knowledge and participation, it is strongly influenced by whether the university actively integrates the SDGs in their curriculum. The study also emphasized that regardless of the initiatives, students might still have differences in knowledge and practice depending on academic background and personal engagement.

However, although 62.93% of students in Cluster 1 exhibited positive KAP levels, the study of Baron, et. al. (2024) [17] suggests that many students might have surface-level awareness, but not fully aware of SDGs. This awareness does not guarantee deep understanding and actionable knowledge, as similarly reflected by the 37.07% of students in Cluster 2. Thus, it is recommended that educational institutions enhance strategies in achieving sustainability by 2030 by infusing these goals in their curriculum.

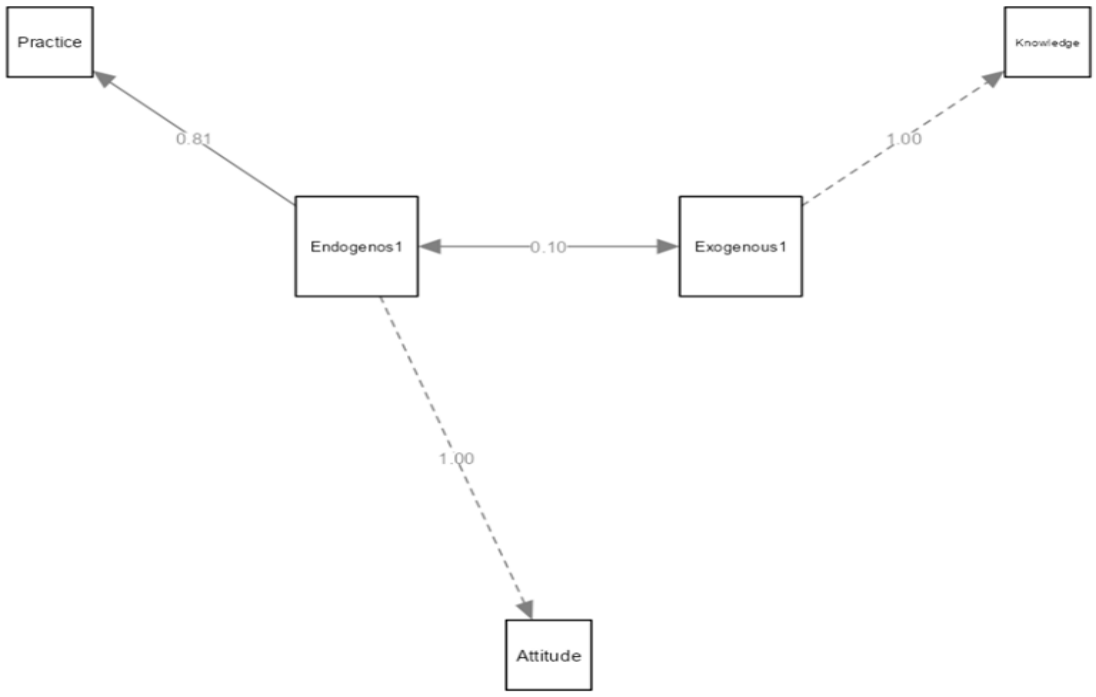

Figure 2: Relationship between KAP and the SDGs.

Figure 2 shows the relationship between Exogenous Latent Variable: Exogenous1 (measured by Knowledge) and the Endogenous Latent Variable: Endogenous1 (measured by Attitude and Practice). Attitude strongly measures Endogenous1 (β = 0.918) while practice moderately measures Endogenous1 (β = 0.634). Exogenous1 (Knowledge) is strongly positively correlated with Endogenous1 (Attitude and Practice), β = 0.757, highly significant.

With this data, the SEM model fits perfectly based on all indices. Knowledge (Exogenous1) is strongly associated with Attitude and Practice (Endogenous1). Both Attitude and Practice are good indicators of Endogenous1, but Attitude has a stronger contribution. The model is statistically sound and reliable.

The structural equation modeling (SEM) analysis indicated an excellent model fit, with all fit indices reaching ideal values (CFI = 1.000, TLI = 1.000, RMSEA = 0.000, SRMR = 0.000). The specified model identified Knowledge as an exogenous latent variable and Attitude and Practice as indicators of an endogenous latent construct. The path analysis revealed a strong and significant positive relationship between Knowledge and the latent endogenous variable (β = 0.757, p <.001). As gleaned in the model, among the parameters, Attitude obtained the highest standardized loading value of β = 0.918 while Practice obtained β = 0.634 which are both significant.

These data accepted the validity of the model used that Knowledge significantly affects the progress of Attitudes and Practices. Also, the data of the Structural Equation Modeling (SEM) analysis explain the positive role of Knowledge in honing the students' Attitudes and Practices in the achievement of the Sustainable Development Goals (SDGs). As demonstrated by the CFI, TLI, RMSEA and SRMR, the used model confirmed the interconnectedness among the latent variables. Students with high knowledge about SDGs most likely to have more positive attitudes towards sustainable habits and practices.

This finding aligns with the study of Sahaharuddin, et al. (2025) [18] showing a strong correlation in terms of students' knowledge, attitude and practice towards SDG. Students who have a higher level of knowledge most likely possess positive attitudes in SDGs. On the other hand, knowledge alone does not always guarantee positive practice or application making attitude as the mediating factor to attain better practice. In contrast with the result, the study of Afroz and Ilham (2020) [16] presented another perspective, indicating that knowledge and attitudes have a weak negative correlation compared to attitude and practice which

demonstrated positive correlation. The result suggests that the awareness through knowledge might be high, but the engagement is weak which disconnects knowledge and action.

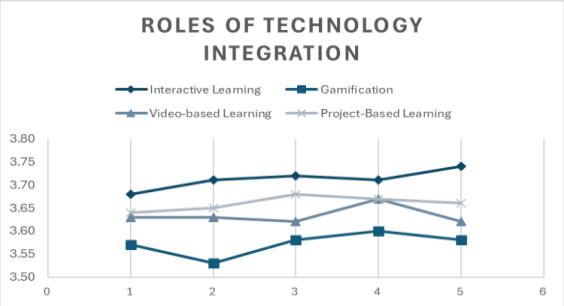

Figure 3: The roles of technology integration.

Figure 3 shows that among all the roles of technology integration, interactive learning consistently scores the highest which suggests that it is the most important due to its engaging and participatory nature that promotes active involvement. Likewise, project-based learning and video-based learning remain close in value reflecting how these two roles lead to overlapping perceptions of their importance. The overlap between video-based Learning and Project-based learning in the graph occurs because these two strategies are often used together in practice and it supports independent learning. It can also be explained that these two roles reflect natural integration and complementarity. Gamification, on the other hand, consistently has the lowest scores which indicate that while gamified elements can enhance motivation, they may not always be perceived as contributing significantly to deeper learning outcomes.

The result supported the study of Cadiz, et al. (2024) [19] which claims the role of technological integration in the educational paradigms to meet the demands of the Fourth Industrial Revolution. These includes the identified five key themes such as the interplay of technology with Education 4.0 and Industrial Revolution 4.0; the role of digital technology; shifts in educational philosophies; transformations in technology education; and the relationship between higher education, learners and technology. Through this, HEIs can promote academic excellence and resilience in the evolving landscape of education in achieving the SDGs through interactive learning set-up.

While gamification yields the lowest score among the four technological-related variables, the study by Navarro-Espinosa et al. (2022) [20] revealed how gamification can effectively boost student motivation and engagement in higher education, creating more interactive and impactful learning experiences if utilized meaningfully. By incorporating game-like elements, institutions can foster sustainable learning environments and promote the development of essential skills, making education more dynamic and student-centered.

However, the results for the other variables were aligned to the results of several studies. In terms of Video-based Learning, Torion and Bacio Jr. (2024) [21] through a developmental research method revealed that the content, instructional quality, technical design, and presentation, use of video lessons is highly acceptable proving their effectiveness as learning tools in computing education. Likewise, a study on the impact of Project-Based Learning (PBL) on students' awareness of SDG gained a positive result [15].

However, even though PBL can effectively increase knowledge in SDGs, it is important to strengthen this through strategies such as curriculum integration to ensure practical application to future endeavors.

Table 1 shows that all the Pearson correlation coefficients (r-values) are positive and statistically significant (p-value < 0.001, marked with *, **, ***) with the 95% Confidence Intervals (CI), indicating that there are strong positive relationships between the variables. The 95% Confidence Intervals (CI) provide additional insight into the range of correlation values, helping to understand the precision of the estimated correlation.

Knowledge is positively correlated with Attitude (r = 0.695), Practice (r = 0.480), Interactive Learning (r = 0.587), Gamification (r = 0.510), Video-Based Learning (r = 0.511), and Project-Based Learning (r = 0.576). The data explain that as students' knowledge of SDGs increases, their attitudes, practices, and engagement with different technology integration strategies (like interactive learning, gamification, and project-based learning) also increase. Attitude shows a strong positive correlation with Knowledge (r = 0.695), Practice (r = 0.582), Interactive Learning (r = 0.676), Gamification (r = 0.591), Video-Based Learning (r = 0.627), and Project-Based Learning (r = 0.662). it shows that students who have a positive attitude toward SDGs tend to show higher knowledge, better practices, and greater engagement with technology-based learning methods. Practice has moderate correlations with Knowledge (r = 0.480), Attitude (r = 0.582), and the technology integration methods. Specifically, Interactive Learning (r = 0.497), Gamification (r = 0.534), Video-Based Learning (r = 0.528), and

Project-Based Learning (r = 0.510). Also, there is a moderate relationship between students' sustainable practices and their knowledge and attitudes towards SDGs, as well as their involvement in technology-enhanced learning.

It can be gleaned in Table 1 that all technology integration methods (Interactive Learning, Gamification, Video-Based Learning, Project-Based Learning) show strong positive correlations with each other, with the highest correlation between Interactive Learning and Project-Based Learning (r = 0.800). Students who engage with one type of technology-based learning (e.g., interactive learning) are more likely to engage with others (e.g., project-based learning, gamification). All correlations have a p-value < 0.001, indicating that the relationships observed are highly statistically significant. This means the likelihood that these correlations happened by chance is very low.

Knowledge and Attitude are highly correlated with each other and the other components, indicating that better knowledge and more positive attitudes toward SDGs are associated with higher practices and engagement with technology-enhanced learning. Practice shows a moderate but significant correlation with Knowledge, Attitude, and the technology integration variables, suggesting that engaging with technology in the classroom helps improve students' sustainable practices. There is a strong relationship between all the technology-enhanced learning variables, implying that students who participate in one form of technology-based learning tend to engage in others as well. The correlation analysis reveals significant positive relationships between Knowledge, Attitude, Practice, and various technology integration variables (Interactive Learning, Gamification, Video-Based Learning, Project-Based Learning). All correlations are statistically significant with p-values less than 0.001, indicating that the relationships are not due to chance.

Figure 4 shows that the Exogenous1 (Technology Integration) has the following estimates for its indicators, Interactive Learning: Estimate = 1.000 (Reference variable), Gamification: Estimate = 1.098 (Strong positive association with Exogenous1), Video-based Learning: Estimate = 1.157, Project Based Learning: Estimate = 1.184. These estimates suggest that Project-Based Learning has the strongest contribution to the Exogenous1 latent variable, followed by Video-based Learning and Gamification.

The Endogenous1 (KAP-Knowledge, Attitude, Practice): Knowledge: Estimate = 1.000, Attitude: Estimate = 0.965 Practice: Estimate = 0.834. The Knowledge indicator is the most strongly associated with Endogenous1, followed by Attitude and Practice.

Table 1: The relationship of KAP Towards SDGs and Technology Integration

Variables	Attitude	Practice	Interactive Learning	Gamification	Video-based Learning	Project-based Learning
Knowledge	r =.695*** df = 203 p <.001	r =.480*** df = 203 p <.001	r =.587*** df = 203 p <.001	r =.510*** df = 203 p <.001	r =.511*** df = 203 p <.001	r =.576*** df = 203 p <.001
Attitude	—	r =.582*** df = 203 p <.001	r =.676*** df = 203 p <.001	r =.591*** df = 203 p <.001	r =.627*** df = 203 p <.001	r =.662*** df = 203 p <.001
Practice		—	r =.497*** df = 203 p <.001	r =.534*** df = 203 p <.001	r =.528*** df = 203 p <.001	r =.510*** df = 203 p <.001
Interactive Learning			—	r =.636*** df = 203 p <.001	r =.684*** df = 203 p <.001	r =.800*** df = 203 p <.001
Gamification				—	r =.690*** df = 203 p <.001	r =.701*** df = 203 p <.001
Video-based Learning					—	r =.796*** df = 203 p <.001
Legend: * p <.05, ** p <.01, *** p <.001						

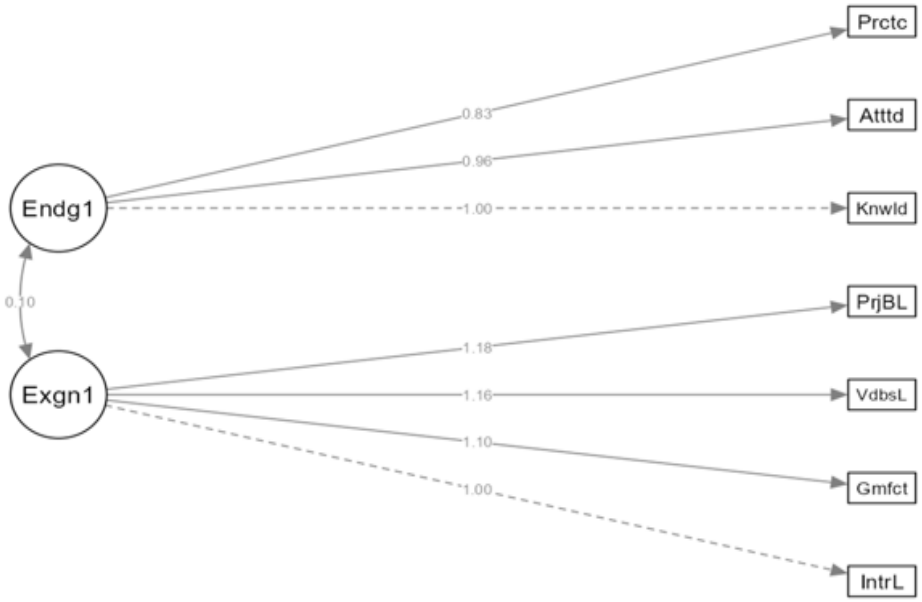

Figure 4: The relationship between the roles of technology integration and the students' KAP (Knowledge, Attitudes, and Practices) on the Sustainable Development Goals (SDGs) using the SEM Model.

The model fit is generally good, as indicated by the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Normed Fit Index (NFI) indices, which are all above 0.90. However, the Root Mean Square Error of Approximation (RMSEA) is slightly above 0.05, suggesting that there may be some room for improvement. As gleaned on the model, the Exogenous 1 (Technology Integration), it is clearly shown that the Exogenous 1 (Technology Integration) is significantly intertwined with its indicators with the highest positive association-project-based learning followed by the video-based learning and the gamification. Also, the KAP Model showed that Knowledge had the strongest indicator of the Endogenous1 latent variable. It was shown that there is a moderate relationship between Exogenous1 (technology Integration) and the Endogenous1 (KAP).

It was also shown that the Exogenous 1 (Technology Integration) has a positive impact on the Endogenous1 (KAP-Knowledge, Attitudes and Practices) with the project-based learning as the most significant component of the Exogenous1. The indices of the SEM model indicate a solid fit with the slight improvements to reduce the RMSEA.

The relationship between the technology integration and the knowledge, attitudes and practices is moderately significant signifying a good data. These findings noted the significant positive relation between technology integration specifically the project-based learning and the KAP dimensions. Additionally, the relationship between Technology Integration and KAP was moderate, implying that the use of technology, particularly in interactive and project-based learning environments, contributes positively to students' knowledge, attitudes, and practices. This study highlights the significance of technology integration into education context to enhance learning outcomes, but also suggests that further refinement of the model, particularly in terms of improving the RMSEA, could offer a more precise understanding of these relationships.

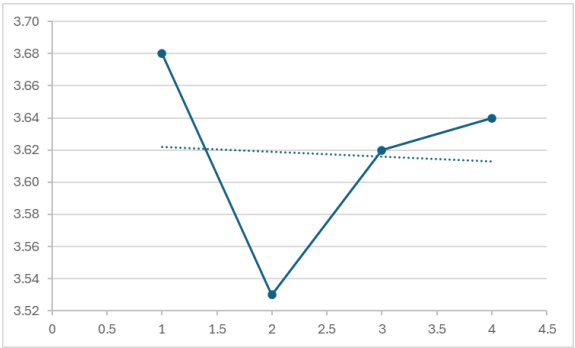

Figure 5: Key patterns and Gaps in students' technology-related practices towards SDGs.

Figure 5 reveals that interactive learning has the most important role while gamification specifically the indicator that states "using gamification to enhance understanding of specific SDGs"

consistently lags highlighting a potential gap in its educational impact. The clear dip in the line highlights this disparity. The moderate scores of video-based and project-based learning suggest that while useful, they do not reach the same level of engagement or learning depth perceived in interactive methods. This visual gap stresses the need to balance engagement with substance when integrating technology in education.

In contrast, while gamification has significant effect in learning, the study of Rodrigues et al. (2022) [22] revealed that gamification's impact follows the novelty effect or the initial interest of a person or excitement which subdue overtime as the newness wears off. This highlighted the importance for educators to reflect and be creative or innovative by considering how long the impact of the used gamification will last and how long does it will take to recover after noticeable reduction in benefits. The results align with the findings of Diaz and Estoque-Loñez (2024) [23] who conducted a study on gamification. Their study reviewed fifteen empirical studies published between 2018 and 2022, examining the impact of gamification across five moderator variables. It was also revealed that gamification meaningfully and significantly related to the student performance. However, analysis revealed that the five moderator variables did not exhibit statistically significant effects. The results of the research lead to believe that gamification is effective in academic courses at all levels in the Asian context.

7 CONCLUSIONS

The analysis revealed several key findings regarding students' awareness of SDGs and the role of technology integration in supporting knowledge, attitudes, and practice:

1) Most students segmented as Cluster 1 are relatively aware and engaged with SDG-related concepts and actions while a notable minority segmented as Cluster 2 requires additional support and intervention.
2) The results of the structural equation modeling (SEM) analysis provide compelling evidence for the significant role of Knowledge in shaping both Attitudes and Practices related to sustainable development goals (SDGs). The positive association between Knowledge and both Attitude ($\beta = 0.918$) and Practice ($\beta = 0.634$) suggests that individuals with higher knowledge about SDGs tend to exhibit more favorable attitudes and engage in more sustainable practices.
3) Among all the roles of technology integration, interactive learning consistently scores the highest which suggests that it is the most important due to its engaging and participatory nature that promotes active involvement.
4) There is a significant positive relationship between Knowledge, Attitude, Practice, and various technology integration variables (Interactive Learning, Gamification, Video-Based Learning, Project-Based Learning).
5) The SEM model suggests that Technology Integration (Exogenous1) has a positive impact on KAP (Knowledge, Attitude, and Practice), with Project-Based Learning being the most influential component of technology integration.
6) Interactive learning has the most important role while gamification, specifically the indicator that states consistently lags highlighting a potential gap in its educational impact.

8 RECOMMENDATIONS

It is recommended that the use of technology, particularly in interactive and project-based learning environments, contributes positively to students' knowledge, attitudes, and practices. This study highlights the significance of technology integration in the classroom settings to enhance learning outcomes but also suggests that further refinement of the model.

To address the gaps of different clusters, teachers can use strategic intervention framework for curriculum instruction based on Vygotsky's Principles. This will provide support enrichment, guided by sociocultural learning theory. For Lower Cluster the instructional focus is on the foundational understanding of SDGs and Globalization. Educators can approach this through scaffolded learning using ZPD. Interactive digital tools such as videos and gamified modules can be utilized with structured prompts for modeling and guided practice. While those on the higher cluster can challenge their critical thinking through capstone projects where they can do policy analysis or digital advocacy campaign. This approach is based on social constructivism learning theory where learning as a social process includes peer collaboration a culturally relevant tools to support deeper understanding).

Since the study was conducted in a Philippine context, it is recommended that CHED and other

HEIs institutionalize the integration of SDG-based performance tasks within the general course specifically The Contemporary World. This may include revision of syllabi to include outcomes-based projects aligned with SDGs, training programs for faculty and administrators on sustainability education and the adoption of digital pedagogical tools to develop greater global awareness and civic responsibility.

Moreover, consistent implementation of monitoring and evaluating mechanisms are necessary to assess effectiveness of SDG integration in course delivery. This will ensure a positive impact on students' knowledge, attitudes, and practices regarding sustainable development.

For teachers, it is highly recommended that they to continue Professional Development Initiatives (PDIs) through In-Service Trainings (INSETs), particularly on the unique goals and content of The Contemporary World course. These trainings will support teachers in enhancing learning materials and digital resources aligned with SDG-related themes. Integration of interactive learning tools, gamification techniques, video-based instruction, and project-based learning are effective ways to enhance students' engagement and global awareness.

Additionally, such training can help educators assess how they can effectively utilize these technologies in key topics of TCW emphasizing related SDGs. It will enable them to deliver more contextualized, meaningful and socially responsive instruction leading to students' development of actionable solution to global issues. Consequently, these trainings can serve as learning avenues for teachers to enrich their own understanding of SDGs which is essential for the genuine, informed, and meaningful delivery of lessons. It is a holistic approach that ensures educators are not only equipped with the right tools but are also well-grounded in the principles and purpose of sustainable development.

Finally, further studies are encouraged to replicate this research across different educational contexts and academic levels to validate the findings and explore additional dimensions of effective educational interventions. Replication may be extended in the context of Environmental Science, English language and Literature and other subjects where SDGs are highly relevant. This encourages interdisciplinary approaches from various perspectives that can enrich pedagogy promoting critical thinking and problem solving, and global awareness. Replication and expansion of the study will help ensure broader applicability and continuous improvement of education in line with both national standards and global commitments.

This study primarily focused on student's level of awareness and understanding of SDGs. Future research may shift the lens towards educators—assessing the depth of teachers' understanding of SDGs and their readiness to deliver meaningful lessons aligned with the global goals. Investigating teachers' pedagogical preparedness could offer insights to capacity-building needs and contribute to the improvement of current curriculum.

Moreover, while the study highlights the positive attitudes of students toward technology integration in achieving SDG-related learning, future studies may also look at the practical challenge of implementing such integration. In the context of the Philippines, questions of technological readiness, access to facilities, availability of possible educational tools must be look at. Investigating these barriers may inspire initiatives of meaningful collaborations between HEIs, policymakers, and educational technology providers to develop sustainable, inclusive digital learning ecosystems.

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