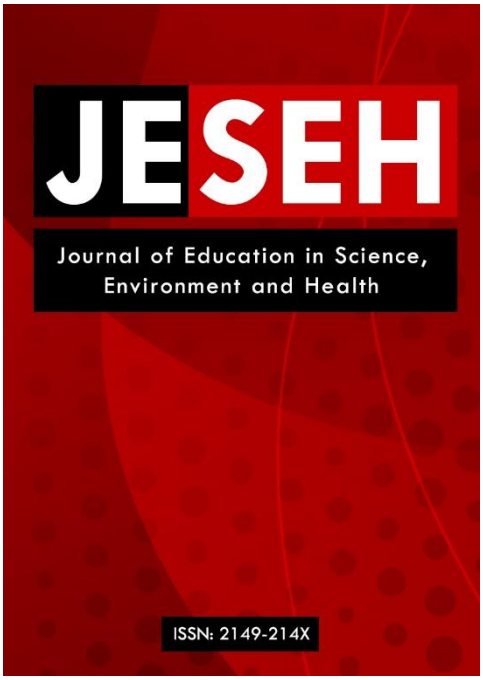

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Abstract

In recent years, the number of studies on artificial intelligence or AI has increased tremendously, and their place in daily life is beginning to be felt more and more each day. Current rise of generative AI tools has brought forth dangers regarding its potential misuse, leading to impacts on the environment. College students were surveyed using an infographic and a 5-point Likert scale to assess their awareness regarding these environmental implications. The students exhibited a lack of awareness on most of the implications, only recognizing generative AI's impact on the environment to a certain extent. In particular, the awareness of students on the environmental implications of generative AI such as its carbon footprint resulted in an unclear consensus. Additionally, students only showed an understanding of the electricity that generative AI demands and not also the fresh water and rare metals it consumes. The data suggests that this lack of awareness may stem from insufficient knowledge regarding generative AI. To address these concerns, further promotion in raising awareness was recommended, and an infographic was proposed.

Introduction

In recent times, artificial intelligence or AI has taken the world by storm and has started to embed itself in our society. AI revolves around digital computers or robots that have the capability to perform tasks that require human intellect. This includes being able to reason, to solve problems, as well as to converse. Shruti (2024) categorizes AI systems by their purpose. It can be trained to be reactive, utilize past information, understand human emotion, or be self-aware. Uppal (2023) instead splits AI systems into two, strong AI and weak AI. Strong AI refers to systems designed to exhibit human-like tendencies and intelligence while weak AI are delegated to performing specific tasks. AI can further be classified into systems that can learn from data and use it to predict outcomes. This process is called machine learning. Machine learning can be supervised, unsupervised or reinforced. Training the system by supervising its learning through proper labeling of data results in its ability to predict outcomes. On the other hand, training the system with unlabeled data allows it to infer patterns and similarities among different data points. The system can also learn through trial-and-error by reinforcing the optimal solutions from a set of choices. A much wider usage of machine learning is called deep learning. Deep learning is done by giving vast amounts of data to the system and designing it in a way so that it can learn from numerical and non-numerical data, functioning almost like a human brain.

Advancements in machine learning and deep learning popularized generative artificial intelligence in the 2000s (Roman, 2023). It uses deep-learning models to generate any form of media such as text, images, graphics, sound, etc. based on training data (Martineau, 2023). Generative AI is deemed to be convenient for producing a desired type of content with a simple query or prompt by a user. A recently popular artificial intelligence program is a chatbot called ChatGPT. Created by OpenAI, it is a form of generative AI that uses the same concept of deep-learning material given by a large data set (University of Central Arkansas, n.d.). It is famous for providing quick yet detailed answers for any question given by a user, based on published references and other sources for data training. While ChatGPT leans more toward text generation, other generative AI programs or sites such as Midjourney, Adobe Firefly, DALL-E, Typecast, and Stable Diffusion generate images, sound, and other forms of media.

To such a degree, AI systems have been used in the field of medicine, finance industry, and facial recognition technologies (Uppal, 2023). In the field of medicine, AI is being used to revolutionize the industry by making the process faster than what humans can do. Some of the various applications of AI in the medical field are AI-led drug discovery, AI-assisted clinical trials, and patient care. AI also helps in reducing human errors especially for large volumes of data that hospitals and other medical related labs need. Additionally, AI-powered technologies

such as healthcare robotics and AI-driven stethoscopes provide a way for more accurate diagnoses that is ultimately beneficial for patients. Despite these, AI in the medical field is still in its early stages and more research is still necessary (Shaheen, 2021).

Meanwhile in the finance industry, a paper published by Cao (2020) claims that AI have also been used in various applications such as market analysis, intelligent investment, blockchain technology, financial forecasting, and risk management. With the use of AI models designed for the finance industry, the risk factors can be lessened by making AI-driven analysis and forecasting. He then concluded that the advancements AI has been making is driving an new era of data and intelligence-driven economics and finance.

Despite these innovations, a conundrum emerges as society deems that AI possesses power that, if uncontrolled, can be devastating. Pazzanese (2020) notes that ethical concerns over the issues of privacy and bias that an AI system might step over are not baseless. Furthermore, the role of human judgment is also in consideration as suspicions of AI systems outright surpassing human intelligence arises. Generative AI, specifically, encountered intensive concerns as some of the popular generative AI programs rely on already available content and works from human creators, instead of the enormous data set used in deep learning and machine learning. This ignited controversy as evidence surfaced, showing that these programs collect training data from artists and creators without their consent or prior notice.

The artificial content produced by generative AI has circulated throughout social media platforms. In some cases, people fail to distinguish between manmade content and AI content. Furthermore, generative AI content can be deemed unnecessary as it fails to integrate with consumer behavior in an economic standpoint. A brand's adoption of generative AI induced negative behavioral follower reactions, affecting the brand's authenticity (Bruns & Meißner, 2024).

Other than ethical concerns, environmental concerns also plague AI systems due to its massive impact on nature. Ren and Wierman (2024) explain that accessing astronomical amounts of data consumes an alarming amount of electricity while also producing carbon emissions. This strain on electricity can lead to a rigorous burning of fossil fuels to match the needs of an AI system. Moreover, bodies of water are also affected as AI systems also require water for the cooling of servers or computers. Generative AI in general has a significant impact on energy consumption from training on large data sets. It is distinct from other labels of AI as it requires a tremendous number of calculations compared to traditional AI models. According to Vincent (2024), in the year 2022, data centers for AI and cryptocurrency used 460 terawatt hours of energy. They predict that in 4 years, it could increase to 620 or 1050 terawatt hours, which is equivalent to the energy consumption of Sweden or Germany respectively.

Objectives of the Study

The research aimed to identify the current awareness and understanding of students about the environmental implications of generative AI. It explored how frequently students use generative AI and their attitudes toward its sustainability. It explored the responses of college students from every course included in the study.

Statement of the Problem

The rapid rise in the popularity of advanced AI technologies has significantly impacted environmental welfare, including its scarcity of resources and severity of pollution. This study investigated the selected students' level of awareness regarding generative AI's environmental impact. The objectives were the following:

- Determining how often students use generative AI technologies for casual use and productivity.
- Assessing the students' awareness of generative AI's high demand for limited resources for its hardware platform, such as electricity, fresh water, and rare metals.
- Assessing the students' awareness of generative AI technology's direct effects on the environment such as:
    - High emissions of carbon footprint
    - Large contribution to the depletion of nonrenewable resources
    - Large contribution to producing electronic waste
- Comparing the answers of students in each course covered in the study.

Environmental Implications of Generative AI

Generative AI is rapidly expanding across various sectors, enabling machines to produce text, images, audio, and even video. These advancements, however, bring with them substantial environmental concerns primarily due to the immense computational requirements involved in training, deploying, and maintaining such models. As generative AI programs continue to grow, so too does their ecological footprint, making it essential to examine the environmental repercussions of these technologies in detail.

One of the most significant environmental concerns is energy consumption and carbon emissions. Large-scale generative AI models, such as Generative Pre-trained Transformers (GPT), require substantial computational resources throughout both the training and inference phases. This process generates considerable carbon emissions. For example, training a single large model like GPT-3 can result in carbon emissions equivalent to driving more than 240,000 miles in a passenger vehicle (Wu et al., 2022). As the size of model parameters increases, so does the need for energy, as more powerful infrastructure is required to support their development. In addition to direct electricity consumption, AI systems contribute to indirect emissions through the cooling systems used to maintain data centers. Although there have been efforts to improve energy efficiency, the rapid growth in computational demand continues to outpace these improvements, leading to a net increase in emissions (Bashir et al., 2024). It is estimated that global electricity consumption by data centers will reach between 620 and 1,050 TWh by 2026, posing significant challenges to sustainability goals, especially in terms of balancing carbon emissions and reducing greenhouse gas emissions.

Another critical aspect of generative AI's environmental effects is resource depletion and the effects of hardware production. Generative AI systems depend heavily on specific hardware like GPUs and AI accelerators, which significantly contribute to resource consumption. The extraction of rare earth minerals and metals for this hardware is energy-intensive and environmentally damaging, leading to habitat destruction, pollution, and the depletion of nonrenewable resources (Bashir et al., 2024). Furthermore, the production of hardware, particularly chips, requires significant amounts of water that leads to adding strain to water-scarce regions. The environmental effects extend throughout the hardware's lifecycle, from production to disposal, forming part of the embodied carbon footprint of generative AI systems. As AI systems scale, the demand for more powerful hardware worsens these environmental issues, making hardware production and maintenance unsustainable (Wu et al., 2022).

Despite efforts to improve efficiency, the rebound effect and other unintended consequences play a role in diminishing the potential environmental benefits of these advancements. The rebound effect occurs when improvements in energy efficiency lead to increased usage, ultimately driving up overall energy consumption (Bashir et al., 2024). For instance, as generative AI models become more efficient, they become more widely adopted across industries, which paradoxically increases their environmental burden despite improvements in per-task efficiency. Additionally, if the growth of AI technologies outpaces the development and adoption of renewable energy sources, industries may become further entrenched in the use of high-emission energy sources, delaying the transition to more sustainable practices.

Moreover, the ecological and system-level effects of generative AI are far-reaching. The expansion of data centers to meet the growing demand for computing power consumes vast areas of land and water, leading to habitat loss and reduced biodiversity in areas where these centers are located. The construction and operation of data centers can also cause environmental degradation, such as soil erosion and increased water usage. At a broader system level, the industrial shifts brought about by AI adoption can worsen environmental problems. For example, while AI innovations in energy management or design may improve efficiency, they can simultaneously increase overall consumption, undermining efforts to reduce the environmental footprint of these systems (Bashir et al., 2024).

Despite its environmental challenges, Generative AI also offers opportunities to support environmental research and communication. One notable benefit is its ability to streamline research workflows by enabling the creation of visual representations from text-based prompts, which can enhance communication between scientific communities and the public. For example, AI-generated images can represent conceptual models of climate change or illustrate complex ecological relationships, thereby aiding public understanding of environmental issues (Rillig et al., 2024). In addition, generative AI can assist in filling data gaps in environmental research, particularly in cases where regions are inaccessible or where instruments fail. AI models can predict missing data points, providing more complete datasets for analysis, particularly in fields such as remote sensing and biodiversity monitoring.

In addition to these environmental applications, the rise of models like ChatGPT and DALL-E has introduced broader implications for the use of generative AI. For instance, these systems that are based on large language

models and neural networks can generate human-like text, images, and even music based on user input. For example, ChatGPT has made content creation, customer service, and education easier by automating tasks that traditionally required human effort. Similarly, DALL-E and many other image generation networks allow users to create unique, visually appealing images based on simple text prompts that change the face of art and design. While these advances boost productivity and creativity, they come with environmental concerns. The extensive computational power required by these models leads to energy consumption and carbon emissions, which raises sustainability questions regarding the environment. Moreover, the ease with which users, particularly students, can create content for academic assignments, social media, or other purposes can lead to greater and sometimes unnecessary computing demands, increasing carbon emissions as a result. Such a development not only spells doom to sustainable technology use but also has a broader implication on environmental issues such as increased energy consumption and depletion of natural resources. In addition, the social implications of generative AI, such as the loss of human employment, require responsible development and regulation to avoid technology advancement that significantly negatively impacts environmental and human well-being.

Students on Generative AI

Today's popularity of generative AI systems like ChatGPT is unmistakable. Due to this recent rise in popularity, extensive knowledge regarding generative AI is not yet common and accessible to the common folk. Thus, it is important to understand the perception and knowledge students have regarding generative AI, to establish whether they can also understand its environmental effects.

Wood and Moss (2024) investigated the usefulness of generative AI in teaching. In their study, students became comfortable enough with using generative AI that they can also understand its strengths and limitations as an instructional tool. The respondents believe that it has significantly helped them in their personal growth as well. Woods and Moss warn, however, that these positive results were achieved through a thorough guidance on how to use generative AI. This eliminates issues of bias, privacy, and misuse while allowing for an understanding on the implications of generative AI.

A study by Amoozadeh et al. (2024) focuses instead on the students themselves and their trust on generative AI. The researchers highlight that the students' trust in these new tools are critical because it gives them confidence to try it out and make use of it, allowing them to harness its potential. By interviewing computer science students who are more likely aware of how AI systems work, they were able to deduce that students have a mostly neutral view of generative AI but are wary of the outputs it provides, despite a majority having used generative AI for their own endeavors. The researchers also observed the difference regarding generative AI systems' inherent lack of transparency and the students' opinions that these systems are in fact transparent, which relates to the level of trust these students give to these systems.

Other studies also gave mixed results on generative AI, where students are both optimistic and reserved regarding generative AI. A select few are unaware, a generous amount do not use generative AI, but most agree that it is useful and there should be guidelines on where, how, and when to use it (Chan & Hu, 2023; Johnston et al., 2024). In particular, students see its usage in tasks such as grammar checking but frown upon its deeper usage in academics such as writing essays, believing it to be unfair and a form of plagiarism (Johnston et al., 2024). Chan and Hu (2023) reported that while their respondents mostly exhibit a positive attitude towards generative AI, they all still have their own concerns and issues regarding its implementation and potential usage in the future. Interestingly, Chan and Hu found that their respondents have a high expectation on the functionalities of generative AI but have a poor understanding of its limited emotional intelligence leading to insensitive outputs. They noted that AI literacy on students must be enhanced to allow them to use generative AI responsibly and request for a better approach regarding its integration into education.

ChatGPT itself was made to be the focus of the study of Abbas et al. (2024). According to them, the amount of workload and time pressure that a student is given increases their tendency to rely on generative AI. While those that are more sensitive to rewards, or fear being caught, are less likely to use generative AI. The study discovers that besides other concerns of generative AI, the overreliance of it causes students to have poor academic performance, procrastinate more, and even have memory loss. This is alarming especially if students are not made aware of these potential effects.

Several studies (Dai, 2024; Deschenes & McMahon, 2024; Obenza et al., 2023) affirm that students are using generative AI. Some reported that half of their respondents confirm using generative AI in their academic works. According to Deschenes and McMahon (2024), ChatGPT is the most used platform by students. Their respondents

were reported to have a tendency to use generative AI in summarizing, getting feedback, and editing their works. Deschenes and McMahon noted that this could lead to an increase in generative AI usage in the future. Their respondents also expressed concerns on the negative impacts of generative AI on their learning. The respondents of Obenza et al. (2023) instead reported concerns over the negative impacts of generative AI in enhancing skills and the possibility of over-reliance on these systems. Despite these concerns, their respondents were still positive in using ChatGPT for academic works while maintaining a high level of awareness regarding the use of ChatGPT.

Research pertaining specifically to the environmental implications of generative AI are still not ample enough and so the perception of students on this topic is also lacking. However, it does not mean that students are not aware of the impact of technology on the environment. A study in the Philippines by de Mesa et al. (2022) recognizes that engineering students have high awareness regarding the impact of technology to the environment. E-waste and energy efficiency, for example, are some of the factors that received the highest awareness from the students in this research. Additionally, the students were reported to have a high level of commitment to environmental sustainability. The research affirms that Filipino students, specifically engineering students, do have some awareness of factors that affect the environment and willingness to take care of the environment. The results of Jahan and Mim's (2023) study reaffirms this statement through a different perspective. The students in their research were reported to be familiar with e-waste and its risks on the environment. Despite this, most of them were discovered to perform acts that are not sustainable to the environment such as not recycling e-wastes. This was not done out of intent but rather from a lack of information. The study found out that most students only have the internet as their source of information, leading to an insufficient knowledge on how to properly recycle e-wastes, programs regarding the recycling of e-wastes, and laws and regulations regarding e-wastes. The research demonstrates a possible outcome of the lack of knowledge regarding technology, and how students may want to perform acts that sustain the environment but cannot due to this insufficiency.

Because generative AI is becoming a trend in the present day, students are even more at risk of the potential demerits of generative AI and need a moderation to ensure its responsible usage. While students may use generative AI for their own purpose, they might not fully comprehend the repercussions of using it. The Philippines is a developing country, and so the need to determine the awareness and perception of students in the Philippines concerning generative AI becomes critical to avoid its misuse. Furthermore, the constant usage of generative AI for entertainment requires attention, especially because of the environmental impacts it can cause. The knowledge of students regarding generative AI's environmental implications needs to be checked in order to maintain its sustainable and responsible usage.

Method

Design

This research is a survey study under quantitative research. The research questions were addressed by gathering the perspectives of college students.

Locale

This study was conducted at Bulacan State University - Main Campus, located in Malolos, Bulacan. The respondents were the currently attending Bachelor of Science (BS) students in the College of Science at the time of this research. This college was selected as it offered courses such as BS in Computer Science that have the higher chance of having knowledge on how generative AI works due to the nature of their field. The college also houses several courses related to the environment such as BS in Environmental Science, BS in Environmental Science with Specialization in Climate Change and Disaster Management, and BS in Environmental Science with Specialization in Pollution Control Management, that aim to help the environment. These courses, along with other courses that have lower relation to generative AI, were expected to provide diverse perspectives of the topic, which is necessary in order to provide deeper insights on both Generative AI and its environmental implications. In doing so, the data can better represent the population at large, which aligns with the objective of this study.

Participants

The aim of this study is to establish the awareness of students. As such, a survey method was employed to gather sufficient data from the students. The letter submitted to the Dean of the College of Science Department requesting

permission to conduct the survey was approved. This letter was then used to get the actual population of students in College of Science Department for the school year 2024-2025. The total population was 2173 across all 9 courses. The courses were the following:

- BS in Biology (BSB)
- BS in Environmental Science (BSES)
- BS in Environmental Science with Specialization in Climate Change and Disaster Management (BSES CCDM)
- BS in Environmental Science with Specialization in Pollution Control Management (BSES PCM)
- BS in Food Technology (BSFT)
- BS in Mathematics with Specialization in Applied Statistics (BSM AS)
- BS in Mathematics with Specialization in Business Application (BSM BA)
- BS in Mathematics with Specialization in Computer Science (BSM CS)
- BS in Medicinal Technology (BSMT)

A stratified random sampling was employed to ensure a statistically accurate data that includes at least one student from every course. A stratum was made to include all the sections of all year levels in every course needed in the study. Then, random sections were picked to be the representative of their respective course. The Cochran formula was used in determining the sample size of 327 with 95% confidence, 5% margin of error, and 0.5 proportion. The sample size was distributed proportionally based on the number of students attending each course. The demographic of the respondents according to their courses follows in Table 1.

Table 1. Frequencies of the respondents' courses

Course	Counts	% of Total	Cumulative %
BSB	69	21.1%	21.1%
BSES	20	6.1%	27.2%
BSES-CCDM	6	1.8%	29.0%
BSES-PCM	5	1.5%	30.5%
BSFT	48	14.7%	45.2%
BSM-AS	43	13.1%	58.3%
BSM-BA	46	14.1%	72.4%
BSM-CS	63	19.3%	91.7%
BSMT	27	8.3%	100.0%

Instrument

The initial instrument was developed by utilizing related studies and questionnaires that tackle on the perception of students on generative AI and the environmental implications of generative AI. The final version of the instrument contains two pages: the first page containing an infographic explaining how generative AI works and the second page containing a 5-point Likert scale with 9 items divided into 3 sections. The sections were comprised of the following:

1. How often do you use generative AI for the following purposes?
    - (p1.a) For casual use (entertainment, social media engagement, etc.)
    - (p1.b) For assistance in productivity (academic, professional, commercial, art, etc.)

2. Please indicate your level of awareness of the following implications related to generative AI. Generative AI highly demands the following resources:
    - (p2.a) Electricity
    - (p2.b) Rare metals used as materials for generative AI's data centers.(e.g. gold, copper, cobalt)
    - (p2.c) Fresh water used to cool generative AI's data centers

3. Please indicate your level of awareness of the following environmental implications related to generative AI.
    - (p3.a) Generative AI's platform produces a high amount of carbon footprint.
    - (p3.b) Generative AI's platform contributes to the depletion of nonrenewable resources.
    - (p3.c) Generative AI's platform produces a large amount of electronic waste.
    - (p3.d) Generative AI's platform has a large impact on the environment.

The sections employ a scoring that ranges from 1 (Never) to 5 (Always), from 1 (Fully Not Aware) to 5 (Fully Aware), and from 1 (Fully Not Aware) to 5 (Fully Aware), respectively. The 5-point Likert scale was determined following a similar instrument from the study of Paguigan and Jacinto (2018). All the questions in the survey were revised rigorously to align with the objectives of the study.

Validity

The instrument underwent content validation wherein three experts were asked to validate the survey. Using the guidelines from Yusoff (2019), the questionnaire received revisions from its performance on the content validity index based on relevance (CVI-R) and clarity (CVI-C).

Reliability

A pilot test was conducted where 30 students were selected using stratified random sampling and were asked to answer the questionnaire. A statistician was sought to perform a reliability test on the instrument using the data collected from the pilot test. Through the Jamovi software, the statistician determined the instrument's Cronbach alphas to be acceptable.

Procedure

The survey was distributed in person within designated areas of the Bulacan State University - Main Campus, and inside the respective classrooms of the chosen sections. The selected sections' mayors and their instructors present at the chosen time frame, when applicable, were approached and asked for their permission to survey the class. Respondents were given a maximum of 20 minutes to scan the infographic and finish the survey. Basic information of the respondents, such as course and year level, were also asked in the survey. Before handing out the survey, the respondents were given information about the objectives of the research, the assurance that their information will remain private, and the permission to call for the attention of the researchers should any concerns arise at any moment. They were also given candies and chocolates as a form of gratitude for giving their consent to participate in the research.

Data Analysis

The study reported all items with descriptive statistics. The first section's items, the frequency of students' use in generative AI tools, were assessed with measures of central tendency and frequency distribution tables, accompanied by histograms. The rest of the items were interpreted by measures of central tendency, along with diverging stacked bar graphs.

The Shapiro-Wilk test was used to determine the normality of each of the items' data. This test resulted with all the items having p-values of <.001. This led to all the items failing the normality hypothesis of the test, leading to use the non-parametric version of the one-way ANOVA, the Kruskal-Wallis test. In the Kruskal-Wallis test to identify significant relationships, only items with p-values less than 0.05 were selected and further elaborated. For each of the selected items, diverging stacked bar graphs were provided a descriptive comparison between the respondents' courses, as the independent variable; and data from the items' Likert scale, as the dependent variable. The use of this test was most appropriate as the data involved the relationship between multiple nominal groups and ordinal data.

The study used an open-source statistical platform, Jamovi, to compute for the collected data's measures of central tendency (median and mode), frequency distribution, the Shapiro-Wilk test, and the Kruskal-Wallis test. The researchers also used Microsoft Excel to illustrate the necessary figures such as histograms and diverging stacked bar graphs.

Results and Discussion

Descriptives

Table 2. Central tendency measures (median and mode) per item

Item	Median	Mode	Scale Median	Mode
(p1.a) Casual	3	3	Sometimes	Sometimes
(p1.b) Productivity	4	4	Often	Often
(p2.a) Electricity	4	4	Aware	Aware
(p2.b) Rare metals	2	2	Not aware	Not aware
(p2.c) Fresh water	2	2	Not aware	Not aware
(p3.a) Carbon footprint	3	4	Neither aware nor not aware	Aware
(p3.b) Resource Depletion	3	2	Neither aware nor not aware	Not aware
(p3.c) E-waste	3	4	Neither aware nor not aware	Aware
(p3.d) Impact on environment	4	4	Aware	Aware

Frequency in Use of Generative AI Tools among Students

Casual use. From Table 2, both of item p1.a's median and mode indicate "Sometimes" as the most common response with 106 students (32.4%). From Table 3, the results indicate that 49.2% of the students never or rarely casually use generative AI tools, while 18.3% of the students often or always use those tools. This indicates that respondents moderately use generative AI for casual purposes, but with a tendency towards less frequent use.

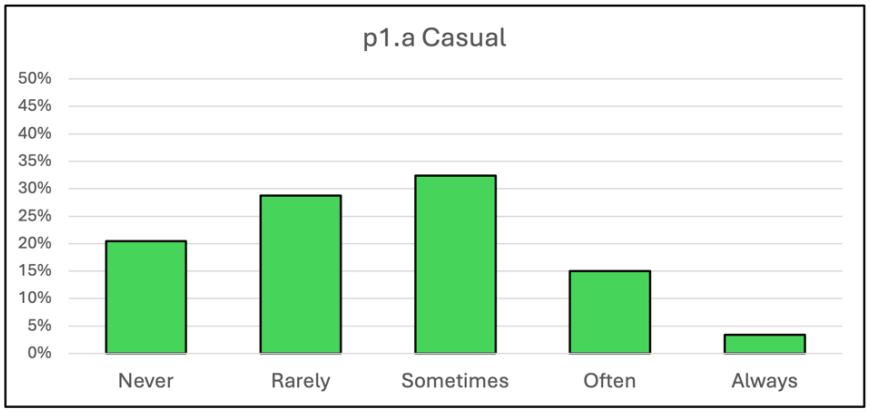

Figure 1. Histogram of the casual use of generative AI tools among respondents

Table 3. Frequencies of the casual use of generative AI tools among respondents

p1.a Casual			
Scale	Counts	% of Total	Cumulative %
Never (1)	67	20.5%	20.5%
Rarely (2)	94	28.7%	49.2%
Sometimes (3)	106	32.4%	81.7%
Often (4)	49	15.0%	96.6%
Always (5)	11	3.4%	100.0%

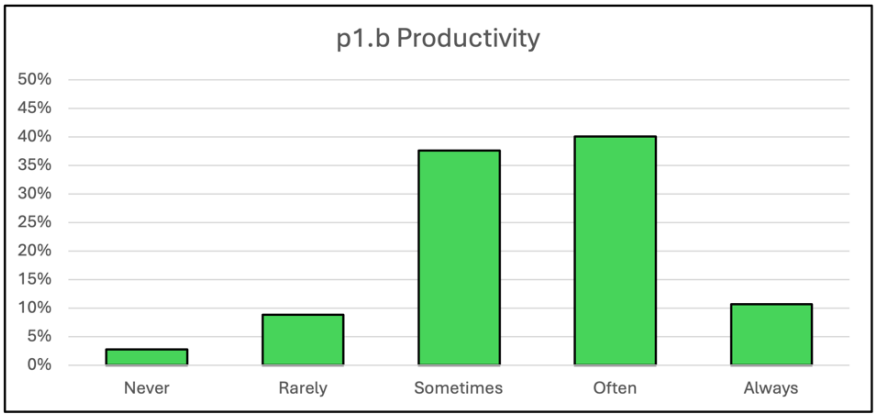

Figure 2. Histogram of the use of generative AI tools for assistance in productivity among respondents

Assistance in productivity. From Table 2, both of item p1.b's median and mode indicate "Often" as the most common response with 131 students (40.1%). From Table 4, the results suggest that 11.6% of the students never or rarely use generative AI tools for assistance in productivity, while 50.8% of the students often or always use those tools. This indicates how the students often use generative AI as assistance in their productivity purposes.

Table 4. Frequencies of the use of generative AI tools for assistance in productivity among respondents

p1.b Productivity			
Scale	Counts	% of Total	Cumulative %
Never (1)	9	2.8%	2.8%
Rarely (2)	29	8.9%	11.6%
Sometimes (3)	123	37.6%	49.2%
Often (4)	131	40.1%	89.3%
Always (5)	35	10.7%	100.0%

Students' Awareness on Generative AI's Resource Demands

From Figure 3, 41% of the respondents answered with "Aware" on generative AI's demand for electricity, which marks both the median and mode from Table 2. Conversely, awareness on generative AI's demand for rare metals and fresh water both receive a median and mode of 2 (Not Aware), the response being 40% and 42%, respectively. This indicates that the respondents are generally aware of generative AI's electricity demand, but they are mostly unaware of generative AI's demand for rare metals and fresh water.

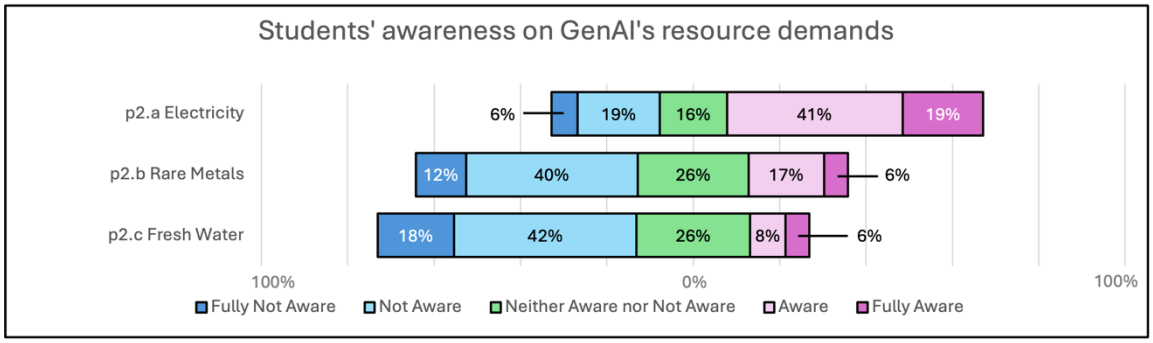

Figure 3. Diverging stacked bar graph of students' awareness on generative AI's resource demands

Students' Awareness on Generative AI's Environmental Implications

From Figure 4, the respondents were generally aware of generative AI causing a significant impact on the environment, with 37% and 20% of them answering "Aware" and "Fully Aware," respectively, marking 4 (Aware) as both the data's median and mode. However, the data provides an unclear consensus among respondents with generative AI's sub-implications on the environment, as the awareness levels are mostly split. Each of the first three implications' data show a mismatch between median and mode.

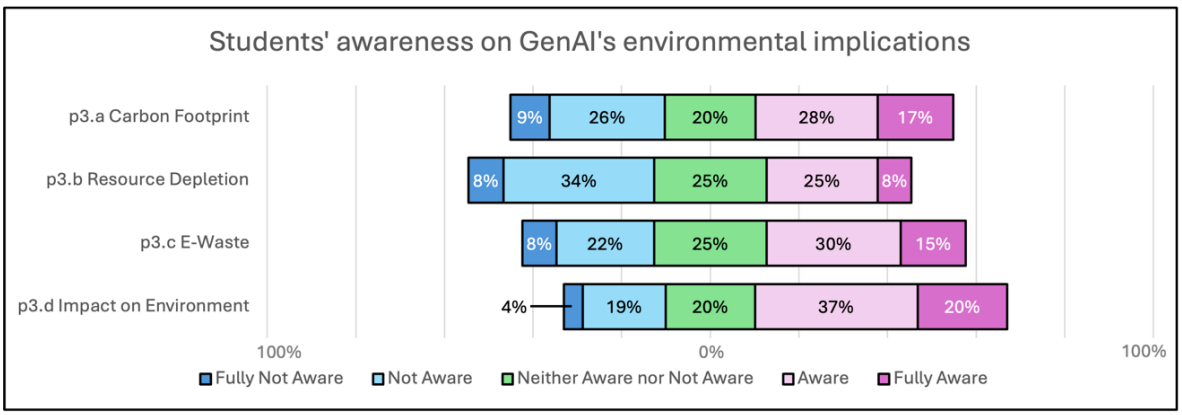

Figure 4. Diverging stacked bar graph of students' awareness on generative AI's impact on the environment

From Table 2, the data on the implications of generative AI's carbon footprint (p3.a) and e-waste (p3.b) both have a median of 3 (Neither Aware nor Not Aware) and a mode of 4 (Aware). This may suggest a distribution close to being balanced, but it still skews towards the most common response (Aware). Also from Table 2, data from the implication of its resource depletion (p3.b) also has a median of 3 (Neither Aware nor Not Aware), but it has a mode of 2 (Not Aware). This may also suggest a distribution close to being balanced, but it still skews towards the most common response (Not Aware).

Comparisons among Courses

From Table 5, with each item having degrees of freedom (df) of 8, items p1.b, p3.a, and p3.c have p-values less than 0.05, showing statistical differences among the responses of the stratified groups, within the highlighted items. Item p1.b possesses a small effect size (ε^2) with 0.0507, while items p3.a and p3.c each possess a medium effect size (ε^2) with 0.1353 and 0.1068, respectively.

Table 5. Kruskal-Wallis p-values for group (course) comparisons

Item	X^2	df	p	ε^2
(p1.a) Casual	10.63	8	0.224	0.0326
(p1.b) Productivity	*16.53*	*8*	*0.035*	*0.0507*
(p2.a) Electricity	11.53	8	0.174	0.0354
(p2.b) Rare metals	9.54	8	0.299	0.0293
(p2.c) Fresh water	11.56	8	0.172	0.0355
(p3.a) Carbon footprint	*44.12*	*8*	*<.001*	*0.1353*
(p3.b) Resource Depletion	13.21	8	0.105	0.0405
(p3.c) E-waste	*34.81*	*8*	*<.001*	*0.1068*
(p3.d) Impact on environment	11.72	8	0.164	0.036

From Figure 5, the data indicates that BSMT students use generative AI the most for productivity purposes, with 81% of their responses being "Often" or "Always," followed by BSES and BSM-CS with 65% and 55%, respectively. However, the effect of attending a specific program on the usage of generative AI for productivity is relatively modest, due to its small effect size (ε^2) in Table 5.

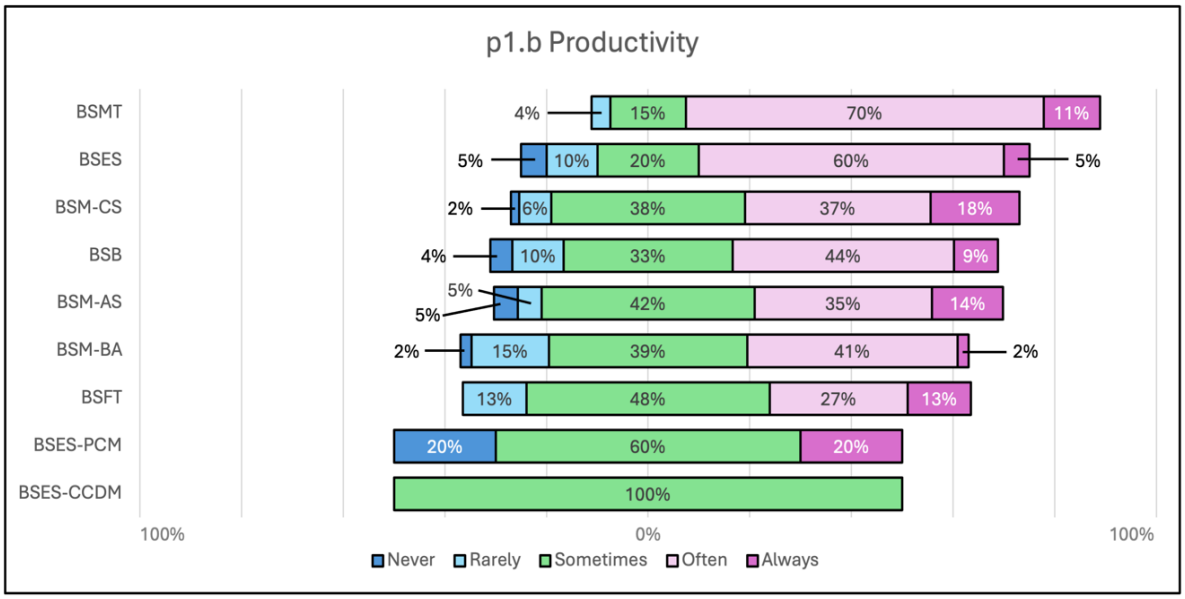

Figure 5. Diverging stacked bar graph of students' usage of generative AI for productivity among each course

From Figure 6, the data indicates that BSES students are the most aware of generative AI's carbon footprint, with 95% of their responses being "Aware" or "Fully Aware," followed by BSES-PCM and BSMT with 80% and 71%, respectively. From Figure 7, the data indicates that BSES-PCM students are the most aware of generative AI's e-waste production, with 80% of their responses being "Aware" or "Fully Aware," followed by BSES and BSMT with 75% and 74%, respectively.

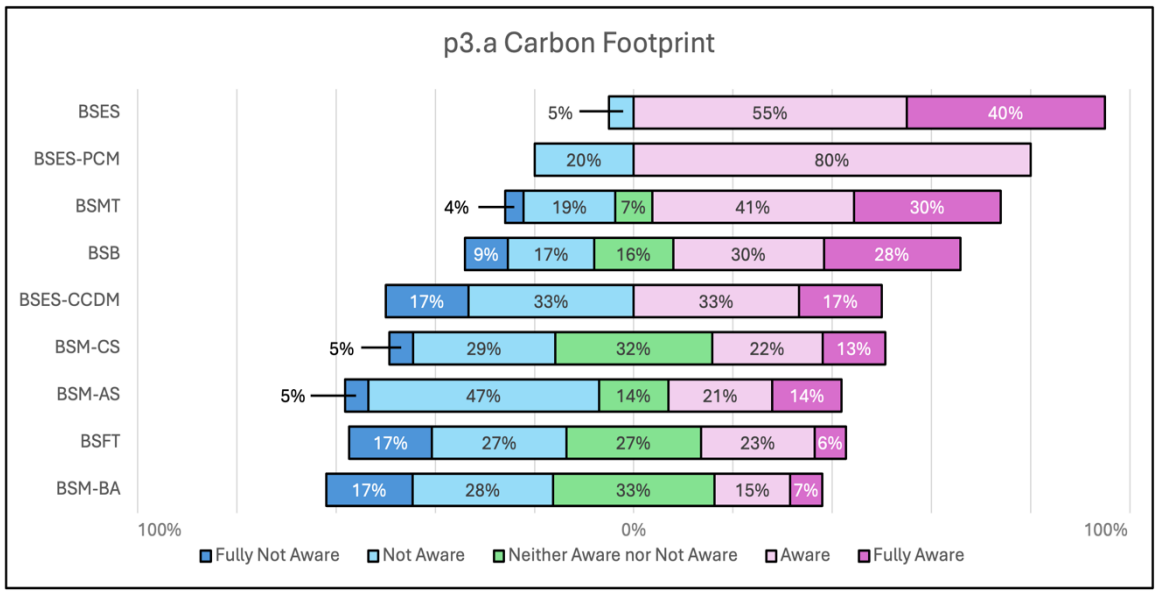

Figure 6. Diverging stacked bar graph of students' awareness on generative AI's carbon footprint among each course

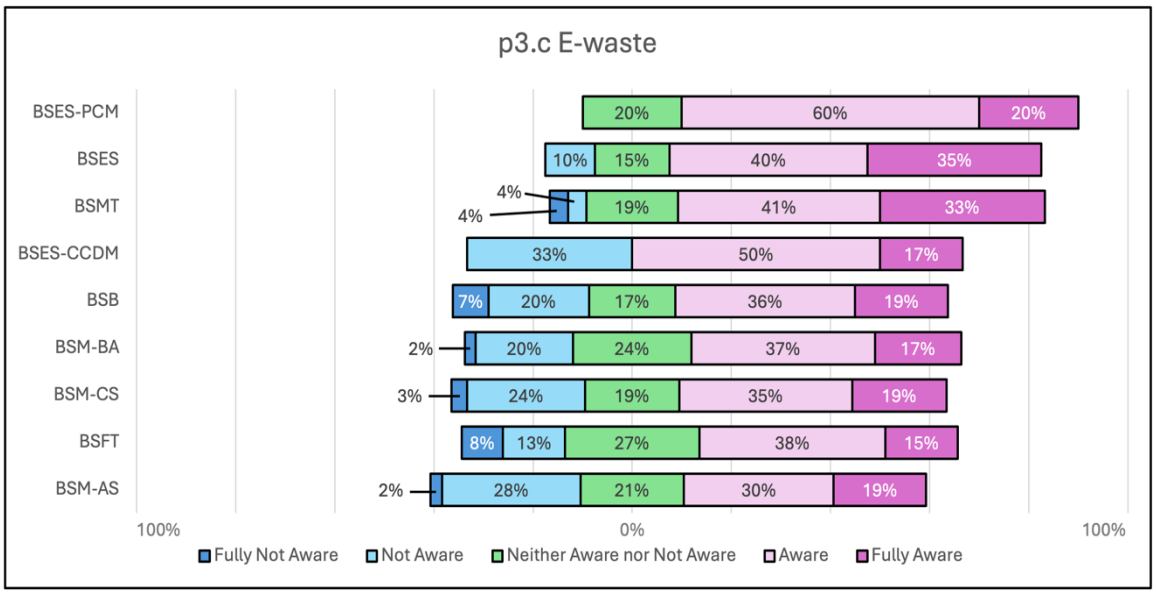

Figure 7. Diverging stacked bar graph of students' awareness on generative AI's contribution to e-waste among each course

Findings

The first objective of this study was to determine how the students use generative AI tools. The study coincides with other studies on this topic that students do use generative AI, and the data reflects that the usefulness of these tools is seen as a boon for productivity. However, the data also reveals that students do not actually have a high tendency to use generative AI. It only appears to be used sparingly, especially for productivity.

The next objective was to assess their awareness on the resource demands of generative AI. Having consistent values of the median and mode, the data shows that the respondents are only aware of the electricity demands of generative AI. This is alarming as poor understanding of these demands can shrink the severity of its misuse. The students' awareness on the electricity demands of generative AI could be due to its relation to devices. Students may be more inclined to think that generative AI generally has a high electricity demand since it is accessible through their own devices, such as computers, which have a high electricity demand in the first place. Additionally, media coverage about generative AI rarely fully explains the data centers it utilizes which is the main cause of the resource demands. The curriculum of students rarely touches upon and explains fully the topic

of generative AI which might also explain their poor understanding. Another thing to note is that the data points to the respondents being aware and not fully aware of its electricity demands. Perhaps their awareness needs to be elevated in all these categories.

Assessing the awareness of the students on environmental effects of generative AI proved to be difficult. The data displayed mixed results regarding each item in this section, as evidenced by the varying values of the median and mode on each item. The only universal answer was that generative AI does influence the environment. The data shows that while some students are aware of generative AI's carbon footprint and e-waste production, a significant portion of them do not have a clear understanding of these specific effects altogether. At the same time, the students are also not confident with their stance on the awareness of generative AI's resource demands, but most of them are clearly not aware of this effect. The diverse opinions may signify that the respondents have certain awareness regarding its environmental implications, but their knowledge on it does not have sufficient depth to specifically identify these effects.

Implication of the Results on the Respondents' Courses

Comparisons can be made regarding some of the data that was determined to have high statistical differences. Investigating the reason why BSMT and BSES students have a notable usage on generative AI tools may be of value to future researchers. In accordance with this information, BSES and BSMT students also showed some of the highest amounts of awareness per student on generative AI's carbon footprint and contribution to E-waste. Further studies should cover how the awareness of these courses can be applied in promoting the awareness of other courses.

The differing curriculum of each course is a factor to consider when observing the results obtained. BSES students are expected to have knowledge regarding this topic due to their curriculum, but they still retained a notable usage of generative AI tools. Their knowledge and confidence in avoiding or lessening the impacts of generative AI on the environment may also be a cause in their significant usage of it. On the other hand, the awareness and usage of BSMT students on generative AI might be attributed to the great value generative AI provides in the medical field (Reddy, 2024). Given the wide range of benefits, BSMT students might also be knowledgeable in these aspects and therefore incorporate generative AI in their practices. In addition, the workload given to BSMT students, who are often instructed to read and memorize information in their field, might increase their tendency to rely on generative AI in helping them in their studies. External factors such as the environment and professors the students have can also explain why they showed such results in the study. Due to the varying factors at play, further exploration on this occurrence is needed.

It can also be observed that BSES-PCM and BSES-CCDM students, BSES students with specializations, are evidently not displaying similar opinions. BSES-PCM students were reported to be one of the highest courses regarding the awareness on generative AI's carbon footprint and contribution to e-waste, but BSES-CCDM students were either equally aware and not aware or only leaning towards aware. This may suggest a difference in their curricula or a difference in the overall opinion of the students under these courses.

Limitations of the Research

The study only surveyed college students under the College of Science Department in Bulacan State University - Main Campus. This was selected because they had the highest potential to have sufficient knowledge on generative AI to answer the questionnaire. Students in other college departments who may not have sufficient knowledge regarding generative AI and its environmental implications yet use these tools unknowingly or regularly are worthy of investigation. The BSES-PCM and BSES-CCDM students were only made up of first-years due to its recency, leading to a small sample size on these courses. Further research regarding this topic should be made when these courses have higher total populations. Lastly, the quantitative nature of this study limits the investigation on this topic. Other methods should be used to explore this topic even further.

Recommendations

Based on the findings of this study, an infographic is proposed that aims to further enhance the awareness of students regarding the environmental implications of generative AI (Figure 8).

Figure 8. The proposed infographic the researchers designed

The researchers suggest an infographic because of its ease in spreading information and its ability to capture attention with its colorful details. The infographic contains concise but adequate information regarding this topic to remain easy to understand and not hard to read. The infographic is made with the goal of steadily elevating the awareness of students. The proposal acts as the first step in educating students on the environmental implications of generative AI and it also serves as a warning on the dangers of its misuse.

Besides the proposed infographic, other ways to disseminate information such as hosting programs, educational workshops, and social media posts are also recommended. For school administrators, specifically, including the implications of generative AI as a topic to discuss in the curriculum of relevant courses as well as encouraging instructors to warn students regarding said effects can greatly benefit in spreading further awareness on the possible misuse of generative AI.

Future researchers may examine the efficiency of the infographic in increasing awareness. Furthermore, investigating the source of knowledge and awareness of students regarding the environmental implications of generative AI and generative AI itself, can prove to be beneficial in developing other methods of increasing awareness. Future researchers may replicate this study and compare their findings, determining whether this study supports or contradicts their results. Lastly, additional studies relating to this topic are essential as the current depth of knowledge is not as extensive as other fields yet.

Conclusion

Generative AI is a powerful tool that has already reshaped the lives of many. If used correctly, it can help people's lives and work. The problem arises with its misuse and the dangers it may cause in society and the environment. This newfound popularity on tools like ChatGPT increases this likelihood, specifically on students. Its demand on electricity, rare metals, and freshwater can further worsen with each misuse of the servers that generate AI content. Furthermore, these servers also produce a large amount of carbon footprint, consume nonrenewable resources, and add to the growing amount of e-waste in the environment. The knowledge of students regarding these environmental implications is crucial in ensuring that the consequences of its misuse are addressed and acknowledged, serving as a warning to the students themselves.

The research establishes that the students have some awareness of the environmental implications of generative AI. The students were also able to assess their usage of these tools which was further magnified by the infographic given to them, allowing them to further identify the tools they use. Despite using it mostly for productive reasons, the students show a shallow understanding on the numerous environmental implications of generative AI. The study reported weakness in the understanding of the rare metals and freshwater that the servers use as well as the nonrenewable resources it diminishes. BSMT and BSES students were found to have the highest tendency to use generative AI. Both courses also displayed considerable awareness on the environmental implications of generative AI. On the other hand, BSES-PCM students displayed consistent awareness on these implications while not particularly using these tools regularly.

Further research on these topics should investigate the deeper correlation of the students' usage of generative AI and their awareness on its environmental implications. Investigating where these students learn and expand their knowledge on the environmental implications of generative AI may contribute greatly to increasing the awareness of students at large. In addition, exploring the extent of the students' usage of generative AI can help gain insights on whether the tools are being used appropriately and ethically.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in JESEH journal belongs to the authors.

Conflicts of Interest

The authors have no competing interests to declare that are relevant to the content of this article.

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