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Conducting Academic Research with the AI Interface ChatGPT: Challenges and Opportunities

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ABSTRACT

Editorial

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Artificial intelligence technologies have become popular in recent years. The question of whether chatbots can be used in academic writing or research in artificial intelligence applications attracts the attention of many researchers. Can conducting a scientific research with artificial intelligence help in the research process? Can AI work like a co-writer? In this study, the opportunities and challenges experienced in the scientific research process using the ChatGPT application were examined. Its critiqued and included a previous study in the scientific research process under specific themes. The results show that while artificial intelligence technologies provide opportunities to researchers in terms of approval, creativity, and offering different perspectives, it is seen that there are reliability problems in producing content and it brings ethical and plundering issues. Therefore, artificial intelligence does not write articles for you but provides some tips and support in article writing.

Keywords: Artificial Intelligence, ChatGPT, Academic research, Chatbots

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INTRODUCTION

Ian Turing's thought on Artificial Intelligence dates back to 1950: "Are machines capable of thinking?" Since then, many technologies have been developed that attempt to pass the Turing Test, such as ELIZA in 1966 and ALICE in 1995, as well as Apple Siri, Amazon Alexa, and Microsoft Cortana in 2021 (Xu et al, 2021). AI chatbots use natural language processing models to interpret human language, which is at the core of artificial intelligence (AI) chatbots (Nagarhalli et al., 2020). ChatGPT is a speech-based artificial intelligence interface (OpenAI, 2023) that interacts realistically and even uses natural language processing (NLP) to "answer follow-up questions, admit mistakes, challenge false premises, and reject inappropriate requests". ChatGPT is a powerful language model based on deep learning, released in 2020, the largest neural network ever produced with 175 billion parameters (Chatterjee & Dethlefs, 2023). It requires further research on how humans can coexist with artificial intelligence and how to minimize the negative impact of technology (Duan et al., 2019). Advances in artificial intelligence may bring new opportunities to experience power. For example, people may feel high power regarding a human-like autonomous digital assistant (Fast & Schroeder, 2020). AI-based digital assistants offer significant opportunities, but can also become a threat (Reddy, 2017; Maedche et al., 2019). In this research, we examine the convenience and difficulties that the use of ChatGPT will bring to researchers in the context of an exemplary scientific research process and published research.

Chatbots are conversational agents that can interact with users through natural languages and can also be defined by the broader term conversational user interfaces (Smestad, 2018). The term "chatbot" is derived from "chatterbot", a term first proposed by Michael Mauldin in 1997 to describe robots with which humans can chat (Derugina, 2010). ChatGPT is a public chatbot developed by OpenAI and based on the GPT language model technology (Kirmani, 2022). The platform reached one million users in its first week alone (Mollman, 2022; Vallance, 2022) and was soon dubbed the "next big disruptor of the industry" (Rudolph et al., 2023) due to the perceived quality of the response outputs from the model. ChatGPT uses machine learning to continuously improve its capabilities and learn from the internet. GPT technology is a powerful tool for NLP (Natural language processing) tasks, but it has limitations. One of the main limitations is that GPT models rely on a statistical approach that can perpetuate existing biases and stereotypes in the data, learning patterns from a large text dataset (Lucy & Bamman, 2021). The ChatGPT was trained on a variety of internet texts, including books, articles, and websites, and covering a wide range of topics such as news, and fiction (Shen et al., 2023). ChatGPT is set up specifically for conversational tasks. Because of its dialog format, ChatGPT can answer follow-up questions, admit mistakes, dispute false premises, and reject inappropriate requests. Question answering, storytelling, logical reasoning, code debugging, machine translation, etc. It integrates various capabilities of natural language processing, including (Jiao et al., 2023). A broad perspective on the emerging role of artificial intelligence in the production of scientific research has been taken by (Grimaldi & Ehrler, 2023). While Alshater (2022) suggested that ChatGPT should be useful for a range of tasks involved in constructing a research study without empirical testing, most applied research focused on the creation of research summaries and literature synthesis. For example, Aydın and Karaarslan (2022) try to create a health literature review suitable for an academic journal and state that although this is possible, there is a

significant amount of 'plagiarism' or insufficient paraphrasing. Chatterjee and Dethlefs (2023) suggest interacting with ChatGPT and sharing their positive and negative experiences with developers and the world so that together they can raise the ethical, integrity, and moral values of future artificial intelligence models like this one. Numerous blog posts and media outlets have reported the educational advantages of ChatGPT (Zhai, 2022); some even provided instructions for its use in classrooms (Lieberman, 2023). Tlili et al. (2023) followed a threestage instrumental case study: a social network analysis of tweets, content analysis of interviews, and research of user experiences to examine concerns about chatbot use in education through the ChatGPT use study. The results revealed that although ChatGPT is a powerful tool in education, it should be used more carefully and more guidelines should be created on how to use it safely in education (Tlili et al., 2023). Although ChatGPT's responses are still flawed and its limitations are easily circumvented, ChatGPT's capabilities have caused much excitement and hysteria among the public since its launch, as reported by many researchers (Taecharungroj, 2023). Therefore, any part of a paper written by an NLP system should be checked by a domain expert for accuracy, bias, relevance, and reasoning. Second, the use of NLP systems raises issues of accountability. If part of an article written by an NLP system contains errors or biases, co-authors must be held accountable for its accuracy, credibility, and integrity (Hosseini et al., 2023). While research on speech systems and user interfaces has been conducted for decades, chatbot research and design are still in their relative infancy (Følstad et al. 2021). Among the many industries affected by ChatGPT, scientific publishing is one that should soon address the potential implications (Grimaldi & Ehrler, 2023). This research tries to examine some stages used in scientific research with ChatGPT, which uses artificial intelligence technology through a case study. It examines the answers given by ChatGPT. It creates a discussion about the opportunities and risks that it will create in its use. The purpose of this study can be determined by the following research questions:

- What are the challenges encountered in using AI interface ChatGPT to support academic research?
- What are the opportunities to use AI interface ChatGPT to support academic research?

METHOD

This study is a qualitative research study using narrative research as an inquiry strategy. Qualitative research allows the researcher to access detailed data in their natural environment and gives the researcher the opportunity to interpret the data as it is interpretive (Cresswell, 2003). It also focuses on the experiences and ideas of the participants. As an inquiry strategy, narrative research aims to understand “the result of interpretation rather than explanations” by providing an opportunity to collect data from real life and lived experiences (Kramp, 2004). There are various approaches developed and widely used regarding the types of narratives in the literature. “Shared Experience Field Notes” were used in this study. In this approach, field records collected through participant observation in a shared practical setting are one of the primary tools of narrative inquiry work (Connelly & Clandinin, 1990).

Analysis of Data

Narratives include only a part of the human experience and stories are based on narratives (Kim, 2016). In narrative analysis, researchers consider personal stories within the personal experiences of the participants (occupation, home), cultures, and historical contexts (time and space) (Uğuz Arsu & Tekindal, 2021). Just as there are various ways of understanding narrative research, digital technologies can be explored in different ways. One approach could examine the ways in which users interact with digital technologies in daily life. This type of research seeks to answer the questions of who (what kind of users), what (technology and impact), when (time of day or event), where (location matters), how (infrastructure or technique requirements), and why (motivation and intended effect) questions around people's activities related to technology (Green et al., 2019). In this study, the content based on the responses of ChatGPT was used in the analysis. Then, according to the answers, the researchers commented on what these answers meant. The findings, data, and experiences discussed in the analysis are expressed as they are and then discussed with the literature.

RESULTS

Finding a Research Question

With the research on ChatGPT, We asked some questions and looked for answers. For this, it is necessary to answer the question of how can I find a research question. Let's start by choosing a topic: We chose "STEM" as our topic and "STEM motivation" in particular (we will have the opportunity to review an article on this subject in the future). We asked my first question: Can you write research questions about STEM Motivation for students?

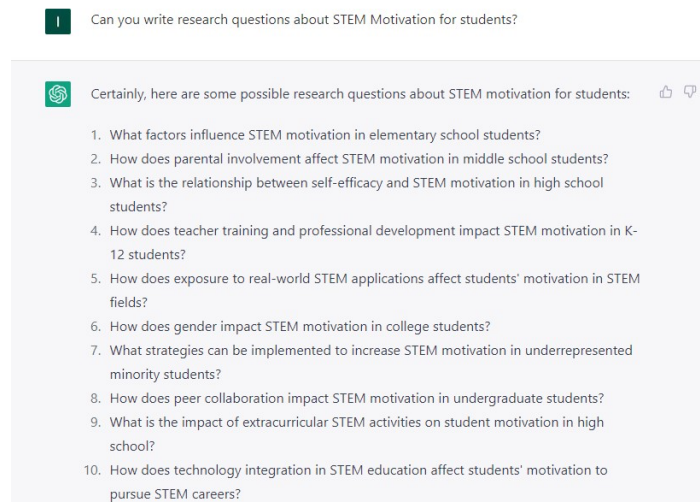


Fig 1. Finding a research question

The questions look interesting and offer different suggestions about motivation. It seems to be consistent within itself from different perspectives. It can be said that the questions are creative. It seems to go out of bounds in propositions 5 and 10. But something that interests me is that in most of the questions, I can only measure indirectly. I want him to iterate on his suggestions in

a more creative way. My question is “Can you write more creative questions about STEM motivation?”

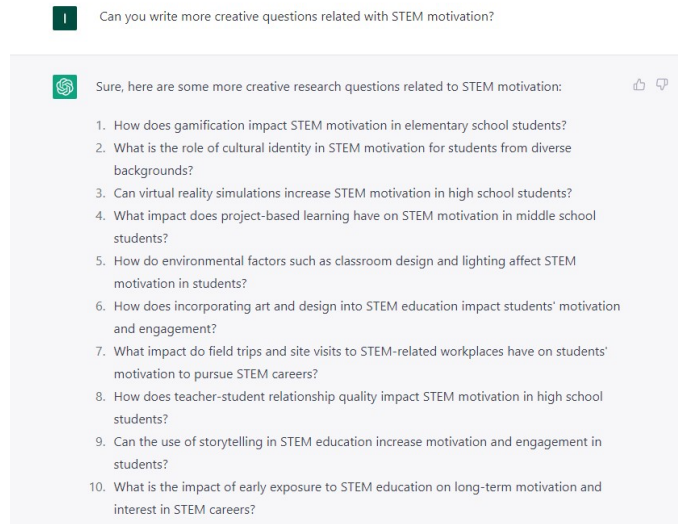


Fig 2. Revision of the research questions

At this stage, it is seen that it raises questions about STEM motivation. The questions are seen as consistent and meaningful in themselves. This time it seems to use the influence of secondary and tertiary tools such as storytelling, environmental factors, and culture. But as a problematic point, how can we choose one of them as a research question? Has any research been conducted on these issues before? Is there such a gap in the literature? As a result, if the question we chose has been asked before, it will not contribute to the literature and will cause unnecessary time and effort. At this stage, we asked ChatGPT if this question has been the subject of research before.

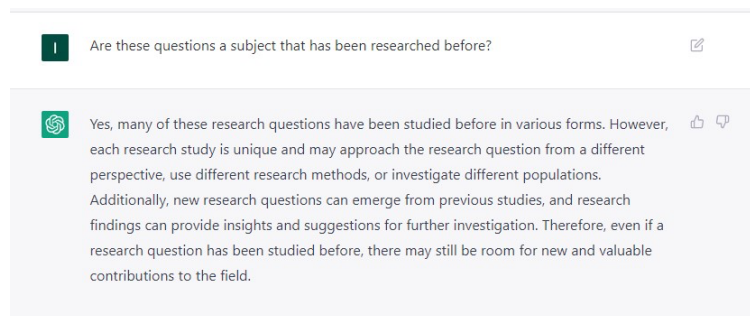


Fig 3. Examination of the research

ChatGPT gives a general answer. It states that these have been revealed from previous studies and may have been handled from different aspects. I know that some of these topics have been researched before. However, for the research process, “How do factors such as gender, ethnicity, and socio-economic status affect students' STEM motivation and how are these factors handled in STEM teaching? we chose the question. Now we need some advice on how to continue the research process. We would like to get an idea about how we should do this

research with ChatGPT. We pose a question like this: “How do factors such as gender, ethnicity, and socioeconomic status affect students' STEM motivation and how are these factors addressed in STEM teaching?” How can we create a research design for the problem?

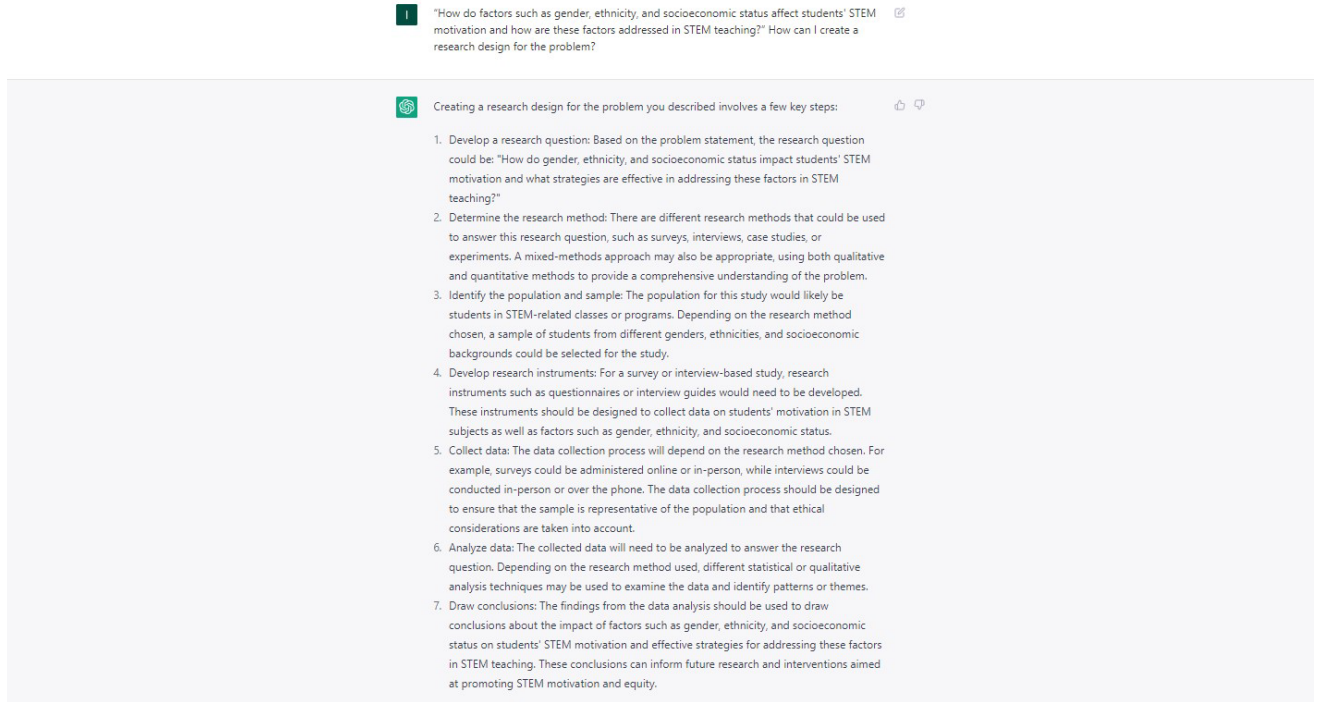


Fig 4. Research design

It lists the stages of scientific research. Asking questions, research method, sample and participant selection, data collection, data analysis, and determining the results are listed as. It also explains what we need to do in these steps. The content can be evaluated logically and systematically. We continue from the participant selection. We will do research for students. However, may we add teachers that it would be appropriate to include them? By posing another question, we are posing the question of “which student and teacher groups should I work with”.

1 With which class students does it make sense to conduct research? And should I collect data from all teachers?

The choice of which class of students to conduct research with depends on the specific research question and the population of interest. For example, if the research question is about the impact of gender on STEM motivation, it may be appropriate to select classes with an equal number of male and female students. Similarly, if the research question is about the impact of socioeconomic status, classes with a diverse range of socioeconomic backgrounds may be selected. It's important to consider the research question and the population of interest when selecting the class of students for the study.

As for collecting data from all teachers, this may not be necessary or feasible, depending on the research question and the scope of the study. If the research question is focused on the impact of teaching strategies on students' STEM motivation, it may be appropriate to collect data from a subset of teachers who are implementing those strategies. Alternatively, if the research question is focused on the impact of student demographics on STEM motivation, it may not be necessary to collect data from all teachers. Instead, data could be collected from a sample of teachers who are representative of the population of interest. The key is to ensure that the sample of teachers and students selected for the study is representative of the population and that the data collected is relevant to the research question.

Fig 5. Research design

At this step, It states that it is meaningless to do research with teachers since we mentioned the students in my research question. Seems totally logical and correct. ChatGPT gives general answers to every question. we need to customize it further with each step. Are there any resources we should refer to when determining the sample size?

1 Are there any resources I should refer to when determining sample size?

Yes, there are various resources that can be helpful when determining sample size for a research study. Here are a few suggestions:

1. Power analysis calculators: Power analysis calculators can help you determine the appropriate sample size for your study based on factors such as the effect size, level of significance, and power. Examples of online power analysis calculators include G*Power (<https://gpower.software.informer.com/>) and Sample Size Calculator (<https://www.surveymonkey.com/mp/sample-size-calculator/>).
2. Sample size guidelines: Different research designs and methods may have different guidelines for sample size. For example, the American Psychological Association (APA) provides general guidelines for sample size in their publication manual. Consulting resources like this can be helpful in determining a starting point for sample size considerations.
3. Consulting with a statistician: A statistician can help guide you in determining an appropriate sample size based on the specific research question, study design, and statistical analysis plan. It can be helpful to consult with a statistician early on in the research planning process to ensure that sample size considerations are appropriately addressed.

Ultimately, sample size considerations will depend on various factors such as the research question, study design, and statistical analysis plan. By consulting these resources and working with experienced professionals, you can ensure that your sample size is appropriate and supports valid and reliable conclusions.

Fig 6. Sample size references

It makes three suggestions for sample size. It shows two sources for calculating the sample with two sources. Resources are running. In the second suggestion, it may be correct to reach the source through the APA. The third item suggests that I should consult a statistician. Is this

information reliable? Here, our expectation is that it will show an academic reference or not. This information is wrong, what are the sources? And are the sources reliable? I'm asking a new question. We want your sources and references.

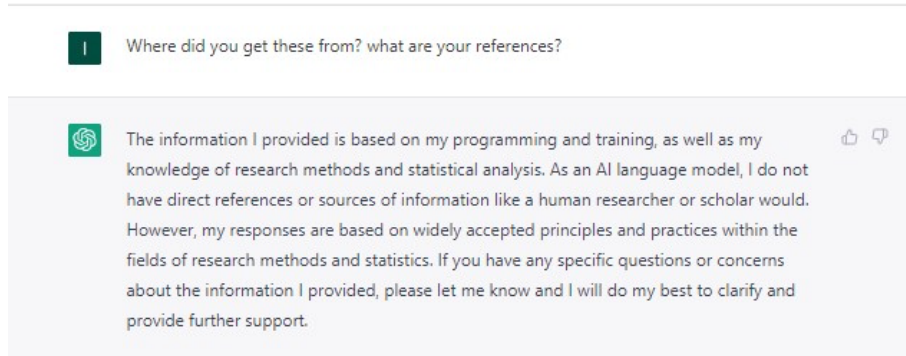


Table 7. Sources and References

It states that the texts it creates cannot provide direct references or sources of information as artificial intelligence would do a human researcher or academic. However, it states that we should trust answers. ChatGPT understands that we have expectations and concerns about this issue. At this point, it becomes clear that the AI application is using a language to relieve the user's concerns. Understanding that I cannot find any other information on this subject, I ask which surveys I should use.

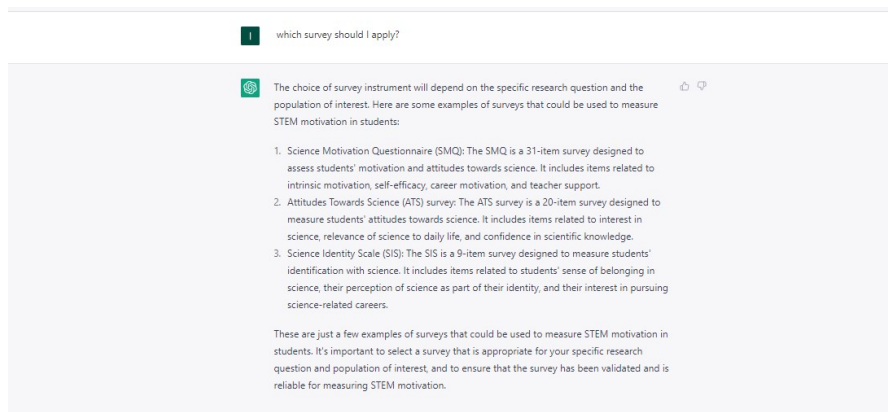


Table 8. Data collection tools

To measure STEM motivation according to the information it gives, STEM Interest Survey, The STEM Career Interest Survey recommends measurement tools such as the STEM Attitude Scale. If we have a chance to measure directly, of course we should prefer it. There are STEM motivation surveys in the literature. It states details such as how many items the questionnaire consists of. But for me the resource is important. We asked where we could find these scales.

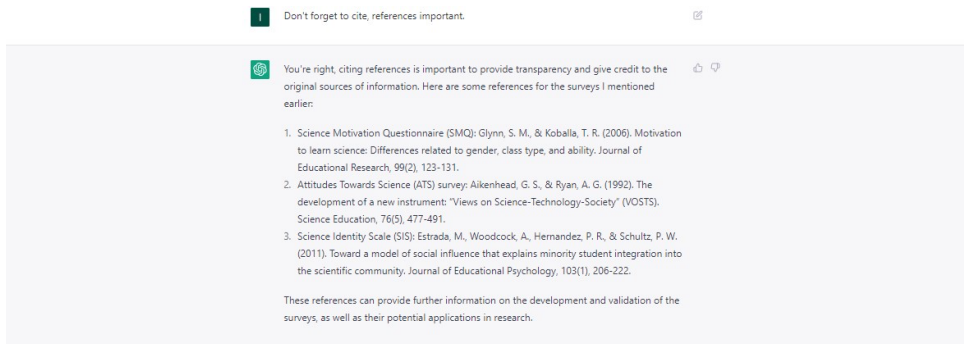


Table 9. Sources of data collection tools

We've been going to the sources and looking. The number one source is science motivation. In fact, the concept of STEM does not pass for the text. As the title suggests, it's an article about success and emotion at an early age. When I go to source number two, I find the article in "Google scholar". However, the source is not about motivation again. I'm going to the third source. However, it is not related to what I want. At this point, it does not meet my expectations. Also, the sources aren't very new, suggesting that either the language's scan dates are out of date or the AI hasn't been swayed. In this regard, it loses its reliability, which is perhaps one of the most important criteria in academic studies. I'm thinking of using different methods to use this program. Therefore, at this stage, ChatGPT should not be trusted in citing and writing literature. Otherwise, fake texts and research content will be supposedly trusted. Is this something that was done on purpose? we don't know yet. The next step is to review a published article before, "Dönmez, I., İdin, S., & Gürbüz, S. (2022). Determining Lower-Secondary Students' STEM Motivation: A Profile from Turkey. *Journal of Baltic Science Education*, 21(1), 38-51." we want to do a review on it.

Revising the Title and Abstract

I want something more creative in your title for the article. At this point, I expected ChatGPT to offer different examples. I decided to listen to some of his suggestions regarding an earlier published article using AI. Can you find a more creative and attractive title for the article "Determining Lower-Secondary Students' STEM Motivation: A Profile From Turkey"? I direct the question.

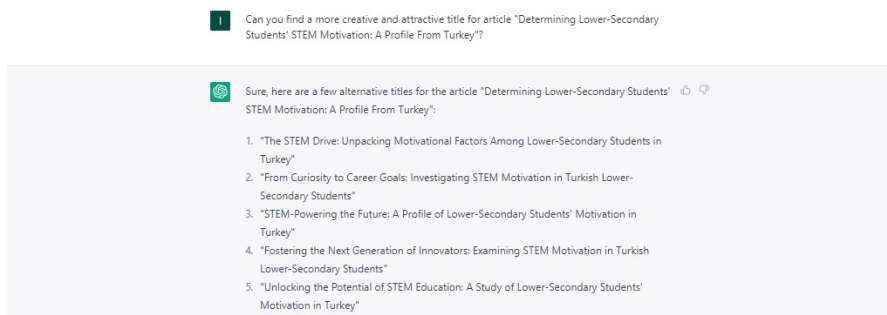


Fig 10. Finding a title

The titles look interesting, but they also bring some methodological errors. It makes a conceptual mistake in items 1. and 2. Other results are more acceptable. It explains the concepts with close concepts and lists the possibilities. It creates partially creative content. We also wonder if it got the titles it prepared from somewhere. We are going through a plagiarism program. The plagiarism program gives 0%. One of the difficulties encountered in academic journal applications is exceeding the word limits. It can be a difficult process to fit your content into certain word limits. We would like him to take the abstract of the same article and shorten it and present it in a more creative way.

1 Could you summarize the summary I shared with 100 words and present it in a more creative way? "The ongoing motivation of students toward the fields of science, technology, engineering, and mathematics (STEM) is a process related to their orientation toward those fields and their active participation in related activities. This study aimed to examine the ongoing STEM motivations of lower-secondary school students in a sample from Turkey according to demographic variables. In this study, in which 1926 students from 12 provinces participated, the students' STEM motivations were compared according to the variables of gender, place of residence, grade level, school type, "mothers' and fathers' education level, and family income level. T-tests and ANOVA testing were used in the analysis process via SPSS package program. As a result, male students' STEM motivations were found to be at higher levels than those of female students. The STEM motivations of gifted students were found to be higher than those of students studying in religiously oriented education institutions. The results also revealed that STEM motivation is directly proportional to the education level of the parents. The results obtained in this study, reflecting the general profile of STEM motivation among students in Turkey, may guide education makers, program developers, teachers, prospective teachers, and researchers on STEM education."

"STEM education is the key to unlocking a world of innovation, but how do we keep students motivated to pursue these fields? A recent study surveyed over 1,900 lower-secondary school students from 12 provinces in Turkey to examine their ongoing STEM motivations, comparing results based on gender, place of residence, grade level, school type, parental education level, and family income level. The study found that male students showed higher levels of STEM motivation than females, gifted students were more motivated than those in religious education institutions, and parental education levels had a direct impact on student motivation. These findings provide insight for educators, program developers, and researchers to improve STEM education for the next generation of innovators."

Fig 11. Revising the summary

When we give ChatGPT the content we had prepared and ask to shorten it, it offers a successful performance. It successfully summarizes the structure consisting of 196 words that we shared first, up to 76 words. It does not appear to have made any difference in meaning. It offers a successful performance in this regard. It is observed that it successfully reduces some points such as the analysis process

Analyzing and determining the results

We have a number of data obtained from my research. Can it summarize what data might mean when we present an obtained table as text in ChatGPT? The same article can be considered as a positive outcome in confirming the accuracy of the content. We are trying to copy the analysis table that we obtained in the same article as the text. We want ChatGPT to interpret the findings.

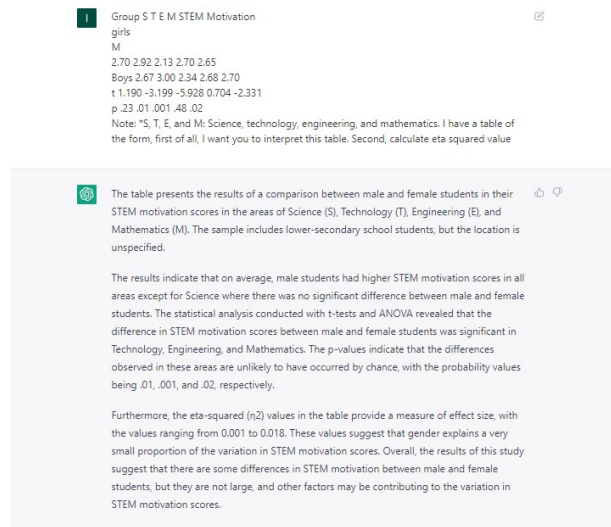


Fig 12. Examining the findings

Fig 12. shows the t-test results for girls and boys related to motivation in the fields of science, technology, engineering, and mathematics. There is a significant difference in favor of boys in the technology dimension ($t = -3.199$, $p < .05$, $\eta^2 = 0.005$) and the engineering dimension ($t = 5.928$, $p < .05$, $\eta^2 = 0.001$). There is no significant difference in the dimensions of science and mathematics. For overall STEM motivation ($t = -2.331$, $p < .05$, $\eta^2 = 0.003$), there was again a significant difference in favor of male students. In Fig 12, S, T, E, and M are given to describe the dimensions of the STEM field (science, technology, engineering, and mathematics). Results appear to be in agreement with the results we found. Our questions are endless and we want to know if you can present this table graphically. However, none of the graphic links it offers are working every time. <https://i.ibb.co/gD5y0V0/STEM-Motivation-by-Gender-andSubcategory.png>

Ethical Issues

There seems to be a real risk that AI-generated articles will soon blur the distinction between original human-written and AI-written or re-edited content. The increase in such applications also raises the question of who the author really is. It opens the door to further discussions on validity and reliability. Predatory adds to the never-ending debate about publishing. Applications such as ChatZero, GPTGenerator, and GPTKit are thought to offer some solutions for understanding artificial intelligence-generated texts. We used the content ChatGPT writes through these applications and examine whether it is written with AI.

Chatzero	After Deleted Text with Chatzero	AI Text Classifier	After Deleted Text with AI Text Classifier	GPTKit	After Deleted Text with GPTKit
Fig 1.	Your text is likely to be written entirely by a human	No data	No Data		
Fig 2.	Your text is likely to be written entirely by a human	The classifier considers the text to be likely AI-generated.	No Data		
Fig 3.	Your text may include parts written by AI	No data	No Data		
Fig 4.	Your text is likely to be written entirely by AI	The classifier considers the text to be likely AI-generated.	No Data		
Fig 5.	Your text is likely to be written entirely by AI	The classifier considers the text to be likely AI-generated.	No Data		
Fig 6.	Your text is likely to be written entirely by AI	The classifier considers the text to be likely AI-generated.	No Data		
Fig 7.	Your text is likely to be written entirely by AI	No data	No data		
Fig 8.	Your text is likely to be written entirely by AI	The classifier considers the text to be likely AI-generated.	No Data		
Fig 9.	Your text may include parts written by AI	The classifier considers the text to be likely AI-generated.	No Data		
Fig 10.	Your text may include parts written by AI	No data	No Data		
Fig 11.	Your text is likely to be written entirely by AI	No data	No Data		
Fig 12.	Your text may include parts written by AI	The classifier considers the text to be likely AI-generated.	No Data		

Fig 13. Scanning text written with Chatzero, AI Text Classifier and GPTKit We've been trying the content it has produced so far with Chatzero, AI Text Classifier, and GPTKit programs. We tried the outputs it gave me in Fig 13 with Chatzero, and we copy and paste the text. Chatzero states that it was written by artificial intelligence, except for figures 1. and 2. Fig 3., 9., 10. 12. states that some chapters are written with AI. It states that there is a good chance that 80% of it was written with AI. AI Text Classifier, on the other hand, states that only figures 6., and 9. are not written by AI. In other tables, it cannot reach any result because it is less than 1000 words. GPTKit, on the other hand, thinks that figures 3., 4., 5., 6., 7., and 8. may have been written by AI. Therefore, the findings show great diversity. I'm deleting the content from ChatGPT to test if ChatGPT is getting the text. ChatGPT changes its decision in three ways. AI Text Classifier differs in 4 ways. GPTKit, on the other hand, gives closer rates. Then we did an itenticate search. Naturally, since these texts are not published anywhere, they cannot get any rate. However, the findings are not sufficient in terms of whether the findings were written by AI.

Review the bibliography

One of the most difficult issues in academic research is revising the bibliography. We asked ChatGPT to delete some references to the previously written article and convert it to APA 7 format. Can you revise the text below in accordance with APA 7? (I wrote "DELETED" where I omitted and removed those parts. Can't find the first source. The second source is not correct. The fourth source's name is incorrect. The fifth source is incorrect. The date indicated in the fifth source is incorrect. Cannot find the seventh source. The eighth source is incorrect. Therefore, it provides 40% accuracy out of the 10 references given. It's a low rate It's unknown where it got the data from or whether it was knowingly manipulating it, but what is known is that it's not reliable.

1 Can you revise the text below in accordance with APA 7? I couldn't find what it should be where it says DELETED. An, G., Wang, J., DELETED, Y., & Du, X. (2018). A study on the effects to students' STEM academic achievement with Chinese parents' participative styles in school education. *Educational Sciences: Theory & Practice*, 19(1), 41-54. DELETED
Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university*. DELETED.
Bybee, R. W. (DELETED). *The case for STEM education: Challenges and opportunities*. NSTA press.
Chachashvili-Bolotin, S., Milner-Bolotin, M., & Lissitsa, S. (2016). DELETED. *International Journal of Science Education*, 38(3), 366-390.
<https://doi.org/10.1080/09500693.2016.1143137>
Chavatzia, T. (DELETED). *Cracking the code: Girls' and women's education in science, technology, engineering, and mathematics (STEM)*. DELETED.
Carrico, C., Murzi, H., & Matusovich, H. (2016, October). The roles of socializers in career choice decisions for high school students in rural central Appalachia: "Who's doing what?". In 2016 IEEE Frontiers in Education Conference (FIE) (pp. 1-6). IEEE.
Chadwell, B. (2016). *The effect of socio-economic status and gender on high school student perceptions about career and technical education (Doctoral dissertation)*. DELETED.
Craig, C., Verma, R., Stokes, D., Evans, P., & Abrol, B. (2018). The influence of parents on undergraduate and graduate students' entering the STEM discipline sand STEM careers. *DELETED*, 40(6), 621- 643. <https://doi.org/10.1080/09500693.2018.1431853>
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Ünlü, Z. K., & Dökme, İ. (2020). Multivariate assessment of middle school students' interest in STEM career: A profile from Turkey. *Research in Science Education*, DELETED(3), 1217-1231. <https://doi.org/10.1007/s11165-018-9729-4>

2 Sure! Here's the revised text:

An, G., Wang, J., DELETED, Y., & Du, X. (2018). A study on the effects to students' STEM academic achievement with Chinese parents' participative styles in school education. *Educational Sciences: Theory & Practice*, 19(1), 41-54.

Biggs, J., & Tang, C. (2011). *Teaching for quality learning at university*. Open University Press.

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Chavatzia, T. (2020). *Cracking the code: Girls' and women's education in science, technology, engineering, and mathematics (STEM)*. Routledge.

Carrico, C., Murzi, H., & Matusovich, H. (2016, October). The roles of socializers in career choice decisions for high school students in rural central Appalachia: "Who's doing what?". In 2016 IEEE Frontiers in Education Conference (FIE) (pp. 1-6). IEEE.

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Creswell, J. W. (2003). *Research design: Qualitative, quantitative and mixed methods approach (2nd ed.)*. SAGE Publications.

Ünlü, Z. K., & Dökme, İ. (2020). Multivariate assessment of middle school students' interest in STEM careers: A profile from Turkey. *Research in Science Education*, 50(3), 1217-1231. <https://doi.org/10.1007/s11165-018-9729-4>

Fig 14. Examination of the bibliography

Writing limitations

I give the findings part of the research to ChatGPT. Then I want the research to identify its limitations.

1 What's limitations of this research "In the survey conducted for this work with a large sample of lower-secondary school students in Turkey, important results regarding STEM motivation were obtained. The results showed that male students had more STEM motivation than girls. In addition, when the dimensions of STEM were examined, it was seen that the motivation levels of female students in the science and technology dimensions were lower. Considering that students' sustained motivations are effective in STEM career development, policymakers and program developers should focus on educational content that will support STEM motivation. It was seen in this study that place of residence affected students' STEM motivations. Students residing in city centers had higher levels of STEM motivation, suggesting that students in urban areas may enjoy more educational opportunities in their schools. This finding furthermore reflects the realities of inequality in educational opportunities among city centers, districts, and villages in Turkey. For this reason, intervention programs for students studying in rural areas are needed. It was furthermore seen that the school types of the participating students affected their levels of motivation for STEM and its dimensions. It seems that religiously oriented educational processes have a particularly negative impact on STEM motivation. Therefore, it is necessary to increase the STEM educational content for students who are receiving religious education. On the other hand, the high levels of STEM motivation among gifted students may be due to individual differences. This could also be considered a result of the educational opportunities supported by the strong infrastructure and plentiful equipment in specific schools for gifted students in Turkey. As grade level increased, a general decrease in STEM motivation was seen in this work and it can be expected that students' future orientations toward STEM fields will suffer accordingly. Considering both other studies conducted elsewhere in the world and previous reports prepared in Turkey, the decrease in students' orientations toward STEM careers in correlation with grade level may be attributed to the nature of the exam-oriented education system with a failure to properly address students' STEM interests and needs. In light of the results outlined here, it is suggested that future studies focus on supportive activities to determine and boost the STEM motivations of teachers who work with or will be working with students of different demographic groups."

2 There are several limitations of the research presented in the statement. Some of them are:

1. **Limited sample:** The research is conducted only with lower-secondary school students in Turkey, which may not be representative of the larger population or other countries. Therefore, it may not be possible to generalize the findings to other populations.
2. **Self-reported data:** The data obtained from the students are self-reported, which may be influenced by various factors such as social desirability bias or the students' lack of understanding of the questions.
3. **Correlational design:** The research is correlational in nature, which means that no cause-and-effect relationship can be established between the variables.
4. **Lack of control variables:** The research did not control for factors such as socioeconomic status, family background, or academic achievement, which may affect STEM motivation levels.
5. **Narrow focus:** The research only examines the motivation levels of students, without taking into account other factors that may affect their interest in STEM fields, such as gender stereotypes or societal expectations.
6. **Inadequate interpretation:** The research draws some conclusions without providing adequate explanation or justification for its findings. For instance, the suggestion that "religiously oriented educational processes have a particularly negative impact on STEM motivation" requires further research and clarification.

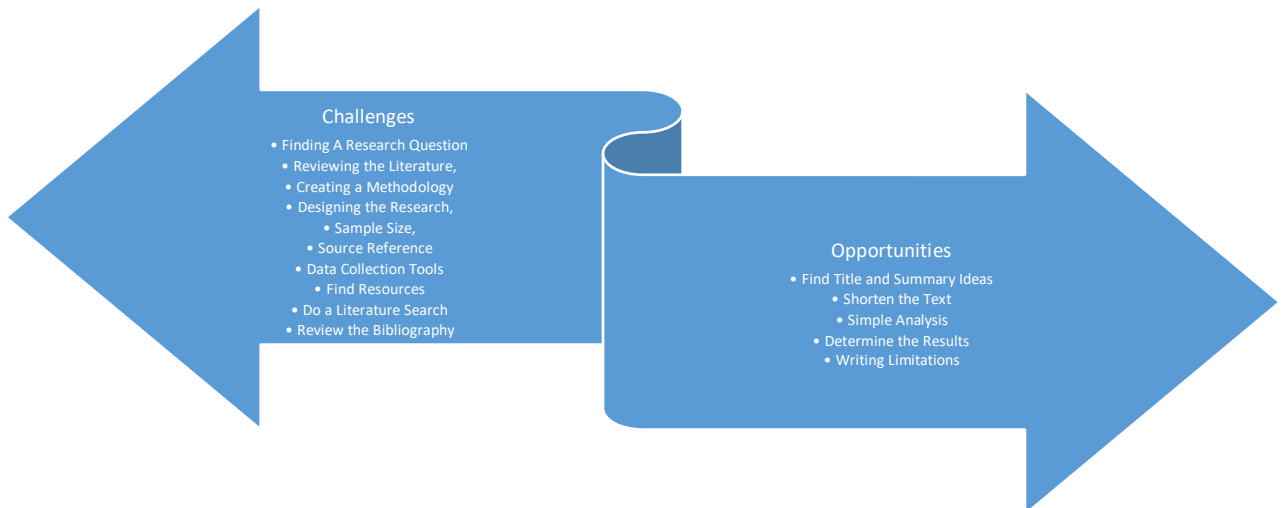
Fig 15. Examination of the limitations

ChatGPT examines the limitations of the research under 4 headings. It makes meaningful comments such as Limited sample, Self-reported data, Correlational design, Lack of control variables, Narrow focus, Inadequate interpretation. The content looks meaningful and creative.

CONCLUSIONS AND DISCUSSIONS

The presented challenges and opportunities can contribute to future studies on the use and challenges of chatbots in scientific research and its broad implications. In summary, the technology always exists with its pros as well as its cons. Artificial intelligence technologies can provide some benefits for studies, such as finding title and summary ideas, shortening the text, identifying simple analyzes and conclusions, and writing limitations. Challenges; can be listed as finding a research question, examining the literature, finding a methodology, designing the research, sample size, source reference, data collection tools, finding sources, reviewing the literature, and reviewing the bibliography. Therefore, if you have some data, you can make some inferences from them. It can be said that it is successful in creativity. But it does not meet the expectations in terms of originality, the information it offers is mostly estimates obtained from "Google" search. One of the concerns is the accuracy of the predictions and predictions made by AI algorithms. While these algorithms can be very accurate, they are only as good as the data they are trained on. The conclusion is that it's not a good idea to have all or part of the research content written entirely on AI yet. Not to mention the ethical issues that come with it. Chatbots often fail to answer users' questions for three reasons: they have trouble with unknown concepts, out-of-field tasks, and misconduct (Lou et al., 2022). ChatGPT is like a smart friend, but you can't figure out when it's saying it right. It seems that more content is needed to explore how artificial intelligence technologies can contribute to scientific research. Additionally,

ChatGPT tends to follow instructions rather than have any real interaction. For example, when the information provided by users is insufficient, ChatGPT tends to make assumptions about what the user wants to hear rather than asking clarifying questions. As a result, Chatbots can have unintended consequences and become a double-edged sword (Shen et al., 2023). The findings overlap with the study of Aydın and Karaarslan (2022); see 'plagiarism' or inadequate paraphrasing. At this point, plagiarism programs should be reviewed and updated. It will cause consequences such as ethics and plunder in academic publishing. Writing the prepared text by AI will also bring a new problem in academic publishing. The software prepared for detecting the topics written by AI seems insufficient. It is important that human authors using artificial intelligence can be held accountable when the software fails or produces incorrect or incorrect output (Hosseini et al., 2023). Another problem is the reference to falsification of ideas, i.e. plagiarism, where ideas sought by AI-driven software like ChatGPT can benefit from others' ideas but is then used to claim originality. It is possible to reach different conclusions from the different experiences of different researchers. Maybe writing scientific papers is another smart activity where computers can learn to be better than humans. But ChatGPT is incapable of generating an article, was it intentionally created by the generators or coders? or future applications can be developed and trained to give better results. It is seen that different applications such as scite, elicite, bing, and concensus have recently been revised with academic concerns about the shortcomings of ChatGPT. Therefore, more research is needed on the advantages or disadvantages of other AI interfaces and other applications that can be used in scientific research.



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Environmental Literacy for Waste Management in an Academic Community: A case study

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ABSTRACT

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Excessive waste production has been one of the main causes for the environmental imbalances caused by humanity. Minimize this problem demands for the promotion of the environmental literacy on waste management and, to do that, an investment in more and better environmental education. However, first, we need to know the level of environmental literacy each community has developed so far and what is missing to reach an adequate performance. As so, environmental education could be conveniently oriented with a most effective approach and with an adequate match between the defined goals and those really needed. Present study evaluates environmental literacy for waste management in the academic community of the University of Madeira (Portugal), characterizing knowledge, attitude and behaviour among students, teachers, and other staff. Results show a good performance for knowledge, even better for attitude, but only sufficient for behaviours. Additionally, it identifies those knowledges and behaviours that need to be prioritized in future environmental education approaches, besides clarifying that the effectiveness on implementing waste management best practices is most dependent on social, physical, and organizational transformations than on knowledge and attitude.

Keywords: Environmental education; Environmental literacy; Portugal; University of Madeira; Waste management.

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INTRODUCTION

Since the 1970's, humanity has been exploiting resources and emitting pollution much far beyond the Planet's biocapacity. The human ecological footprint is now much bigger than the Planet Earth (75% bigger), and we are facing an ecological crisis and a global climate change due to our inability to respect the natural balance (Lumsden, 2018). Waste production accounts for an important part of our ecological footprint due to the material and energy consumption it represents, as well as its carbon dioxide emissions and other pollution it makes (Kissinger et. al., 2013). Each year, about 7–9 billion tonnes of waste are produced globally (Wilson & Velis, 2015), being 2 billion tonnes of it Municipal Solid Wastes (MSW), a category that includes valuable materials (glass, paper, plastic, metals, organics, etc.) but, at the same time, with a great negative impact on the environment if not properly managed (Chen et. al., 2020). Since the past 60 years, the production of MSW tripled, and it is estimated that it could increase more than 150% until 2050 (Chen et. al., 2020).

If not conveniently managed, wastes can result in serious pollution problems. For example, it was estimated that Ocean Atlantic hold 17-47 million tonnes of plastic (Pabortsava & Lampitt, 2020), and that the intake of microplastics, through the food we eat and the water we drink, may represent in average 280 microparticles of plastic per day (Dalberg Advisors, 2019), being already present in the human blood (Leslie et. al., 2022). Despite the implementation of waste collection systems around the world, littering still is a widespread problem with negative impacts for the environment and human health. Additionally, even when they are collected, the amount that is sent for recycling does not reach 20% globally (Chen et. al., 2020).

The 12sd United Nations Sustainable Development Goal (SDG12) intends to 'ensure sustainable consumption and production patterns', which require proper waste management. SDG12 defines several targets to be achieved by 2030, namely a sustainable management and efficient use of natural resources, halve the per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses, and, among other, substantially reduce waste generation through prevention, reduction, recycling, and reuse (Department of Economic and Social Affairs, n.d.a). SDG12 also included a target that should be achieved by 2020: an environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment; but so far it is clear that has not been achieved. Additionally, the 14th SDG (Conserve and sustainably use the oceans, seas and marine resources for sustainable development) defines as one of its targets to prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution, by 2025 (Department of Economic and Social Affairs, n.d.b). Considering the short schedule, we have to achieve this ambitious goals and targets and how far we are from them, it is quite evident that we need to boost environmental literacy for waste management among our citizens and societies, moving away from a consumer society and approach environmental culture and circular economy. First step is, after decades of environmental education (Spínola, 2014), to know where we are and how far we still have to go.

Environmental literacy is the primary goal of environmental education, being a prerequisite to achieve environmental quality and, among others, to have an adequate waste management (Disinger & Roth, 1992). Besides knowledge, environmental literacy also includes affective dispositions and cognitive skills and abilities, together with practices that could improve our performance on environmental sustainability (Hollweg et al., 2011). Nevertheless the above simplification, environmental literacy hold a complex structure, namely because, among others, it should include: knowledge on physical, ecological, social, cultural and political systems; sensitivity, attitudes, personal responsibility and motivation; competencies on identifying, analyse, investigate, evaluate and resolve environmental issues; and environmentally responsible behaviour with practices in eco-management, persuasion, consumer/economic action, political action and legal action (Cook & Berrenberg, 1981; Hollweg et. al., 2011; Hungerford & Volk, 1990; Stern, 2000). However, to evaluate environmental literacy, such a complex structure makes difficult to include all the components in a single assessment. To overcome that problem, knowledge, attitude and environmentally responsible behaviour were identified as the major components to be included in the surveys (Hallfreðsdóttir, 2011; Igbokwe, 2012; Krnel & Naglič, 2009; Kuhlemeier et. al., 1999; McBeth & Volk, 2010; Pe'er et. al., 2007).

Since the past decades, a comprehensive effort on environmental education was put in place. Evaluating environmental literacy in a group or a context is the best strategy to assess its achievements and address the need for better practices and strategies. However, in Portugal and worldwide, environmental education lacks evaluation, working mainly in the dark, and since the ecological crisis is getting worse, namely the problems that results from a lack of an adequate waste management, it is legitimate to question its effectiveness (Blumstein & Saylan, 2007; Schmidt et al., 2010). In Portugal, environmental education curricular integration has been centred in a specific group of classical disciplines, namely Natural Sciences, Geography and Biology (Tracana et al., 2012), and suffers from ‘infantilization’, being mostly focused on younger students, with entertaining and recreational pedagogical strategies (Schmidt et al., 2010; Schmidt et al., 2011). As students grow, they are less involved in environmental education projects and curriculum (Schmidt et al., 2011), being symptomatic that, in Portugal, the main environmental education program (the Eco-Schools Program) involves about 66% of students from basic education and only 2.2% of those from higher education. From the scarce information available for higher education in Portugal, it seems that the fragilities found for other levels of the educational system may be herein exacerbated (Amador et al., 2015; Azeiteiro et al., 2015; Caeiro et al., 2020; Farinha et al., 2019; Farinha et al., 2018; Farinha et al., 2017; Filho et al., 2017; Fonseca et al., 2018; Leite & Dourado, 2015; Otto et al., 2019; Spínola, 2012). In fact, a study that includes Portugal showed that the top five obstacles to implementing sustainability at universities are the lack of awareness and concern (Filho et al., 2017). Also, a case study in Portugal, on a master’s program in Environmental Citizenship and Participation, reveals inconsistency between theory and praxis on its education for sustainable development contributions, asking for curricula improvements (Amador et al., 2015). Additionally, the analysis of the Portuguese public universities plans and strategies shows that higher education institutions were not sufficiently engaged in education for sustainability and that the subject is not integrated into a whole-institution approach (Farinha et al. 2019).

As so, considering the strong influence that graduated citizens could have in societies, that about half of young people attends this level of education, and that higher education in Portugal and overseas could be falling behind its responsibilities in promoting environmental literacy (Farinha et al., 2017; Farinha et al., 2018; Spínola, 2012), it is of utmost importance to know the environmental literacy present in this level of education in order to better define and implement environmental education programs and strategies. Besides the relevance for the Portuguese reality, the evaluation of the environmental literacy on particular contexts is also of international interest. In fact, the enrichment of the set of case studies on environmental literacy, in waste management or in general, is a contribution for benchmarking, to understand its global evolution, and to distinguish context-dependent influences from those that could be generalized.

Purpose of the research

Thus, as a baseline characterization, understanding and identification of opportunities of improvement for future developments through environmental education approaches, present study intends to characterize the levels of knowledge, attitudes, and behaviours for waste management among students, teachers and other staff at the University of Madeira. As so, the research question was defined as: Which are the levels of waste management environmental literacy on the University of Madeira academic community?

METHOD

Research design

To characterize the environmental literacy (knowledge, attitudes and behaviours) for waste management among students, teachers and other staff at the University of Madeira, an online, cross-sectional, closed-ended, and anonymous quantitative survey questionnaire was self-administered. In February 2019, the access link for the online questionnaire was sent in an e-mail message to all the students (about 3500), teachers (230) and other employees (138) that constitutes the University of Madeira academic community.

Participants

The University of Madeira is a public institution of higher education located in the city of Funchal (Madeira Island- Portugal), with its teaching and research activities concentrated in a single pole, the Penteada Campus. It assumes itself as a centre for the creation, transmission and dissemination of culture, science, and technology at the service of the humanity, and aims to prepare its students to be technically and scientifically competent, cultured, and innovative citizens, acting on the basis of the values of transparency, justice, equality, fraternity and to the sustainable development of the Planet. The University of Madeira is made up of 4 faculties (Arts and Humanities, Exact and Engineering Sciences, Social Sciences, and Life Sciences) and 2 higher schools (Health, and Technology and Management), involving around 3,500 students distributed over 20 degrees, 23 masters, 8 doctorates and 14 Professional Higher Technical Courses. The teaching staff is made up of more than 230 professionals and the institution's operation is supported by the involvement of 138 non-teaching staff. Until this study was carried out, in February 2019, the University of Madeira did not have any formal or systematic

environmental education program, with only a few specific activities included in subjects and courses related to the environment.

Between February and March 2019, after an online questionnaire application at the University of Madeira, 130 answers were collected, mostly from students (92) but also with the contribution of teachers (19) and other staff (19). Among the 92 students, 15 were from Professional Courses, 54 from Graduations (22 from the first year; 13 from the second year, and 20 from the third year), 17 from Masters, and 5 from Doctoral courses (PhD). As so, the total number of respondents allow, for a 95% confidence interval, a margin of error below $\pm 10\%$ (Brace et al., 2016), enough to minimize sampling bias, but $\pm 20\%$ if considering only teachers and other employees.

Data collection tool

An online, cross-sectional, closed-ended, and anonymous quantitative survey questionnaire was developed to address the specific purpose of the present study and considering the reality lived under the University of Madeira campus. After a first version, the questionnaire was given out for revision by other experts and tested on a sample of 20 students. A final revision was done to correct some statements and one question was completely removed since the answers doesn't shown consistency.

With a total of 15 questions focused on the reality of waste management at the University of Madeira Campus, the questionnaire (appendix 1) was organized in three main sections to evaluate knowledge (section 1- 4 questions), attitudes (section 2- 5 questions) and behaviours (section 3- 6 questions). First section, for knowledge, ask respondents to choose the waste they consider worst for the environment, to select the most effective approach to achieve a better waste management, to properly segregate 19 different kinds of waste for recycling, and to select a set of 9 statements that reveals their knowledge on how to reduce waste generation as also their believes on the consequences of littering. For analysis purpose, the answers for each of the 19 wastes items for recycling and the 9 statements on how to reduce waste generation and their consequences from littering were individualized, which increased the knowledge section from 4 to 30 questions. For attitude, in the 2nd section, the questionnaire presents five statements and ask respondents to classify their grade of concordance in a Likert-type scale of five points ranging from totally disagree (1) to totally agree (5). The statements used goes through attitudes towards the amount of wastes produced and its consequences, the possibility of avoiding the use of plastics, and the importance of individual contribution on waste management. Finally, the third section presents six behaviours on recycling, preventing pollution and waste production, and ask respondents to select the frequency they practice them in a Likert-type scale ranging from never (1) to always (5).

The questionnaire was not intended to collect participants' personal data, namely age and gender, only the year and the course level attended by students and identify teachers and other staff among respondents. Despite this option could be seen as a limitation for data interpretation, our choice was based on the fact that, for the sample number we knew we could collect, such data would be statistically irrelevant due to the small sample number for those subgroups. As

so, we opt to keep the questionnaire as short as possible thinking in consideration our research question.

Data analysis

Data collected in the survey were normalized as if all statements were environmentally positive and converted to numeral scores ranging from 1 to 5, for attitude and behavioural domains, and, for knowledge, scored “1” or “0” if answers were correct or incorrect, respectively. Blank responses were scored as missing values. With IBM SPSS statistics software (version 27), reliability (through Cronbach’s Alpha) and validity (confirmed by positive and significant Pearson correlations) were evaluated, followed by percentages calculation and test for significant differences. Pearson’s correlations (r), and their one-tailed significance, were calculated for each pair of items. As a guideline, a correlation coefficient interval of $r=0.10$ to 0.29 represents a small positive relationship, a $r=0.30$ to 0.49 represents a medium positive relationship and a $r=0.50$ to 1.0 represents a large positive relationship (Pallant, 2007). The Cronbach’s Alpha score was 0.665 for Knowledge section, 0.521 for Attitude section and 0.200 for Behaviour section, the latter a very low value that push down to 0.399 the score for the entire measuring instrument. Nevertheless, this low score could be a consequence of the low number of questions used and the lack of correlation between different behaviours (Graham, 2006; Nunnally & Bernstein, 1994). Validity of the instrument were confirmed for 8 of the 15 questions since they show positive and significant ($p<0.05$) Pearson correlations.

RESULTS

Considering total samples, 81.7% of the answers were correct for knowledge, 91.8% agree or totally agree with a positive waste management attitude, and 61.6% perform waste management best practices ‘often’ and ‘always’ (Figure 1).

For knowledge, a large majority (higher than 80%) identify plastic as a dangerous waste for the environment (86.9%) and considers that it is worse than glass (97.7%), knows that cigarette butts are not biodegradable (96.9%) and that the lack of bins is not a reason to toss wastes (85.4%), agree that the use of reusable mugs (82.3%) and bringing lunch from home (98.5%) is important to reduce waste production, identifies bottled water consumption (89.2%) and the use of paper towels (85.4%) as resulting in increased waste production, select Reduce, Reuse or Recycle as the most important approach for waste management (97.7%), and knows how to sort for recycling newspapers (99.2%), soda cans (89.2%), plastic bags (96.2%), plastic bottles (98.5%), glass bottles (100%), French fries’ package (80.8%), yogurt plastic cups (90%) and banana peels (98.5%) or apple cores (94.6%) (Table 1 and Figure 2). However, in the opposite direction, few on the University of Madeira academic community knows how to correctly dispose paper coffee cups (26.2%) and even broken glass cups (29.2%). Due to the low sample number, only two groups were organized to allow comparisons: Students ($n=92$) and Teachers and other staff, henceforth treated as Staff ($n=38$). For knowledge, the comparison between Students (80.7%) and Staff (84.9%) doesn’t reach significant differences ($p=0.3$). Nevertheless, Teachers and other staff show a statistically significant higher prevalence of correct answers for a few specific questions, especially in how to sort wastes, namely Tetra Pak packaging [Students (73.9%) and Staff (89.5%) $p=0.003$], broken teacups [Students (61.1%) and Staff

(76.3%) $p=0.003$], metallic caps [Students (64.1%) and Staff (78.9%) $p=0.013$] paper coffee cups [Students (25.3%) and Staff (28.2%) $p<0.001$] and dirty napkins [Students (62.9%) and Staff (81.6%) $p=0.002$], but also identifying plastic as a dangerous waste for the environment [Students (83.7%) and Staff (94.7%) $p=0.01$] and bottled water as a source of wastes [Students (86.8%) and Staff (97.4%) $p=0.006$], also knowing that even recycling pollutes [Students (71.4%) and Staff (84.2%) $p=0.02$], and that tap water in Madeira Island is of good quality [Students (71.4%) and Staff (84.2%) $p=0.02$] (Table 1). The only exceptions are on the separation of yogurt plastic cups for recycling, with Students (92.4%) showing a higher prevalence of correct answers than Staff (84.2%) ($p=0.042$), and knowing that reduce, reuse or recycle allows a better waste management [Students (97.8%) and Staff (94.9%) $p=0.016$].

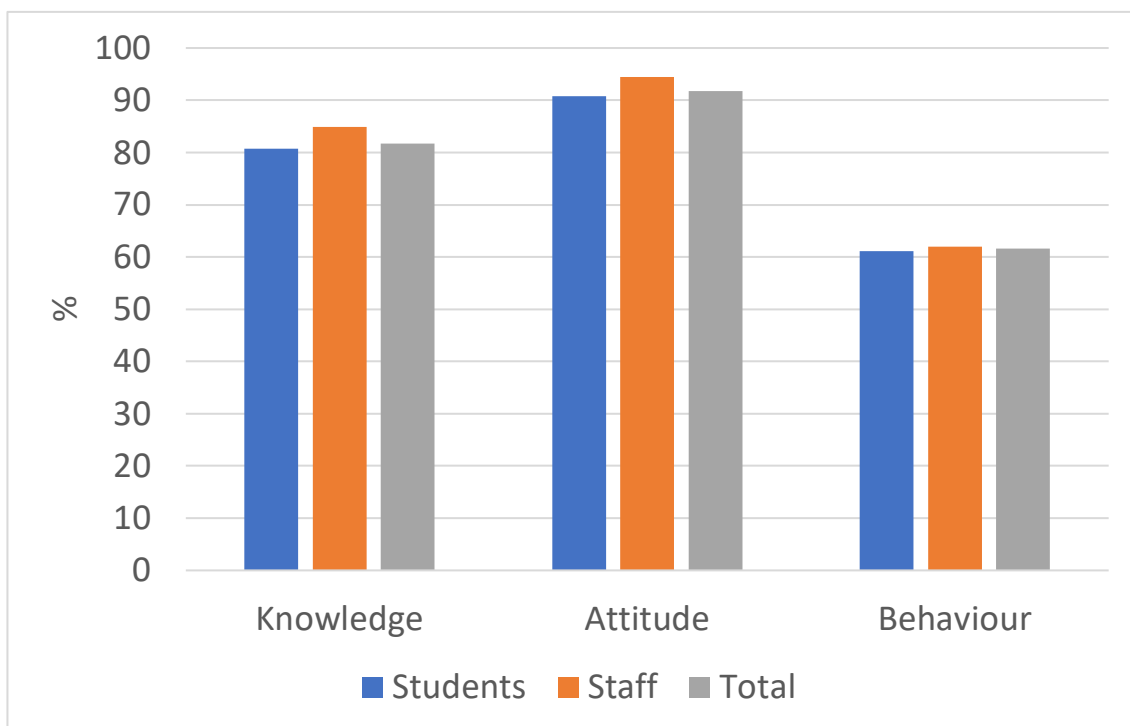


Figure 1. Overall performance on Environmental Literacy for waste management (knowledge, attitude and behaviour). Knowledge- correct answers; Attitude- concordance (agree and totally agree) with a positive waste management attitude; Behaviour- prevalence (often and always) of waste management best practices.

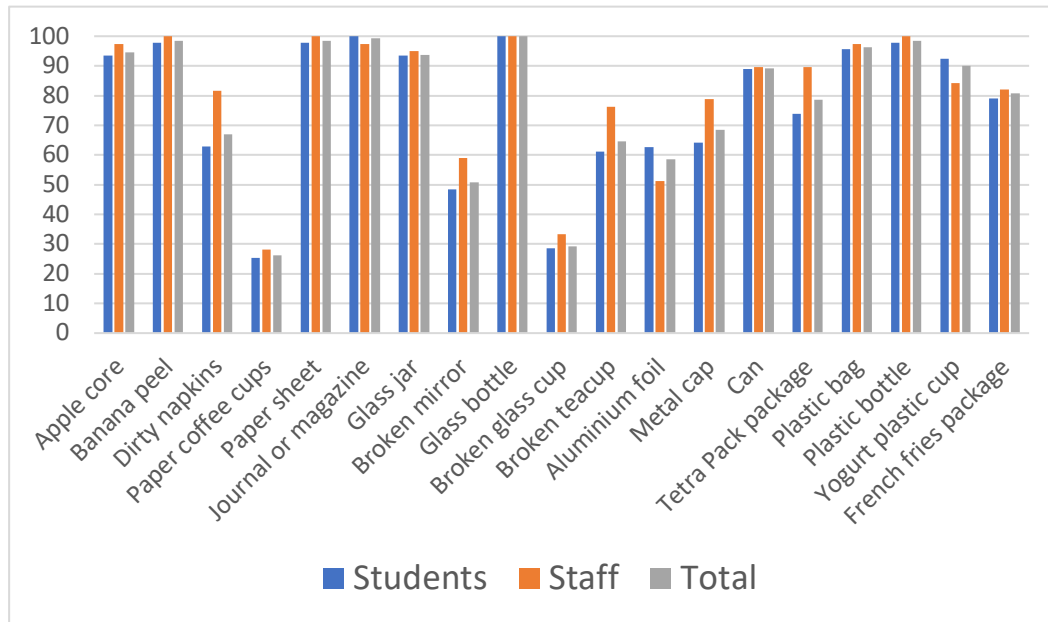


Figure 2. Prevalence of knowledge on how to sort wastes for recycling, or dispose.

On how to sort wastes for recycling, several knowledge's shown positive and significant correlations, being the highest values of Pearson correlation coefficient achieved between the knowledge on how to sort: soda cans and French fries' package ($r=0.461$, $p<0.001$) or Tetra Pak packaging ($r=0.461$, $p<0.001$); plastic bags and plastic bottles ($r=0.494$, $p<0.001$) or paper sheets ($r=0.573$, $p<0.001$); plastic bottles and paper sheets ($r=1$, $p<0.001$); broken teacups and broken glass cups ($r=0.476$, $p<0.001$) or broken mirrors ($r=0.644$, $p<0.001$); broken glass cups and broken mirrors ($r=0.628$, $p<0.001$); and banana peels and apple cores ($r=0.573$, $p<0.001$). Also, despite with lower values, a positive and significant correlation was found between some knowledges' in how to sort wastes for recycling and other types of knowledge, namely: how to sort Tetra Pak packaging and that bottled water consumption produces wastes ($r=0.271$, $p=0.002$), that the lack of bins is not a reason to toss wastes ($r=0.178$, $p=0.044$), that recycling does not prevent all pollution ($r=0.19$, $p=0.031$), that drying hands with paper napkins increases the production of waste ($r=0.233$, $p=0.008$), or that tap water is of good quality ($r=0.366$, $p<0.001$); how to sort a broken teacup and that drinking bottled water increases waste production ($r=0.3$, $p=0.001$), that drying hands with paper napkins increases the production of waste ($r=0.179$, $p=0.045$), or that cigarette butts are not biodegradable ($r=0.214$, $p=0.016$); how to sort a broken mirror and that bottled water consumption produces wastes ($r=0.19$, $p=0.033$) or that recycling does not prevent all pollution ($r=0.236$, $p=0.008$); how to sort an apple core and that the reusable cups reduce the production of waste ($r=0.209$, $p=0.019$); how to sort a dirty napkin and that garbage on the floor doesn't result from the lack of dustbins ($r=0.23$, $p=0.01$) or that tap water is of good quality ($r=0.268$, $p=0.002$); how to sort a glass jar and that bringing lunch from home decreases the production of waste ($r=0.369$, $p<0.001$); how to sort a French fries package and that recycling does not prevent all pollution ($r=0.187$, $p=0.034$), that bringing lunch from home decreases the production of waste ($r=0.185$, $p=0.036$), or that cigarette butts are not biodegradable ($r=0.191$, $p=0.031$); and how to sort a yogurt plastic cup and that tap water is of good quality ($r=0.187$, $p=0.034$). Besides sorting wastes, others

knowledge's also correlate significantly, namely knowing: that plastic is the worst for the environment and that plastic bottles are worst for the environment than glass ones ($r=0.396$, $p<0.001$); that drinking bottled water increases waste production and that recycling does not prevent all pollution ($r=0.285$, $p=0.001$), or that tap water is of good quality ($r=0.225$, $p=0.01$); that garbage on the floor doesn't results from the lack of dustbins and that tap water is of good quality ($r=0.185$, $p=0.038$): that reusable cups reduces the production of waste and that cigarette butts are not biodegradable ($r=0.204$, $p=0.021$) or that tap water is of good quality ($r=0.183$, $p=0.038$).

Table 1. Prevalence of knowledge on how to sort wastes for recycling, or dispose.

Knowledge	Students	Staff	Significance	Total	
Knows that plastic is worst for the environment	83.7%	94.7%	$p=0.010$	86.9%	
Knows that reduce, reuse or recycle allows a better waste management	97.8%	94.9%	$P=0.016$	97.7%	
Knows how to sort...	Apple core	93.4%	$p=0.137$	94.6%	
	Banana peel	97.8%	$p=0.076$	98.5%	
	Dirty napkins	62.9%	81.6%	$p=0.002$	66.9%
	Paper coffee cups	25.3%	28.2%	$P<0.001$	26.2%
	Paper sheet	97.8%	100%	$p=0.076$	98.5%
	Journal or magazine	100%	97.4%	$p=0.845$	99.2%
	Glass jar	93.4%	94.9%	$p=0.375$	93.8%
	Broken mirror	48.4%	59.0%	$p=0.143$	50.8%
	Glass bottle	100%	100%	-	100%
	Broken glass cup	28.6%	33.3%	$p=0.284$	29.2%
	Broken teacup	61.1%	76.3%	$p=0.003$	64.6%
	Aluminium foil	62.6%	51.3%	$p=0.893$	58.5%
	Metal cap	64.1%	78.9%	$p=0.013$	68.5%
	Can	89.0%	89.7%	$p=0.458$	89.2%
	Tetra Pack package	73.9%	89.5%	$p=0.003$	78.5%
	Plastic bag	95.6%	97.4%	$p=0.295$	96.2%
Plastic bottle	97.8%	100%	$p=0.076$	98.5%	
Yogurt plastic cup	92.4%	84.2%	$p=0.042$	90.0%	
French fries package	79.1%	82.1%	$p=0.358$	80.8%	
Knows that drinking bottled water increases waste production	86.8%	97.4%	$p=0.006$	89.2%	
Knows that the lack of bins is not a reason to toss wastes	84.6%	87.2%	$p=0.357$	85.4%	
Knows that reusable cups reduce the production of waste	80.2%	87.2%	$p=0.159$	82.3%	
Knows that plastic bottles are worse for the environment than glass ones	96.7%	97.4%	$p=0.204$	96.9%	
Knows that that even recycling pollutes	71.4%	84.2%	$p=0.020$	74.6%	
Knows that drying hands with paper napkins increases the production of waste	86.8%	82.1%	$p=0.756$	85.4%	
Knows that bringing lunch from home reduce waste production	97.8%	100%	$p=0.076$	98.5%	
Knows that cigarette butts are not biodegradable	96.7%	97.4%	$p=0.412$	96.9%	
Knows that tap water is of good quality	71.4%	84.2%	$p=0.020$	74.6%	
Total	80.7%	84.9%	$p=0.300$	81.7%	

The levels of concordance with the statements selected to evaluate attitudes towards waste management show high pro-environmental levels (Table 2). More than 90% agree or totally agree that waste production is currently excessive (95.4%), that pollution due to waste production is not a minor issue concern (91.6%), that abandoned garbage makes places unpleasant (96.9%), and that the contribution of each one of us is essential for a proper waste management (97.7%). With lower levels of concordance is the idea that, despite they are light and practical, plastic packaging can be avoided (77.5%). As for knowledge, there are no significant differences between Staff and Students regarding overall Attitude [Students (90.8%) and Staff (94.4%) $p=0.231$], but for three of the five statements the level of concordance is significantly higher in Staff: concern with the pollution originated from waste [Students (87.9%) and Staff (100%) $p<0.001$]; that abandoned garbage makes places unpleasant [Students (95.6%) and Staff (100%) $p=0.0204$]; and that contribution of each one of us is essential for a proper waste management [Students (96.7%) and Staff (100%) $p=0.039$]. For attitude, some positive and significant correlations were found between the concordance of the following statements: ‘waste production is currently excessive’ with ‘despite they are light and practical, plastic packaging can be avoided’ ($r=0.18$, $p=0.041$); ‘the pollution due to waste production is not a minor issue’ with ‘the contribution of each one of us is essential for the proper waste management’ ($r=0.198$, $p=0.024$); and ‘abandoned garbage makes places unpleasant’ with ‘the contribution of each one of us is essential for the proper waste management’ ($r=0.397$, $p<0.001$).

Table 2. Levels of concordance (agree or totally agree) with adequate attitudes towards waste management among Students and Staff.

Attitudes	Students	Staff	Significance	Total
Waste production is currently excessive	95.6%	94.9%	$p=0.575$	95.4%
Pollution due to waste production is not a minor issue concern	87.9%	100%	$P<0.001$	91.6%
Abandoned garbage makes places unpleasant	95.6%	100%	$p=0.020$	96.9%
Contribution of each one of us is essential for a proper waste management	96.7%	100%	$p=0.039$	97.7%
Despite they are light and practical, plastic packaging can be avoided	78.0%	76.9%	$p=0.566$	77.5%
Total	90.8%	94.4%	$p=0.231$	91.8%

Despite waste management best practices show a lower prevalence than the levels of knowledge and attitudes, the enquiry identifies some with high incidence, namely separating wastes for recycling (75.4%), and never toss wastes (99.2%) and cigarette butts (87.5%, among smokers), considering the prevalence of ‘always’ and ‘often’ (Table 3). On the contrary, other behaviours

shows prevalence much lower than 50%, as ‘never’ or ‘rarely’ use paper towel to dry hands (38.5%), ‘always’ or ‘often’ using reusable cups at the coffee machine (23.5%, among coffee machine users) and ‘never’ or ‘rarely’ drinking bottled water (45.3%). For ‘often’ and ‘always’ prevalence’s, overall waste management best practices were similar between Students (61.1%) and Staff (62.0%) ($p=0.403$) and, at specific behaviours, none is statistically different between both groups. Additionally, only a pair of behaviour shows a significant positive correlation: using reusable cups in coffee machines and ashtrays for cigarette butts ($r=0.287$, $p=0.001$), among smokers and coffee machine users.

Table 3. Prevalence of waste management best practices among Students and Staff.

Behaviours	Students	Staff	Significance	Total
Always and often separating wastes for recycling	72.5%	82.1%	$p=0.115$	75.4%
Never toss wastes	98.9%	100%	$p=0.157$	99.2%
Never toss cigarette butts*	86.5%	90%	$p=0.370$	87.5%
Never or rarely use paper towel to dry hands	38.5%	41.0%	$p=0.375$	38.5%
Always or often using reusable cups at the coffee machine**	25.0%	12.8%	$p=0.820$	23.5%
Never or rarely drinking bottled water	45.1%	46.2%	$p=0.479$	45.3%
Total	61.1%	62.0%	$p=0.403$	61,6%

*Among smokers, $n=56$ (Students $n=37$; Staff $n=19$)

**Among coffee machine users, $n=85$ (Students $n=60$; Staff $n=25$)

The correlations between Knowledge, Attitude and Behaviour on waste management shows small significant results ($r<0.326$), mostly positive but some negative (data not shown). Six significant positive correlations ($r= 0.147 - 0.244$, $p<0.05$) were found between Knowledge and Attitude, mostly on knowledge on how to sort unusual materials and all the attitude statements. For example, knowing how to sort a broken teacup and a metal cap correlates with the concordance that ‘contribution of each one of us is essential for a proper waste management’ ($r=0.174$, $p=0.025$ and $r=0.187$ $p=0.017$, respectively) and knowing that plastic is worst for the environment correlates with the concordance that ‘abandoned garbage makes places unpleasant’ ($r=0.244$ $p=0.003$). Fifteen significant correlations were found between Knowledge and Behaviour, 7 negative and 8 positive ($r<0.326$), mostly with the behaviours of separating wastes for recycling and using reusable cups at the coffee machine. Always and often separating wastes for recycling correlates positively with knowing how to sort a plastic bottle ($r=0.157$ $p=0.038$), a banana peel ($r=0.160$ $p=0.035$), an apple core ($r=0.161$ $p=0.036$), and a paper sheet ($r=0.157$ $p=0.038$), but negatively with knowing how to sort a Tetra Pack package ($r=-0.164$ $p=0.032$), that reusable cups reduce the production of wastes ($r=-0,161$ $p=0.035$), that the lack of bins is not a reason to toss wastes ($r=-0,176$ $p=0.023$) and that drying hands with paper

napkins increases the production of wastes ($r=-0,176$ $p=0.023$). Three knowledge's on how to sort wastes, broken glass cup ($r=-0.218$ $p=0.007$), broken mirror ($r=-0.175$ $p=0.024$) and apple cores ($r=-0.195$ $p=0.014$), correlates negatively with the behaviour of always or often using reusable cups at the coffee machine. On Knowledge's and Behaviours directly related, the only positive correlations were between knowing that drying hands with paper napkins increases the production of waste and never or rarely use paper towel to dry hands ($r=0,183$ $p=0.019$) and knowing that drinking bottled water increases waste production and never or rarely drinking bottled water ($r=0.152$ $p=0.042$). However, the highest correlation found was between knowing that drying hands with paper napkins increases the production of waste and never or rarely drinking bottled water ($r=0,325$ $p=0.004$). Ten significant correlations were found between Attitude and Behaviour, two of them negative. The concordance that 'despite they are light and practical, plastic packaging can be avoided' correlates positively with 'separating wastes for recycling' ($r=0.173$ $p=0.025$), 'using reusable cups at the coffee machine' ($r=0.146$ $p=0.049$), 'never toss wastes' ($r=0.164$ $p=0.032$) or 'cigarette butts' ($r=0.179$ $p=0.021$), and 'never or rarely drinking bottled water' ($r=0.159$ $p=0.036$). 'Using reusable cups' and 'never or rarely drinking bottled water' also correlates with the concordance that 'waste production is currently excessive' ($r=0.178$ $p=0.022$; and $r=0.184$ $p=0.018$, respectively). The highest positive and significant correlation between an attitude and a behaviour was found between the concordance that the 'contribution of each one of us is essential for a proper waste management and 'always and often separating wastes for recycling' ($r=0.223$ $p=0.006$). The two small negative correlations found were between 'never or rarely use paper towel to dry hands' and concordance with that 'abandoned garbage makes places unpleasant' ($r=-0.194$ $p=0.014$), and that the 'contribution of each one of us is essential for a proper waste management' ($r=-0.158$ $p=0.037$).

DISCUSSION

The University of Madeira academic community shows good levels of knowledge (81.7%) and excellent for attitudes (91.8%) on waste management, this latter being significantly higher ($p=0.009$). The low sample number in each subcategory only allowed a comparative analysis between two main groups, Students and Staff, but without revealing significant differences between them on those two components of the environmental literacy. However, attending specific aspects of knowledge and attitude, there are strong evidence that teachers and other staff tend to perform better than students. In fact, among the eleven (in thirty) items of knowledge in which there are significant differences between students and staff, nine were better for staff and only two for students. Also, for attitude, among the five items evaluated, three shows significant differences, all of them better for teachers and other staff. Despite we commonly assume that teachers should perform better than students, our results couldn't be explained as simple as that. Since waste management isn't a topic integrated in the curricula of the courses taught at the University of Madeira, except for 3 situations but all at the responsibility of only one teacher, and that half the sample classified as staff is not composed by teachers, the tendency to perform better on knowledge and attitudes could be explained by factors dependent on other characteristics of the group sample, namely the fact that, most probably, they must be older, more cultured and experienced, and with higher levels of education and income. In fact, previous studies shown that people with higher socioeconomic

status and levels of education, as well as older, tend to show high levels of environmental literacy (Kellert, 1985; Lyons & Breakwell, 1994; Shin et al., 2005; Tikka et al., 2000).

On the prevalence of waste management best practices (behaviour) the situation is quite different than for knowledge and attitudes. At this component of the environmental literacy, the average global result (61.6%) is significantly lower than knowledge ($p < 0.001$) and attitudes ($p < 0.001$), with a performance that could only be classified as moderate, and with similar results between Students (61.1%) and Staff (62%) ($p = 0.403$). As so, behaviour shows a sharp drop comparing to knowledge and attitude, a situation that is common to find in other studies (Goulgouti et al., 2019; Liang et al., 2018; Spínola, 2015). This wide gap between behaviour and knowledge/attitude has been revised and explained by previous authors (McDonald, 2014; Schäufole & Janssen, 2021; Tarfaoui & Zkim, 2017) point out the barriers that needs to be surpassed in order to move from intentions to action. These barriers range from the degree of difficulty, convenience and costs to, among many others, the availability of facilitating infrastructure or solutions to perform a certain behaviour. Additionally, the knowledge/attitude-behaviour gap is also dependent on the influence of the social structure to which individuals and groups belongs and their social norms. In fact, the widely variable prevalence's of the different behaviours evaluated, ranging from almost 100% for 'never toss wastes' to only 23.5% for 'always or often using reusable cups at the coffee machine', may be a consequence, partly, of the respective degrees of difficulty associated with the different barriers for each behaviour. For example, separating wastes for recycling or never toss wastes and cigarettes butts is facilitated since there are numerous containers for selective waste collection on campus. On the contrary, avoiding the use of paper towels to dry hands in the bathrooms or the use of disposable cups in coffee vending machines, the only solutions institutionally provided, implies that each one equips oneself with reusable cups and cloth tissues as alternative solutions. This is much more difficult because it implies adopt a different solution than the one provided, and even more because there are no social support for those new behaviours.

The profile of environmental literacy for waste management found at the University of Madeira shows that the environmental education needed must centre its attention on behaviours. Since behaviours change have shown to be the most difficult goal to achieve, we propose a most effective approach based on socio-education and transformation of the physical and organizational context. For example, to reduce the prevalence of drinking bottled water, we suggest the installation of water refill stations and the distribution of reusable bottles. To increase the use of reusable cups at the coffee machines, we propose a discount on the price for those who bring their own glass, and the distribution of reusable cups. To reduce the use of paper towels to dry hands at the bathroom, we recommend the availability of other solutions, namely electric hand dryers, which has been shown to be more sustainable (Gregory et al., 2013), and the promotion of cloth handkerchiefs use. However, it is not enough to make solutions available, we need to boost a social learning process to make the behaviours of adopting it expected and desirable among the community, and to be integrated in its social norms. For that, and based on the Social Learning Theory (Jadallah et al., 2021), we recommend the adoption of an influencers approach, mobilizing groups of students, teachers and other staff to adopt those behaviours and, as live models, disseminate them among friends and colleagues.

Despite overall knowledge on waste management is good, and some excellent, there are specific ones that needs to be improved, especially on sorting for recycling certain materials. This is the case of paper coffee cups, dirty napkins, and non-packaging glass (mirror and cups), with some values much lower than 50%, requiring direct approaches for its improvement. Except for non-packaging glass, because it's not present among the wastes produced by the University of Madeira academic community, paper coffee cups, dirty napkins and Tetra Pack package are those that have been observed has the most commonly sorted at the wrong bin (data not shown). These results highlight the relevance of evaluating environmental literacy on the people environmental education is working for, as it is the only way to know to where redirect its approaches, strategies, and subjects.

The Pearson correlations help us to understand the relationship between the different items included in the characterization of the environmental literacy on waste management. The significant Pearson coefficients found were the highest among knowledge on how to sort wastes for recycling ($r>0.46$), showing medium to large positive relationships, specially between wastes with similar characteristics or degree of knowledge dissemination. Some knowledge's in how to sort wastes also correlate with other types of knowledge, namely those in knowing how to reduce waste production. Correlations between knowledge's others than those on how to sort wastes were also found, especially among the most related. As so, these findings show us that related knowledges are most prone to be learned altogether than independently, which should be taken in account when defining environmental education strategies and approaches.

Correlations between different attitudes were, despite positive, few and small, except for concordance with that 'abandoned garbage makes places unpleasant' and that 'the contribution of each one of us is essential for the proper waste management', with a medium level ($r=0.397$, $p<0.001$). Taking in consideration that Attitude levels were excellent but showing low correlations among the evaluated items, we may consider that it is an indication that each one has its own path and process to be achieved and that environmental education needs to take each one in consideration, and do not trust that only working with some the others will be reached by dragging. If Attitude shows lower levels of correlation than Knowledge, for Behaviour the results are even lowest. A relationship was only found between those that use reusable cups in coffee machines and ashtrays for cigarette butts ($r=0.287$, $p=0.001$), that is, those participants how use reusable cups and are also smokers tend to not toss cigarette butts. As interpreted for Attitude, our lack of correlations between environmental best practices could be a consequence of the existence of pathways, processes, and barriers very specific for the adoption of each behaviour. Again, environmental education should work each behaviour as a specific goal to be achieved and define the needed approaches and strategies.

When considering correlations between Knowledge, Attitude and Behaviour items, the level of correlations remains at a small level, which remembers previous studies and the lack of dependence between them (Digby, 2010; Spínola, 2020; Timur et al., 2014). The correlations found between Knowledge and Behaviour are divided evenly between negative and positive, in both situations at small level, showing the lack of dependence between both aspects. However, the fact that the positive correlations were mostly between the behaviour of sorting wastes for recycling and the knowledge in how to do it, as well as others directly related, could mean, as other authors stated (Kaiser, et al., 1999), that knowledge important to perform specific

behaviours relate each other most. The negative correlation between knowledges and behaviours also reminds us that knowing is far from being a precept for doing it. The belief that plastic packaging can be avoided represents half of the ten significant correlations found between attitudes and behaviours, which could mean that this specific item could represent a positive attitude with higher influence in changing people practices. Difficult to explain is the correlations found with the concordance that the ‘contribution of each one of us is essential for a proper waste management, because it is positive with ‘always and often separating wastes for recycling’ ($r=0.223$ $p=0.006$) but negative with ‘never or rarely use paper towel to dry hands’ ($r=-0.158$ $p=0.037$).

Limitations

Although the present study contributes to the understanding of how environmental literacy is structured in a context such as that of the University of Madeira, we must take into account that it suffers from some drawbacks that may weaken its conclusions. First, the instrument designed to evaluate environmental literacy on waste management among the academic community of the University of Madeira (Portugal) doesn’t show high strength on its reliability and validity indicators. Additionally, the sample number, despite sufficient, wasn’t large enough to clarify the performance of more specific subgroups of the academic community and, in this way, to better understand its structure in terms of environmental literacy, namely across the different years and levels of education. To be taken in consideration is also the possibility that, among academic community, those more environmentally literate were also more prone to voluntarily answer the questionnaire, which, together with some desirability bias, could show us a picture better than the reality. In future studies, besides improving the questionnaire structure, we should choose another approach to collect samples, prioritizing the preparation of a larger and structured sample so that subgroups and demographic variables could be included. No less important will be the need to ensure the participation of members of the academic community who may be less motivated by the environmental issues, which can be obviated through individual and direct approaches that, even so, maintain anonymity.

CONCLUSION AND SUGGESTIONS

In the present context, in which we are running against time to mitigate environmental imbalances, the evaluation of the environmental literacy is of the utmost importance to redirect environmental education approaches and strategies to improve its efficacy. Present study evaluates environmental literacy on waste management on a Portuguese academic community and finds a picture in which the levels of knowledge, and even more for attitude, are very promising, despite behaviours needing substantial improvements. In a refined interpretation of the results, the study unveils the need for an environmental education approach tailored for each specific knowledge, attitude, and behaviour, and help us to select those that need to be prioritized in the near future. In this sense, in addition to very specific aspects of knowledge and attitude, the environmental education approach in the context of the University of Madeira must be redirected towards the adoption of the appropriate behaviours that could improve waste management, realizing that the success of this approach will be more dependent on changes that minimize the effect of physical and social barriers rather than strengthening levels of knowledge and attitude, as, once again, their weak relationship is confirmed.

DECLARATIONS

Data Availability: Data is available upon request to the author.

Ethical Rules: *At the time data was collected for the present study, no ethical body existed at the University of Madeira and, as so, the consent for the development of the study were tacitly given by the rectorship. Author followed ethical guidelines as outlined by the British Educational Research Association as also the General Data Protection Regulations.*

Authors Contributions: All the work was done by the author.

Conflict of Interest: There is no conflict of interests.

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Appendix 1- Questionnaire

Environmental literacy on waste management

This survey is anonymous and aims to assess the level of environmental literacy of the academic community of the University of Madeira regarding waste management. It covers knowledge (section 1), attitudes (section 2) and behaviour (section 3) and the entire survey takes less than 10 minutes to complete.

I am...

Student of a technical course

Undergraduate student (1st year)

Undergraduate student (2nd year)

Undergraduate student (3rd year)

Master student

Doctoral student

Teacher

Staff (non-teacher)

Section I- Knowledge

I.1- Which of the following materials, as a residue, is the worst for the environment?

Paper; Plastic; Orange peel; Can; Glass; Ceramics.

I.2- For a better waste management, what do you consider to be more important?

Reuse; Incinerate; Recycle; Abandon; Reduce; Bury.

I.3- Separate the following list of waste for each of the indicated containers (Paper-blue; Glass- green; Plastic/metal packaging- yellow; General garbage bin; I don't know):

Yogurt plastic cup; French fries' package; Glass jar; Dirty napkins; Apple core; Aluminium foil; Paper sheet; Broken mirror; Banana peel; Glass bottle; Plastic bottle; Metal cap; Broken glass cup; Broken teacup; Tetra Pack package; Plastic bag; Paper coffee cups; Soda can; Journal or magazine.

I.4- Select all the statements with which you agree:

Drinking bottled water increases waste production.

Garbage on the floor results from the lack of dustbins.

Reusable cups reduce the production of waste.

Plastic bottles are better for the environment than glass ones.

Garbage, if recycled, does not cause pollution.

Drying hands with paper napkins increases the production of waste.

Bringing lunch from home increases the production of waste.

Cigarette butts are biodegradable.

Tap water is of questionable quality.

Section II- Attitude

Please indicate your level of agreement with each of the following statements:

II.1- Waste production is currently excessive.

1-Totally disagree; 2-Disagree; 3- Don't agree nor disagree; 4- Agree; 5-Totally agree.

II.2- The pollution due to waste production is a minor issue.

1-Totally disagree; 2-Disagree; 3- Don't agree nor disagree; 4- Agree; 5-Totally agree.

II.3- Abandoned garbage makes places unpleasant.

1-Totally disagree; 2-Disagree; 3- Don't agree nor disagree; 4- Agree; 5-Totally agree.

II.4- Because they are light and practical, plastic packaging cannot be avoided.

1-Totally disagree; 2-Disagree; 3- Don't agree nor disagree; 4- Agree; 5-Totally agree.

II.5- The contribution of each one of us is essential for the proper waste management.

1-Totally disagree; 2-Disagree; 3- Don't agree nor disagree; 4- Agree; 5-Totally agree.

Section III- Behaviour

Define how often you develop the following behaviours at the University of Madeira:

III.1- I sort my wastes for recycling.

1- Never; 2- Rarely; 3- Sometimes; 4- Often; 5- Always

III.2- In the bathroom, I dry my hands with paper towels.

1- Never; 2- Rarely; 3- Sometimes; 4- Often; 5- Always

III.3- I use reusable cups in coffee machines.

1- Never; 2- Rarely; 3- Sometimes; 4- Often; 5- Always; 6- I don't use coffee machines.

III.4- I leave garbage out of the trash cans.

1- Never; 2- Rarely; 3- Sometimes; 4- Often; 5- Always

III.5- I drink bottled water.

1- Never; 2- Rarely; 3- Sometimes; 4- Often; 5- Always

III.6- I toss cigarette butts on the floor.

1- Never; 2- Rarely; 3- Sometimes; 4- Often; 5- Always; 6- I'm not a smoker.

Acquisition and use of Environmental Education in Solid Waste Management Practices

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ABSTRACT

Research Article

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Environmental issues are becoming more multifaceted and difficult to manage, and with the preponderance of pollution shifting toward problems caused by individuals and small entities, a stronger and wider public understanding of environmental management and related issues is a growing necessity. This study identifies contents of environmental education in solid waste management (Reduce, Reuse and Recycle) and assesses the recycling interests of households through a participatory assessment. Using a survey questionnaire that addressed five stages of environmental literacy; (awareness, knowledge, understanding, attitude and skills) as well as solid waste generation, disposal and management, a multistage sampling technique was adopted for data collection. The probability sampling was used to draw 1,230 respondents not less than 18 years of age in selected households from three local government areas, classified into high, medium and low density areas. A correlation test was used to determine the relationship between the knowledge of respondents about waste management and their waste management practices. Findings showed that the knowledge for employing reduction/avoidance, reuse and recycling methods was acquired at a tender age through parents, siblings or relations, and at school. Findings also showed no significant relationship between the knowledge of respondents about the content of Environmental Education (EE) and their waste management practices with a coefficient correlation of 0.107 and $p: 0.552 > 0.05$. Furthermore, the assessment showed that 96% of the individuals were interested in recycling. Deploying environmental education has a significant impact on waste management practices and early childhood knowledge acquisition is vital to environmental education

Keywords: Environmental education; environmental literacy; reduce; recycling; reuse; solid waste management.

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INTRODUCTION

The menace of solid waste is the most enduring of all the urbanization-induced problems in Nigeria (Agbola and Jinadu, 2006). Agbola (1996), asserted that, while most nations of the world seek innovative ways to solve their enduring and contemporary environmental problems, Nigeria seem to be overwhelmed with the sheer magnitude of its environmental problems, the most noticeable being the abysmal lack of sanitation and general unkemptness of the urban environment with heaps of uncleared refuse. This assertion still holds true even today. Glenn (2009) affirmed that improper disposal of household solid waste is a source of air, land and water pollution which creates hazards to humans and the physical environment. It is a major environmental concern to many nations especially the developing countries. In most urban areas, solid waste is indiscriminately disposed of at any available space without considering the negative impacts on the environment. This poses serious threat to human health and the environment. Improper management of solid wastes defaces the environment, spreads disease, and contaminates ground water, air and land quality (Festus and Offor, 2012). A key solution to this menace is environmental education. Environmental education in the Nigerian ambience has very much been overlooked to a worrying point for the average environmental conscious mind (Eze, 2021).

Hungerford, and Tomera (1987) maintained that environmental education goes beyond the mere imparting of information to provide: a working knowledge of environmental issues, specific knowledge of approaches to address those issues, the ability to make appropriate decisions, and possession of certain affective qualities (attitudes) that make people care about and pay more attention to environmental conditions. Ajiboye and Ajitoni (2008) asserted that an effective environmental education should involve strategies and learning experiences that are planned, focused, experiential, participatory, anticipatory, and cumulative. They opined that all individuals should have access to learning about the environment. In essence, the goal of environmental education is environmental literacy.

The 1978 Tbilisi Declaration suggests that environmental education programmes do not only build knowledge but also attitudes and skills which people need to address environmental problems (United Nations Educational, Scientific and Cultural Organization, 1978). Sometimes, environmental education provides the knowledge and skills to take action immediately, with educational intervention programmes capable of building behavioural changes. Environmental education programmes aim to instil a stewardship ethic and promote learning, caring, and skills that will lead to future pro-environmental behaviours. Coyle (2005) affirmed that as environmental topics and problems become more complex and pervasive, decades of reliance on trained experts within the private and public sectors to handle human needs are nearing an end. In the future, many leading environmental problems, ranging from water quality, waste management to ecosystem management, will require the efforts of more skilled non-experts acting as individuals, through small business, or as community leaders.

Similarly, waste production is an inevitable by-product of human existence, consequently, its disposal is a must (Afon, 2007). The sheer magnitude of the municipal solid waste problem in Nigeria is hard to comprehend. There are not enough public waste receptacles. Municipal solid waste accumulates and overflow the receptacles. Households and businesses do not help the situation; they pile up the waste in the median of major roads and set them on open fire without

pollution control (Walling, Fosko, Geraminejad, Whitaker, and Arpey, 2004). In some parts of the municipality, waste is indiscriminately dumped around market places, homes, road sides and open land. The municipal solid waste finds its way into water ways and drainage system resulting to serious environmental problems (Peter, 2016).

In Plateau State, Nigeria, the government has attempted to solve the solid waste problem in the state by improving the operations of the existing waste management system through the engagement of tasks force on environmental sanitation, however, the effort has not yielded the desired results (Peter and Ayuba, 2014). The management of solid waste stands as the most visible environmental problem facing Jos Metropolis. It is attaining a worrisome dimension with the increased urbanization. This is reflected in the wide spread of indiscriminate dumping of solid waste across the city urban centers; on the roads, within the neighborhoods, around residential buildings and in different places within the state capital (Da'am, Wungakah, Kanma, and Bikalsoem, 2020). This underscores the importance of a competent and well-applied environmental education, able to help achieve an improved environment, better planned communities, a more vibrant economy, and even optimal human health. These are environmental education's principles and they are achievable (Hungerford *et al.* 2005).

In this study, the underpinning theory adopted for the acquisition and use of environmental education in solid waste management practices is the Theory of Reasoned Action (TRA). This theory was propounded by Ajzen and Fishbein (1980). TRA proposes a causal model of the cognitive processes leading to behavioral decisions. The Theory of Reasoned Action predicts behavior based on seven causal variables which include; behavioral intention, attitude, subjective norm, belief strength, evaluation, normative belief, and motivation to comply. The model, thus, shows that a better understanding of a behavior can be gained by tracing its determinants back to underlying factors such as intention to act and beliefs among others. Accordingly, the behavior can be influenced when sufficient number of the beliefs are changed. This presupposition gives a foundation for the use of this model in understanding variables capable of impacting an individual's waste management practices as they positively or negatively affect the environment. The content of Environmental Education (EE) in waste management is ultimately reflected in the individuals' ability to possess knowledge on the types of solid waste they generate and a knowledge of how each type of waste is managed (reduced, reused and recycled) as well as an ability to translate this knowledge into daily living.

Solid waste management knowledge acquisition starts from childhood and remains a continuous process through growth. Several media, events, circumstances, people and places contribute to the process and types of knowledge acquired. It is, thus, against this background that this study examined the learning and acquisition of EE contents in waste reduction, reuse and recycling in three local government areas of Plateau state (Jos: North, South, East). The study also assessed the recycling interest through a participatory assessment in Plateau State, Nigeria. The choice for the selected LGAs was because, Jos: North, South and East, are the major local government areas located within the state capital of Plateau State, where the waste management problem is most pervasive.

METHOD

The study employed primary and secondary data sources. The primary sources included key informant interviews and survey questionnaire that addressed the five stages of environmental literacy; (awareness, knowledge, understanding, attitude and skills) as well as solid waste generation, disposal and management within the milieu of reduce, reuse and recycle. The outcome of the survey provided information on socioeconomic and demographic characteristics of respondents, the content of EL in solid waste management practices, waste management practices and factors responsible for such practices. Questionnaire and interviews were the major instruments employed for the data collection. The questionnaire, rated on a 5-point likert scale, ranged from “strongly agree=5” to “strongly disagree = 1”. It contained sections that addressed the five stages of environmental literacy; (awareness, knowledge, understanding, attitude and skills) as well as sections on solid waste generation, disposal and management within the milieu of reduce, reuse and recycle. The interview was conducted among the directors and administrators of environmental and waste management organizations in Plateau state.

The reliability co-efficient of the instrument was 0.87. This was obtained, having administered a pre-survey questionnaire to about 20% (200) of the total sample for the study across the different residential densities (high, medium and low). The data obtained was computed and the cronbach alpha derived on the SPSS to obtain a value of 0.87. This implies that the questionnaire instrument had an 87% reliability.

Municipal solid waste management was conceptualized within the ambiance of Environmental Education (EE) using the Environmental Literacy (EL) ladder as an index of measurement. The five stages of environmental literacy are (awareness, knowledge, understanding, attitude and skills). The survey questionnaire addressed these as well as the practices involved in solid waste management within the milieu of reduce, reuse and recycle. A multistage sampling technique was adopted for data collection. The probability sampling was also employed for the selection of one participant not less than 18 years of age in sampled households. A total of 1,230 respondents were randomly selected from three LGAs (Jos North, Jos South and Jos East) classified into high, medium and low density areas.

Data obtained through the use of questionnaires were coded, entered, tested and analysed using the Statistical Package for Social Sciences software (SPSS, 22), the NVIVO and Microsoft Office applications were used for qualitative analysis. Descriptive statistics was used to generate the frequency distributions and other measures of central tendency. A correlation test was used to determine the relationship between the waste management knowledge of respondents and their waste management practices.

The study was carried out in Jos, the capital of Plateau State, Nigeria. Jos Plateau is located in Nigeria’s middle belt with an area of about 26,899 square kilometers and a population of 3.5 million people. Plateau State is located between latitude 8⁰ and 10⁰N, longitude 10⁰ and 15⁰ East while Jos, the Plateau state capital, is located between 9°56’N 8°53’E. Jos has three local government areas- Jos North, South and East for ease of administration and the three LGAs were the study areas (Figure 1).

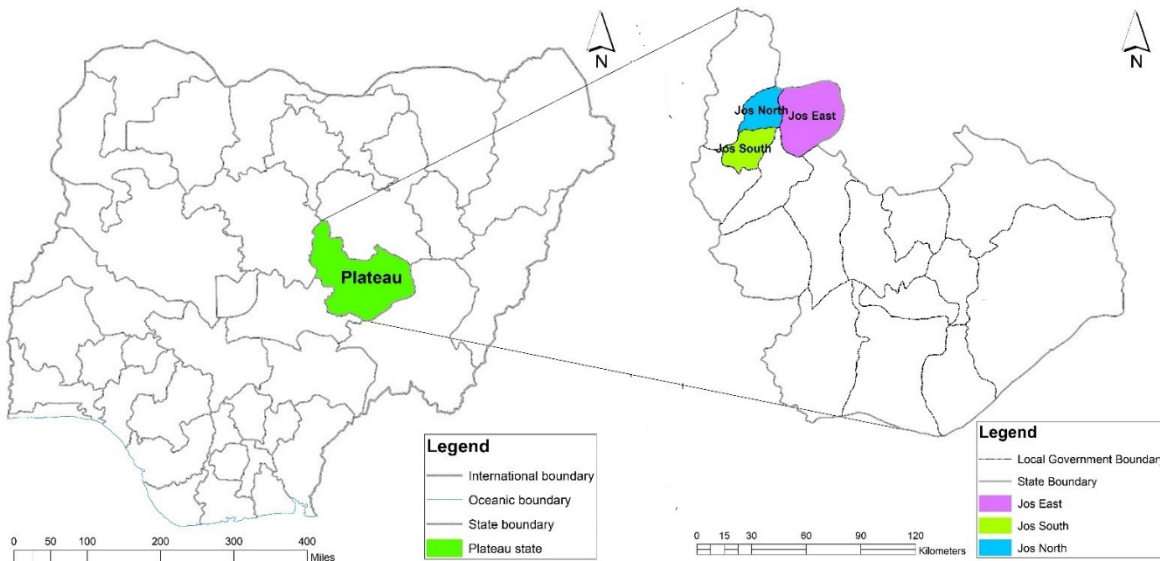


Figure 1: Plateau State in Nigeria; Jos North, Jos South and Jos East in Plateau State.

Source: *Geographic Information Science Lab; University of Jos.*

These were selected on the basis of their location in the state capital and the pervasiveness of waste management problems in these areas. Also, solid waste management practices in Jos Metropolis has not reached acceptable standard of orderly collection, transportation, processing, treatment and disposal. This has led to numerous social and environmental problems (Da'am, Wungakah, Kanma, and Bikalsoem, 2020). In addition, these local government areas have a representation of the entire population of the state capital (National Population Commission, 2006). This article is spatially limited to Jos North, South and East. The content is limited to the acquisition and the use of environmental education in solid waste management practices.

RESULTS AND DISCUSSION

Demographic characteristics of respondents

Only one household was interviewed in each house and one person not below the age of eighteen (18) years. The largest cohort, constituting 489 (39.8%) persons were youths aged 25 – 34 years. This is followed by those between the age of 35 years – 44 years (21.4%), 18 years – 24 years (21.2%). This shows that over 80% of the respondents were between the age group of 18 years and 44 years. The implication of this to SWM is that there is a vast potential of human resource that can be deployed into SWM since much of the active population are in this cohort. Over half of the sampled respondents were married 54.5%, 42.7 % unmarried and 3% widowed or divorced. Findings showed that 6% households had more than 10 occupants as shown in table 1, 55% had between 1 and 5 persons, while 38.8% had 6 – 10 persons in a house. The household size plays a significant role in the type and quantity of waste solid generated. The larger the household size, the more the solid waste likely to be generated and vice versa. Furthermore, respondents had one form of education or the other save for 65 persons (5.3%) who did not have a formal education. 1.5% have vocational education while 10.6%, 42.4% and

40.3% had acquired primary, secondary and tertiary education respectively. It is expected that with this relatively high level of education, environmental literacy and knowledge on MSWM should be considerably high.

Table 1: General Demographic Characteristics of Respondents

Demographic Characteristics		Frequency	Percent
Residential Density	High	700	56.9
	Medium	370	30.1
	Low	160	13.0
	Total	1230	100.0
Gender	Male	566	46.0
	Female	664	54.0
	Total	1230	100.0
Age	18 years - 24 years	261	21.2
	25 years - 34 years	489	39.8
	35 years - 44 years	263	21.4
	45 years - 54 years	124	10.1
	55 years - 64 years	65	5.3
	65 years and above	28	2.3
Total	1230	100.0	
Marital Status	Single	525	42.7
	Married	670	54.5
	Divorced	13	1.1
	Widowed	22	1.8
	Total	1230	100.0
Educational Level	Primary	130	10.6
	Secondary	521	42.4
	Tertiary	496	40.3
	Vocational	18	1.5
	No Formal Education	65	5.3
	Total	1230	100.0
Religion	Christian	1024	83.3
	Islam	203	16.5
	Traditional	3	.2
	Total	1230	100.0
Occupation	Farming	37	3.0
	Public/Civil Service	125	10.2
	Private Company	150	12.2
	Trading/Artisan	572	46.5
	Unemployed	127	10.3
	Others	219	17.8
	Total	1230	100.0
Income	No Income	305	24.8
	Less than N20,000	508	41.3
	N21,000 - N40,000	239	19.4
	N 41,000 - N 60,000	108	8.8
	N61,000 - N80,000	29	2.4
	N81,000 - N100,000	12	1.0
	N100,000 or more	29	2.4
	Total	1230	100.0
Household Size	1 - 5 persons	679	55.2
	6 - 10 persons	477	38.8
	11 - 15 persons	47	3.8
	16 - 20 persons	20	1.6
	> 20 persons	7	.6
	Total	1230	100.0

Source: Author's Field Work (2017)

Furthermore, the main occupations of respondents include: trading, private jobs and public service. A negligible number 3% engaged in farming, reason being that the study was conducted in the municipal area. Artisans and traders constituted 46.5% of the total population, those engaged in private jobs, 12.2%, 10.2% and 10.1% respectively for those engaged in public service and the unemployed. Other details of occupational involvement are shown in table 1, including the income earned. Income levels are generally low in the study area. 24.8% of the respondents had no income, while 41.3% earned less than ₺20,000. 19.4% earned 21,000 – 40,000, 8.8% earned 41,000 – 60,0000 while less than 10% earned above 60,000. The lack of income and the low income level characterizing these areas have an impact on the quantity and the nature of waste generated. Studies of Zia, Batool, Chauhdry and Munir (2017) have established that the higher the income levels, the more the quantity of solid waste generated.

Ideal age for acquiring environmental education

Learning is continuous and cumulative over time. When the wrong knowledge is acquired in any phase of an individual’s growth, such knowledge is likely to be carried on through life unless there is reorientation. The danger of such is over reaching. Many of the respondents, 70%, acquired their knowledge on waste practices and management in their childhood, only 13% did when they became teenagers and 17% as adults (Figure 2).

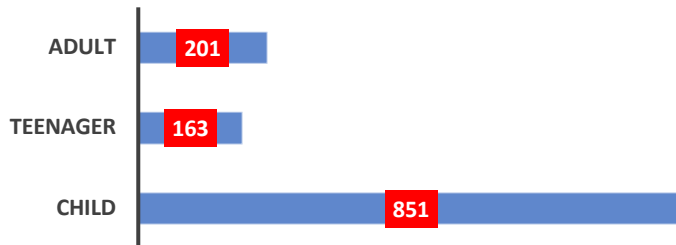


Figure 2: Stage in life when waste knowledge was acquired
 Source: Author’s Analysis (2017)

While research attention has been focused on parents’ ability to shape the behaviour of their children (Clark, 2007), far less attention has been paid to the ways that this more traditional dynamic can be turned around with children shaping the behaviour of their parents (Akintunde, 2017). When EE is attained from an early stage, there is a great probability that the child will grow with such knowledge as admitted by 76.8% of the respondents. Several reasons given for why EE should be taught at an early age include: the children’s ability to learn fast, easily and grow with such knowledge; ability to retain lots of information in their memory because at that level, they are very impressionable; ability to learn by observing and practicing what others do as well as contribute to waste management practices. Environmental education programmes aim to instil a stewardship ethic and promote learning, caring, and skills that will lead to future pro-environmental behaviours. This longer-term perspective of environmental education aims at creating a citizenry that is prepared to deal with a variety of environmental issues they will face not just at the moment but also in the future (Ardoin, Heimlich, Braus and Merrick, 2013).

The sources of environmental knowledge was first studied in details by Evers (1976) several studies have since been conducted across the world (Hungerford and Volk, 1990; Wahab, 1996; Coyle, 2005; WEEF. 2011; Wahab. and Ogunlola. 2014). In North America and Europe, formal schooling is thought to contribute 40% or less to the environmental education of students while 60% of the environmental education knowledge and attitude held, comes from reading, talking, radio and the Television (Evers, 1976). In modern African cities, 50% - 80% of environmental knowledge could come through formal schooling. However, in rural areas, especially where there is little formal education beyond the primary level, close to 100% of environmental knowledge and practically all attitudes come from the community (Atchia, 1982).

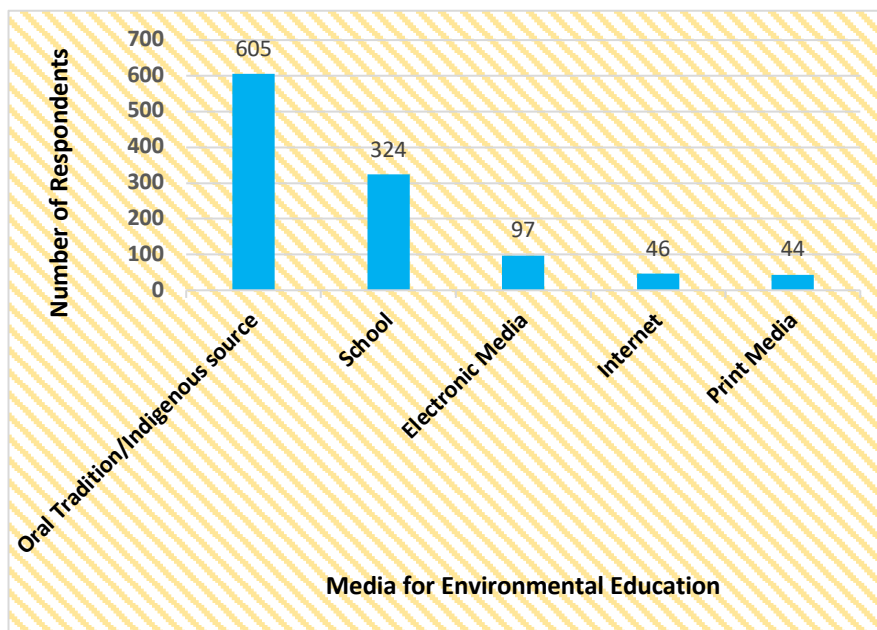


Figure 3: Major Sources of MSWM Knowledge
Source: Author's Field Work (2017)

Despite majority of respondents having at least a primary school education, over 50% indicated that they obtained their knowledge of MSWM from oral tradition or indigenous sources. These findings align with the assertions of Wahab (1996) who stated that Indigenous Knowledge (IK) is part of the people and their development. It represents a people's creativity, ingenuity, novelty, technology and skill. He stated further that IKS are timeless and capable of being adopted at any period to solve varying problems in any given society. The remaining sources are schools, and the print and electronic media as shown in figure 3. This finding is important because it will help redirect the point of information empowerment and concentration in event of intervention. So much is spent today on waste sensitization through the print and electronic media while the indigenous sources which have been proven vital are neglected. The findings show that knowledge passed down to generations have proven to be credible, strong and reliable.

Environmental education and solid waste management through waste reduction, reuse and recycling

- (1) ***Reduction/Avoidance:*** Findings from the household survey indicated that the knowledge for employing reduction/avoidance method was acquired through parents, siblings or relations, at school, and experience/common sense. Majority claimed it was the current hard and biting economic situation in the country that constrained them to adopt the method(s) they were using, while others indicated that they acquired the knowledge from friends and associates, immediate community/environment, grandparents, the media and house to house campaign. Most of the respondents stated that they learnt reduction method while they were growing up. They grew into families and communities where this practice was the norm.
- (2) ***Reuse:*** Findings showed that the major sources for reuse knowledge were parents, siblings or relations, at school, market/work colleagues, neighbors, and experience/common sense. Sometimes, it came in a bid to manage lean resources and finances. Cans were sold for pot making/exchange, Rusted zinc or spare parts of machines were kept for reuse, old zincs, metals and iron rods were gathered for those who bought them for bending or melting, old/spoilt television were exchanged for other items, desktop computer and cooking stoves were converted to other items. Used or spoilt pots were used to make new ones while metals were melted to make rods for building. In the words of one of the respondents,

“My wife has gathered up to 3 sacks of Aluminum cans”

Gathering such a large quantity of resiliently hardly degradable waste has preserved the quality of the environment and reduced the volume of potential waste in no small measure.

- (3) ***Recycling:*** Recycling knowledge was acquired through friends and family, school, elders, neighbors and buyers of the products from the community. There were others who acquired this knowledge through personal initiative, some learnt it from waste pickers that go around collecting used and disposed metals. Some engaged in this for income generation. The level of poverty in the country brings about creativity and ingenuity. One of the findings on recycling was that buyers for recycled items played very significant roles in creating knowledge and value for such items. Respondents affirmed that they did not know such wasted items had any value until they were approached by buyers or when they saw their neighbors selling and exchanging such waste items for other valuable items. Plate 1 shows some management practices exhibited by respondents.



Plate 1: Contents of environmental education applied in solid waste management
Source: Author's Field Work (2017)

Relationship between waste management knowledge and waste management practices

To further explore the nexus between content and use of environmental education in solid waste management, a correlation analysis was used to determine the relationship between waste management knowledge of respondents and waste management practices. No significant relationship was found between the waste management knowledge of respondents and their waste management practices. The results produced a coefficient of correlation of 0.107 and $p: 0.552 > 0.05$, displayed in Table 2.

Table 2: Relationship between waste management knowledge and waste management practices

		Waste management practices	Waste management knowledge
Waste management practices	Pearson Correlation	1	0.107
	Sig. (2-tailed)		0.552
	N	1230	1230

Source: Author's Field Work (2017)

This indicated that, though a very negligible positive relationship existed, this relationship was not significant enough to cause such knowledge, or the lack of it, to influence waste management practices. In other words, there are other factors such as the internal and external locus of control, attitude and disposition towards solid waste management, skills, capacity for individual and group actions among others that significantly influence waste management practices. This result has been corroborated by Liu, Teng & Han, (2020) who found that good environmental knowledge alone does not necessarily translate into pro-environmental behaviors among youths. Furthermore, a good knowledge of environmental variables may not necessarily translate to good and sustainable waste management practice, and the lack of environmental knowledge or awareness may also not necessarily imply a poor waste

management practice (Hungerford and Volk, 1990; Akintunde, 2017). Environmental knowledge has been established as a behavior-distal, but necessary antecedent of pro-environmental behavior (Geiger, Geiger and Wilhelm, 2019).

Application of environmental education in solid waste management

Regarding the involvements of respondents in any of the waste management practices; reduce, reuse or recycle, those involved in waste reduction were less than those who were not, a ratio of 508:687. In waste reuse, 767 persons were involved in one form of reuse or the other more than the 428 who were not. Recycling also had smaller number of people involved than those who were not, a ratio of 528:660 (Figure 4). Attention for policy formulation should therefore be channelled towards sensitization on waste reuse and recycling.

Considering the different ways respondents practically engaged in waste reduction, reuse and recycling, respondents indicated that they were involved in waste reduction by avoiding food waste; measuring what to cook, warming left overs, buying exactly what was needed and minimizing the use of perishable food items. Furthermore, they disengaged from businesses that generated much waste, insisted on the use of computers in order to save paper, like typing directly on computers instead of writing on papers before typing. Similarly, others downloaded programmes on the internet rather than buying CDs, Some avoided breakables to avoid glass wastes, others bought reusable items, some avoided collecting nylons when they purchased items. One of the respondents in Jos East stated thus:

“Instead of bringing purchased garri (cassava flour) home in a nylon, we go to the shop owners to consume it there”

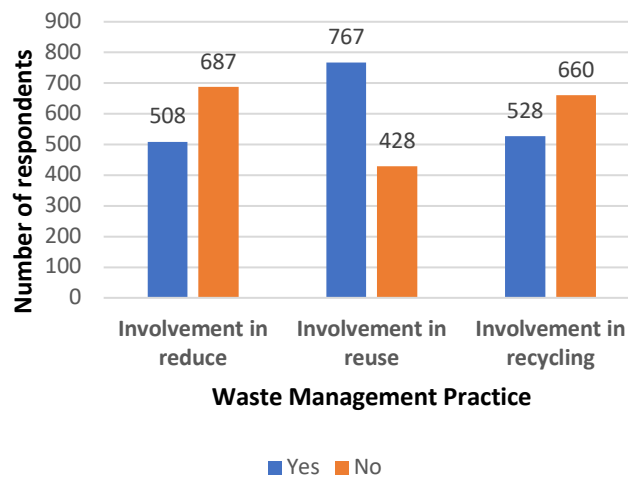


Figure 4: Waste management practices
 Source: Author’s Analysis (2017)

Describing ways they were involved in reuse, respondents indicated that they gathered black or any type of nylons at home to be reused; they used animal farm waste product as fertilizer on farm; burned waste to ashes and sold them; fed dogs and pigs with wasted food; gave polythene to vegetable sellers; used empty plastic bottles for drinks, oil and fuel; used polythene to make fire when cooking; used broken plastics to make fire and they gathered ashes after cooking for

washing back of pots. Furthermore, empty perfume bottles were refilled, used sacks were used to display vegetables, plastic rubbers were used for waste storage, old metals were used in patching rusted doors and windows, used papers were used as toiletries, used cartons, sacks and milk tins were used to package other items, yard trimmings and unwanted food were given to animals and used water was reused to flush toilet and wash bathroom.

Waste reduction from source was identified as one of the most effective ways of curbing municipal solid waste problems. Findings also revealed that some individuals, when buying items, occasionally thought of the outcome of the item after it had been used. Others did not care at all. Table 3 indicates that those who bought less of items and bought only what they needed constituted 57%, while 43% did not care and would not buy less of what they needed.

Table 3: Waste Reduction from Source

	Buy less of items, or only what you need		Buy reusable instead of disposable items		Buy used items instead of new ones		Buy organic food & products	
	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%	<i>f</i>	%
Yes	690	57.0	649	54.0	291	24.4	833	69.3
No	330	27.3	293	24.4	555	46.5	270	22.5
I don't care	190	15.7	260	21.6	348	29.1	99	8.2
Total Responses	1210	100	1202	100	1194	100	1202	100

Source: Author's Field Work (2017)

Those who bought reusable items instead of disposable items were 54% while 46% of individuals did not. Many individuals expressed their aloofness at buying used items instead of new ones. Only 24.4%, 291 of the respondents were willing to buy used items like clothes, shoes, pots, plastic bottles, used sacks and nylon bags, while 46.5% would not and 28.1% did not care about this.

Recycling Participatory Assessment for Households

One way of curbing the intractable problem of municipal solid waste disposal is by encouraging waste recycling. Waste recycling will slowly but surely decrease the size of landfills, it can help keep pollution in check and decrease it gradually. Scrap metals, cans, old bottles, plastics, junk mail and used rubber tyres are becoming common features of our landfills. All of these may seem endless, but the resources required to make them are depleting rather quickly. Recycling allows junk items to be used over and over again so that new resources do not have to be exploited while at the same time, reducing the volume of waste that would otherwise be generated. Recycling conserves natural resources such as water, minerals, coal, oil, gas and timber. A global recycling rate of 30% used cans is almost equivalent to removing 30 million cars from the roads (CEF, 2017). The following section assessed the willingness of respondents in participating in waste reduction through recycling. Table 4 shows the recycling interest and participatory assessment carried out.

Table 4: Recycling Participatory Assessment for Households

<i>Willingness to Participate in Waste Reduction and Recycling in your community</i>	Yes %	No %
Willingness to separate materials like plastic, paper, metals into separate bags for collection	87.1	12.9
Willingness to pay for pickup of recycling materials from your home	73.3	26.7
Willingness to participate in a program to compost food and yard waste	90.4	9.6
Willingness to participate in a program to return plastic bottles to places of purchase if paid for every plastic returned	89.4	10.6
Willingness to purchase less throwaway products (such as, plastic bottles) to help reduce the amount of garbage, if an alternative product of the same cost was provided	88.5	11.5
Request for more information about how and what types of garbage you can compost, reuse, and recycle	93.1	6.9
Willingness to carry garbage to skiff if located in community	95.6	4.4
Willingness to participate in building the skiff for community	91.5	8.5
Willingness to participate in the maintenance of skiff	89.4	10.6

Source: Author's Field Work (2017)

The assessment in Table 4 showed that if certain structures were established, recycling would be embraced and encouraged greatly. If a recycling program was set up that collected materials like plastic, paper, metals, 87% of individuals would be willing to separate these items into separate bags for collection, however, 26.7% would not be willing to pay for pickup of these recycling materials from their homes. Findings also showed that 90.4% of the respondents would be willing to participate in a program to compost food and yard waste. Likewise, 90% individuals will participate in a program to return the plastic bottles to grocery stores if they were paid for every plastic bottle returned. About 90% would be willing to purchase less throwaway products (such as, plastic bottles) to help reduce the amount of garbage to be disposed. 93.1% of respondents would appreciate more information about how and what types of garbage they can compost, reuse, and recycle in order to reduce the amount of garbage to get rid of. Overall, 96% of individuals were highly interested in recycling and only 4% were not interested. Skiffs are large open-topped waste containers designed for loading onto a special type of lorry (truck). Instead of being emptied into a garbage truck, they are very important in managing solid waste at community levels. It was observed that almost all respondents 95.6% would be willing to carry garbage to a skiff if it was located in the community, 91.5% would be willing to participate in building the skiff for the community and about the same number of individuals would be willing to participate in the maintenance of this skiff.

Recycling cuts down the number of pollutants that are released into the environment during production and disposal. Recycling conserves resources and saves energy. When aluminum cans are recycled, 95% of the energy required to produce those cans from raw materials is saved, energy saved from recycling one glass bottle is enough to light a bulb for four hours. Recycling can also bring different groups and communities together. Whether it is by picking up trash from the roads or collecting waste materials to raise money for schools and programmes, many simple programmes that make a community stronger can be built upon the many benefits of recycling (CEF, 2017).

Age and pro-environmental attitude

Overall, students tended to have a pro-environmental attitude (NEP global score mean = 4.23). To examine the relationship between age and NEP-score, we conducted a linear regression analysis, revealing that age is a significant predictor for NEP-score ($\beta = -0.086$, $t = -2.83$, $p < .005$, see Figure 1a). With each year that a person gets older, their NEP-score decreases by approximately 0.08 points. This variable also predicted a significant proportion of NEP-score variance in our regression model ($F(1, 168) = 7.997$, $p < 0.005$, $R^2 = 0.046$). As younger students scored higher values, they appear to have a higher pro-environmental attitude than older students.

CONCLUSION AND SUGGESTIONS

This study examined the learning and acquisition of environmental education contents in waste reduction, reuse and recycling and the extent to which they have been applied in the management of solid waste in three selected local government areas of Plateau state (Jos: North, South, East). The study also assessed the recycling interest of the respondents through a participatory assessment. Findings showed that knowledge was very important in stimulating waste management actions. This knowledge is best acquired at childhood. Furthermore, findings showed that knowledge, or the lack of it, was insufficient to influence waste management practices. In other words, there are other factors such as the internal and external locus of control, attitude and disposition towards solid waste management, skills, capacity for individual and group actions among others that significantly influence waste management practices.

Contents of environmental education (waste reduction, reuse and recycling) were evident in the waste management practices of residents. This knowledge was acquired through various media; from the homes, through the communities, experiences and formal institutions. The study affirms that environmental education, its content and its use has significant impact on waste management practices. Early childhood knowledge acquisition is vital. When empowered with quality information and required skills for action, environmental education is capable of influencing a large portion of the citizenry, transforming their knowledge into action and producing an environmentally sensitive population.

The goal of environmental education is environmental literacy. That environmental education goes beyond the mere imparting of information to providing a working knowledge of environmental issues, specific knowledge of approaches to address those issues and make appropriate decisions, and the possession of certain attitudes that predisposes people to care about and pay more attention to environmental conditions.

DECLARATIONS

Data Availability

All or part of the datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Ethical Approval

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors. The authors, thus, fully agree to the terms of this journal and its license.

Authors Contributions:

EAA conceived the study, guided the study design, data collection, interpretation and manuscript revision.

CAA supported the data collection, entry, and preparation of the manuscript draft.

Conflict of Interest:

On behalf of all authors, the corresponding author states that there is no conflict of interest.

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ABBREVIATIONS (NOMENCLATURE)

EE	Environmental Education
EL	Environmental Literacy
TRA	Theory of Reason Action
NPC	National Population Commission
CEF	Conserve Energy Future
Sig.	Significance
n	Sample size
p -value	Probability value
r	Pearson correlation coefficient
LGA	Local Government Area
MSW	Municipal Solid Waste
MSWM	Municipal Solid Waste Management

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Simulations development for inclusive physics education

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ABSTRACT

Teaching Practice

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In this paper we present the development of two simulations that demonstrate the importance of the relationship between the inclusion process and the teaching of Physics. The simulations were designed so that their use, in the classroom or as a complementary form of study, would favor inclusive education. The innovation of these simulations is related to the capture of some data directly by the cell phone, that is, the simulation work using the cell phone as a virtual laboratory, while presenting the experimental behavior and explaining the physical processes. This work presents the creation and use of simulations and the importance of study and research in inclusive education not only for future teachers, but for students from any area of knowledge, since a culture of respect and inclusion must be experienced at any time in school and in the society.

Keywords: Technical Education; Physics teaching; Inclusion, STEM.

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INTRODUCTION

Inclusive education is a reality of the school environment. Each year, regular classrooms receive a larger and more diverse number of students (Censo da Educação Básica, 2019) who were previously served only by special schools. However, receiving these students does not, in fact, characterize an inclusive education when many teachers and educational institutions do not know how to include these students in the learning process (Peres & Martins, 2021), and continue to maintain their methods of teaching, in most cases, expository, comparative and quantitative, which often, does not reach even typical students, that is, those who do not have any specific educational need and, therefore, will not objectively reach atypical students either, for example, those with specific educational needs.

In this work we report the creation of two simulations that throughout their development were designed for inclusive education, making them accessible by all students, in a more equitable way throughout the learning process. In addition, we will present the simulations created and how they can help students of special education at educational institutions. For Sasaki (2003), education in Brazil, one of the signatory countries of the Salamanca Statement (ONU, 1994), has already gone through the phases of exclusion, segregation, integration and inclusion. The decree 7611/2011 for special education and specialized educational service in the school environment (Brazil, 2011). Ensures that special education in Brazil with special care must be integrated into the pedagogical project of each school. Thus, inclusive education, a term that describes a general approach to special education, takes place when schools and, consequently, classrooms, welcome all types of students, regardless of their specific educational needs, religion, race or their economic and social situation. An inclusive educational environment must be welcoming, respect differences, enable equity and have adequate structure, such as resource rooms, ramps for the disabled, trained teachers, interpreters for the hearing-impaired and also inclusive teaching materials.

Learning is more than internalizing knowledge, the learning process requires an attitudinal change towards the environment in which one lives and must allow this change to make sense (Dos Santos et. al., 2019). In addition, working on inclusive education not only with future teachers or education professionals is also an important issue, since inclusion should not only happen in inclusive schools, but also in society as a whole. Thus, working on inclusive education with technical high school students allows for a greater dissemination of the subject, promoting school socialization for all people, whether they are disabled, of different nationalities or races, who participate in another religion or social environment. The research on inclusive education permeated by integrated technical high school allows the generation of more respectful and ethical behaviors among all citizens in social life. For effective inclusive education to take place, it is important that in addition to prepared institutions and education professionals with continuing education, there are also pedagogical resources, inclusive materials and assistive technologies that allow the inclusion of all who attend educational institutions. In this sense, the use of computers helps the process of inclusion in many situations, whether in communication, through specific software for screen reading or even for the use of alternative augmentative communication, which is a tool that allows communication between people who have expression difficulties, whether they are autistic with low functionality, people with cerebral palsy, among others (Sartoretto & Bersch, 2010), either as a tool that allows access to virtual laboratories or even serving, the computer itself,

as a learning tool. As learning tools, we can mention websites and simulations in general, which allow students to use them in a more practical way, often replacing laboratories, allowing students to understand some processes, whether in technical education or at other levels, including in subjects considered more difficult such as science, technology, engineering, and mathematics (STEM), in addition of course, the use of computers to access video classes, remote study, films and other content that are part of the learning process. Considering, therefore, the learning process and inclusion, this work presents the creation of two simulations related them to the learning of inclusion already in the technical high school, raising awareness, inclusion and the creation of technological teaching materials that at the same time that are developed towards inclusion, they allow independence and a possibility of an effective and efficient learning process for all citizens, whether they have specific educational needs or not.

SCIENCE, TECHNOLOGY, ENGINEERING, MATHEMATICS AND THE RESEARCH ON INCLUSION IN THE TECHNICAL HIGH SCHOOL CONTEXT

In the 1950s, there was an educational reform in science in the United States, when this country began to seek a trip to the Moon (Bybee, 2013; DeBoer, 2000; Hahn, 2023). At this time, curriculum change, in science and mathematics, was developed and created for everyone (Koehler, 2016; Hahn, 2023), however, this everyone still did not include people with disabilities. The curriculum based on the STEM methodology, whether in STEM teaching, where the way of teaching is a complement to the disciplines involved in the term STEM, or in the STEM area, where there is an integration of the areas involved in the term (Breiner et al., 2012; Bryan et al., 2016; Holmund et al., 2018), can be an aid in inclusive education since with different approaches, science content, in particular, physics, can be learned in an inclusive way, that is, accessible to all people and being an excellent ally in scientific areas, making students better develop their skills (Hahn, 2023). Inclusive education has been, through present legislation in the signatory countries of the Salamanca Statement (Uno, 1994), discussed for more than twenty years. However, unfortunately, even today, in some countries it is not widespread and finds several barriers in several schools. In order to promote inclusive education in a technical high school in the south of Brazil, and to show the importance of respecting differences, scientific initiation is carried out with students linked to high school technical courses and who have the possibility to develop inclusive teaching materials in their areas of technical training, with scholarships. In order to make accessible teaching materials that can be used by all students who have or do not have specific needs, some students from technical courses in studies and research related to inclusive education and, in this way, develop in their technical areas, promoting respect, interaction, knowledge and, as a result of these aspects, true educational inclusion. An inclusive school is a quality school, where differences are respected, where the opportunity to knowledge is for everyone. In an inclusive school, the most important thing is to get to know the student, carry out diversified activities and provide opportunities for the learning process for everyone (Santos, 2022).

For the development of the simulations considered here, first and for a few months, we discuss about inclusion and accessibility issues with high school students of computer science, where concepts such as scientific methodology, accessibility, special education and different specific needs were evaluated in order to show them the importance of research, inclusion, the

creation of accessible educational materials and recent existing research on inclusive physics education. This process was relevant, as indicated by Fleuri (2009), as education as knowledge is important for the dissemination and guarantee of fundamental rights. Through the process of researching and developing materials for inclusive physics teaching, high school students gain a deeper understanding of the value of inclusion and the importance of ensuring that all students have access to education. This unique perspective on the learning process also enables students to view their classmates with a greater level of respect, particularly those who may not have the same level of access or resources. It is up to the teacher, however, to know how to use different tools to reach all students (Alves et. al., 2021) and in this sense, to create simulations that allow, in addition to learning, the autonomy of students with disabilities it was one of the focuses of this work. Following a review of the specialized literature on the indicated topics, questions about the discipline of Physics were discussed and to the development of prototypes of adapted materials that could be made to allow the learning of Physics by all students. It is important to emphasize, in this process, that in a professional teaching institution, the discipline of Physics has a small number of classes during the week and, therefore, the research motivated the students about the discipline also increased their interest and the search for knowledge by the students involved in the research. It was then sought to create tools that would make Physics learning more real, more technological and, therefore, within the reality of the students, since as Garcia (2010) indicates, Physics activities should be more focused on practical issues to be better understood. In this way, the creation of simulations, allows better accessibility and also more meaningful learning by different students, whether they have or not specific educational needs. For the development of the two simulations, considering the learning process in the discipline of Physics, students from the technical high school computer course were sought after by their professional training profile. The curriculum of this course brings subjects such as: computer architecture and organization, laboratory of architecture and operating systems, programming logic, among others, where the students learn about computer assembly, programming in several languages, creation of systems, web development and Android application creation. The use of simulations in physics teaching is not new like the simulations created by Colorado University (Phet, 2002) or Physlet created at Davison College (Christian & Belloni, 2023), however, creating a tool thinking about that its use can be of wide access, giving opportunities to all students to participate in the learning process in an egalitarian and fair way, is an important way of making education. It is worth mentioning that technological artifacts, if used properly in the school environment or on account of it, enable the discussion of diverse topics related to human rights in a critical way (Santos & Farias, 2009) and thus, technology is allied to the inclusion process in order to create spaces for debates, learning, ethical and professional training.

Thus, the use of technology and the help of training professionals in this area, become even more important considering the aspect of career and professional development for the construction of a truly democratic society whose education becomes really accessible to everyone.

RESULTS AND DISCUSSION

Simulations and Applicability

Information and communication technologies (ICT) are allies of the educational process and, mainly, of inclusive education. In addition to efficiency during the pandemic, and in the future of the educational process, they are indispensable tools for the continuity of the teaching and learning process. In general, ICTs are thought as individual tools, and, in many situations, working in group seems to be unnecessary when these technologies are used (Rodrigues, 2012), however, creating inclusive information technologies makes it an important tool for the process of re-signification of ICTs, since, even when used individually, it allows the user, whoever he may be, greater access and possible understanding of what is intended to be learned. In addition, of course, to allow the exchange of experiences, when this tool can be used by all individuals, whether with or without specific needs. For the development of the simulations presented here, the applicability of the tool was studied as enabling it to be used by students with physical disabilities of upper limbs, blind students, autistic students and deaf students, in addition to thinking about the universal design, considering the development of a tool usable by any other students, characterizing the inclusion of all.

Technically, for the development of the simulations, we opted for the JavaScript programming language associated with HTML (HyperText Markup Language) and CSS (Cascading Style Sheets) (Duckett, 2016), which are generally used for web applications. HTML, the hypertext markup language, and CSS, the style definition language of HTML elements, were used together to develop the program's interface, such as the positioning of buttons and texts. JavaScript was used for the logical part of the simulation, such as performing mathematical calculations, network requests and event control. For the visualization of the study objects, such as the inclined plane, block and vectors, the HTML Canvas element was used, in which, with the use of JavaScript, lines, circles and texts can be drawn in a customizable way, creating the entire simulation. The Electron tool (Zhao, 2013), an open source software, was used to convert the simulations into a portable executable program, whose installation is not necessary, that is, without the need for an internet browser. To increase the dynamics of the simulations, giving a more laboratory and tactile aspect for the activities, cell phone sensors were used to collect data in real time, connected to the computer via WiFi (via local network), using the Phyphox application (Staacks et al., 2018), a free app available for Android and Ios.

The simulations are not accessed directly from internet sites, they need to be run on portable¹ computers considering the importance of the relationship that the cell phone and the simulator must have, both being on the same Wifi network. Therefore, unlike the standard simulations, these simulations must be downloaded on the computer, both of the students, if they use them at home, and of the teachers who will use them as a tool in the teaching process, in the classroom. The main objective of the simulations is that they are easy to handle, inclusive and allow physics learning in a way that makes it possible to perceive, with the help of the cell phone, of some modifications how the luminosity intensity or the angle of inclined plane that are not commonly used for the learning process in the classroom.

¹ The download address for the executable simulators (.exe) can be found at the end of the references.

Inclined Plane Simulation

The first simulation presented here seeks to facilitate the understanding, in a more interactive way, the behavior of a block on an inclined plane. This subject, due to its mathematical aspect, often ends up being a barrier for students with intellectual disabilities, for example. In this sense an image related to movement can improve the learning process, disregarding the mathematics of the problem. Thus, the use of the simulation by the teacher, as a tool associated with a teaching methodology, includes the student with a disability, while improving the learning experience of other students, enabling the same learning process, in the same space, considering the existing differences. The simulation makes it possible to choose four different materials between the block and the inclined plane to study the friction force. This consideration is important because through its students can perceive that different materials will generate different movements of objects on the surface. In the simulation, each force acting on the block over the inclined plane is represented by its vectors and explained by text and by a voice synthesizer, that is, the explanatory texts about the forces are also heard without the need for a screen reader. The mass of the block that slides on the surface of the inclined plane and the local acceleration of gravity can also be modified in the simulation and, one can compare two planes with blocks of different masses, different local accelerations of gravity and different materials, which, again, it allows a better understanding of the forces acting on the system, when comparing different situations, for example, with an object on Earth or on the Moon, and it is also possible to modify all or only one of the variables available in the simulator. The novelty in this simulation is that some data, in this specific case, the angle of the inclined plane, is collected through the Phyphox app (Stacks, et al., 2018), which is a free data acquisition application, thus making the simulation a type of virtual laboratory where data can be acquired directly from the cell phone. In order to use the simulation, the computer must be on the same wi-fi network as the cell phone that must be connected to the Phyphox app. At the beginning of the use of the simulation, a QR code will appear, after this will be necessary to permit the remote access in Phyphox setting and, this way, this code will connect the simulation to the Phyphox app that will transmit the angles read by the cell phone to the simulation and this, with the other data chosen by the user, in the simulation, will show the movement of the block over the inclined plane. Figure 1 represents the use of the cell phone and the appearance of the simulation of only one inclined plane when in operation. It is important to remember that the simulation can also compare two planes with the same angle, but with different materials and gravity accelerations.

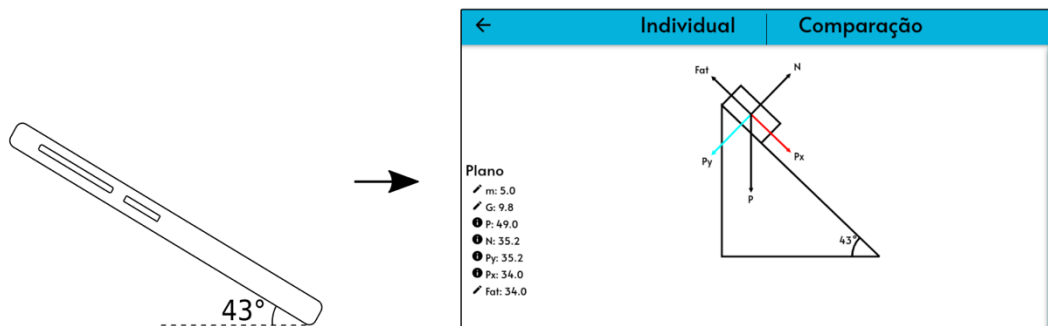


Figure 1. Drawing on the left represents the position of the cell phone that is connected to the Phyphox app, while the figure on the right is the image of the simulation, on the computer screen, which varies the angles of the inclined planes, according to the variation of the angle of the cell phone.

This simulation, with the help of the Phyphox app, is an excellent virtual laboratory, because with the help of the app it makes the simulations more realistic since some data are not chosen by the user, but collected by the cell phone. The possibility of acquiring data directly by mobile phone movement, not just choosing values, makes this simulator even more accessible to students who need tactile material to understand some more technical aspects or that are difficult to understand more abstractly, for example. It is important to remember that the accessibility of the simulation can also be evaluated through the fact that all the physical concepts that are explained in the texts, in Portuguese, are also explained through sound, that is, the voice synthesis of Google translator is used and reads the texts of the explanations existing in the simulation.

Wave Simulation

This simulation enables the students to perceive how a wave amplitude varies with the intensity of light. For this, unlike other existing simulators, the light sensor data is captured by the cell phone and sent to the simulator, using the Phyphox app. With this process, in the study of light as a wave, the transverse waves generated on the computer screen, by the simulation, allow the visualization of the increase or decrease of the wave amplitude, showing that the wave intensity is a characteristic related to the amplitude of the wave and not to its frequency, which is often confused by students. This simulation also allows the comparison between two waves, varying or not their frequencies and also their speeds, allowing the understanding of the relationship between the amplitude of a wave and its intensity, for example. In addition, the variation of physical parameters, speed and frequency, in the comparison of waves, allows a greater understanding of the characteristics of a wave, relating them to the wave aspects that are captured by the cell phone, generating a more effective learning. Figure 2 shows the relationship between what happens with the light intensity on the cell phone light sensor, which is sent by the Phyphox app and the simulation screen. With regard to the teaching and learning process, it is worth mentioning that the image is an important item for the learning of deaf students, with intellectual disabilities and also for those with autism spectrum disorder. Thus, even though many physical phenomena are not linked to the visual sense, the images, through the use of simulators, become important to help the learning process of these students. It is also important to emphasize that a simulator, alone, does not generate learning, it is just another tool in the development of the teaching and learning process and must be used as another element to enable the inclusion and improvement of knowledge, on the part of the students. The students, currently, seek technological aids to complement their studies and, in this aspect, the simulations provide a more active way of learning, since with their help, the student has more autonomy and seeks his/her meaningful learning through issues more related to their daily lives (Barbosa & Moura, 2013).

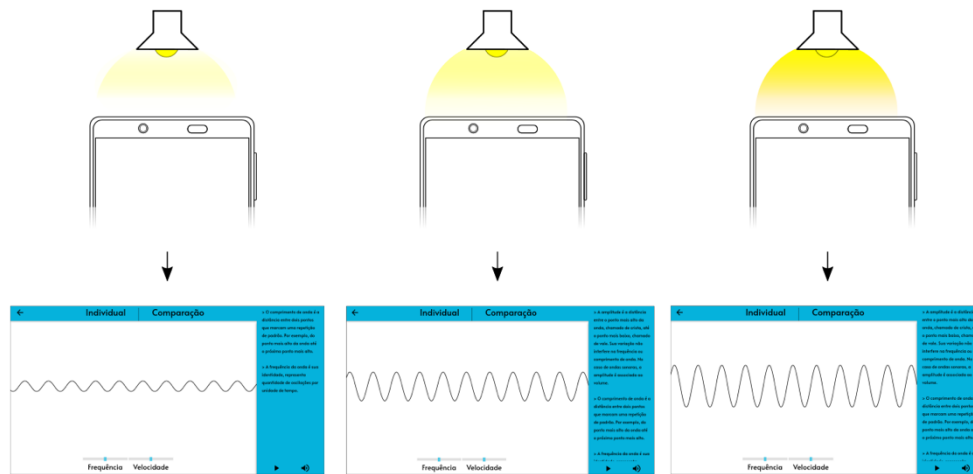


Figure 2. Representation of what happens in the simulation (bottom figure) of transverse waves, whose amplitudes can be varied with the light intensity that reaches the cell phone sensor connected to the app (top figure).

During the development of simulators, we worked with ICTs as assistive educational technologies, aiming the inclusion process from the beginning of the tool's creation to its final use in the classroom.

FINAL CONSIDERATIONS AND SUGGESTIONS

Inclusive education indicates that society must accept differences and do not permit discrimination between people. In this way, information and communication technologies, as assistive educational technologies, allow the teaching and learning process to be accessed by any students, anywhere.

Presenting the simulations created by a technical high school student aims to demonstrate, first, the importance of applied inclusive education, that is, the students themselves understanding the need for the construction of assistive technologies and to learn physics by STEM method (Timms et. al., 2018; Park et. al., 2020), considering that they use technologies and engineering to helps the learn of another students. Next, we want to emphasize that the use of some tools, built with the universal design for learning in mind (King-Sears, 2009), both by teachers as a teaching tool and by students as a learning tool, helps the process of knowledge and assimilation of the content of the Physics discipline. In addition, the use of simulations, with the help of the Phyphox app, provides a more practical process in schools that may not have laboratories that can be used in Physics classes, or even a good internet connection that can access various simulations from different websites, and these simulations presented here need only with mobile data from cell phones to connect to the portable computer. The tool is, therefore, an inclusive aid to the development of young students who need a more concrete process for their human and cognitive development. In addition, the learning process by simulations fosters in students a scientific possibility and an anticipatory attitude towards their discoveries that generates greater knowledge (de Jong, 2006).

Finally, presenting the simulations and allowing them to be used by other teachers and students, with or without disabilities, is a way of disseminating and improving the inclusion process in schools that still need more training and more engagement of professionals to make sure that education, at any level, in addition to academic and professional training, must also be guided by the formation of citizens concerned with a more egalitarian and increasingly democratic society. To improve the quality of physics teaching for all students of different learning levels, it would be important to increase research on inclusive teaching materials, inclusive simulations and other assistive technology.

DECLARATIONS

Data Availability

Address for access to simulators:

https://drive.google.com/file/d/1v1qf6sPY5M5GiR_V926EEHtB0_yx6TZ9/view?usp=sharing.

Ethical Approval

This study is a teaching application. No studies have been conducted in humans.

Ethical sensitivity was shown during the development process.

Authors Contributions

David Lucas Pereira Gomes did the simulations and helped correct the article in English. Reginaldo Ferreira and Angela Maria dos Santos wrote the article and guided all the work carried out.

Conflict of Interest

There is no conflict of interest between the authors.

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