Deploying Multidisciplinary AI-Personas to Enhance Critical Thinking and Communication Skills in STEM Education

Liezl van Dyk
Faculty of Engineering - North-West University, South Africa, Liezl.Vandyk@nwu.ac.za

Roelof Burger
Faculty of Natural and Agricultural Science - North-West University, South Africa, Roelof.Burger@nwu.ac.za

Jacoba H. Bührmann
School of Industrial Engineering - North-West University, South Africa, Joke.Buhrmann@nwu.ac.za

Abstract

This paper explores the integration of multidisciplinary AI personas as educational tools to enhance critical thinking, communication, and decision-making skills in STEM education. Drawing from two case studies at the North-West University, South Africa, students engaged with AI personas representing varied disciplinary perspectives in Decision Science and Environmental Science modules. In the first case, students applied the Analytic Hierarchy Process (AHP) to a business acquisition scenario, relying on AI personas to provide comparative input on decision criteria. The second case involved reflective essays on environmental worldviews, where students interacted with personas representing distinct ecological perspectives. It is concluded that AI personas across multiple disciplines can potentially enhance STEM students' critical thinking, engagement, and professional skills, provided their use is paired with structured methodological guidance and real-time instructional support. Keywords: AI personas, critical thinking, engineering education, decision-making, student engagement

Keywords: AI personas, critical thinking, engineering education, decision-making, student engagement

1 Introduction

Engineers operate in complex, multidisciplinary environments where effective communication and collaboration are essential for problem-solving and innovation. Engaging with professionals from diverse backgrounds—whether technical, managerial, or regulatory—demands the ability to convey complex engineering concepts clearly (GA 6: Professional & Technical Communication)(ECSA,2023). This responsibility includes the translation of technical findings for non-engineers, actively listening to stakeholders to grasp their needs, and synthesizing information from multiple sources to inform decision-making.Moreover, multidisciplinary collaboration is a cornerstone of modern engineering practice (GA 8: Individual, Teamwork & Multidisciplinary Collaboration). Engineers often work alongside experts in finance, environmental science, policy, and manufacturing, requiring not only technical expertise but also a deep appreciation for the broader social, economic, and environmental implications of their work (GA 7: Impact of Engineering on Society and the Environment)(ECSA,2023).

Social Role Theory offers a useful framework for understanding how learners adopt different roles during educational interactions. It suggests that behaviour is shaped by the expectations attached to social roles, which in turn influence communication patterns and engagement. Nguyen (2023) demonstrated that students interacting with AI conversational agents portraying peer roles—rather than authoritative expert roles—engaged in more meaningful, transactive dialogue. This indicates that simulating varied roles can foster empathy, critical thinking, and open communication, especially in multidisciplinary settings.

The incorporation of AI personas into STEM education provides a novel approach to cultivating these essential GAs among students. By simulating interactions with AI personas representing varied worldviews and disciplinary backgrounds, students can practice and enhance their critical thinking and communication skills. This innovative methodology not only encourages empathy and understanding of diverse perspectives but also prepares students to navigate the complexities of their future professional environments. Despite growing interest in educational AI, the application of multidisciplinary AI personas in engineering education remains underexplored. This study addresses this gap by integrating AI personas into STEM modules to simulate realistic interactions with diverse stakeholders. In doing so, it aims to cultivate essential graduate attributes and prepare students for communication and decision-making challenges in professional practice.

2 Methodology

Two case studies were conducted at North-West University to implement AI personas in STEM modules: Decision Science for final-year Industrial Engineering students and Environmental Science for third-year Natural and Agricultural Sciences students.

In both case studies, a similar methodological approach was adopted:

First, A specific problem was defined, requiring students to gather information from multiple stakeholders. Then, AI personas were created through prompting techniques to emulate typical individuals with whom students would need to engage and students were provided opportunities to interact with these personas.

In both cases the Mindjoy platform was used (www.mindjoy.com). Mindjoy is an embedded AI system for STEM education, using prompting to create AI assistants and personas that enhance learning. By crafting structured prompts, users generate AI tutors or mentors that guide students, support inquiry-based learning, and adapt to individual needs. These AI personas provide expert knowledge, interactive problem-solving, and contextualized feedback, fostering engagement and deeper STEM understanding. For each of these two case studies the 1. Background and Assessment Outcome is described, followed by the rationale for 2. Selection and Creation of Personas. Then the 3. Engagement Process is described followed by 4. Reflection by the respective lecturer and 5. Conclusions. Findings and conclusion from respective case studies are culminated towards final conclusions and recommendation for future work.

3 Case Study 1: Decision Science

3.1 Background and Assessment Outcome

The assignment aimed to assess students' proficiency in applying the Analytic Hierarchy Process (AHP) (Vaidya & Kumar, 2006). Introduced by Thomas Saaty in 1977 (Saaty, 1977), AHP is a tool used in multi-criteria decision-making to evaluate alternatives and develop a weighted scoring model for selecting the best option (Vaidya & Kumar, 2006). In general, weighted scoring models involve first identifying the criteria for evaluating decision alternatives (Saaty, 2001b). Each alternative is then compared against the others for each criterion, resulting in a comparison matrix. Additionally, a separate matrix is created to compare the criteria themselves, determining their relative importance. After these matrices are established, a sum of products calculation is performed to derive the final weighted scores of the alternatives. The alternative with the highest score is recommended.

AHP differs from traditional weighted scoring methods in both how scores are assigned and in its built-in mechanism for detecting decision-maker bias, known as AHP consistency (Saaty, 1977). Instead of evaluating all alternatives simultaneously, AHP uses pairwise comparisons, with Saaty arguing that comparing two options at a time helps reduce bias and leads to more accurate evaluations. Scores are assigned using a logarithmic preference scale ranging from 1 to 9 (Saaty, 2001a; 2001b), with a variant of this scale introduced to students in their textbook (Taylor, 2013). Grounded in the Weber-Fechner law for response to a stimulus, the scale follows a logarithmic progression to more accurately capture differences in relative importance between alternatives. To further ensure rigor, AHP incorporates consistency checks that verify the logical coherence of pairwise comparison matrices (Saaty, 2008). These checks flag contradictions in scoring, such as preferring A over B, B over C, but then C over A, prompting a review to correct inconsistencies and strengthen the decision-making process (Saaty, 2001b).

3.2 Selection and Creation of Personas

The assignment tasked students with determining the best location for Sunrise Cookies to acquire an existing bakery from a competitor. Sylvester Kodal, CEO of Sunrise Cookies, recently learned that Brokers Cookies, a rival brand, was downsizing and selling off some of its bakeries. He identified three potential locations within budget: Bloemfontein, Pietermaritzburg, and Nelspruit. To guide the selection, the CEO chose three evaluation criteria and specified how these criteria should be weighted relative to each other. Additionally, he designated key personnel to provide insights for comparing the locations based on each criterion:

- Expected monthly expenses – Kobus Marais, Financial Manager
- Marketplace potential of each location – Anya Shezi, Marketing Research Analyst
- Impact on logistics – Johnny Kosil, Distribution Manager
- The AI prompts for each of these personas can be provided by authors.

3.3 Engagement Process

Students were required to interview four AI personas representing the CEO and the three keypersons. Each persona provided the necessary information to construct a pairwise comparison matrix. To mimic real-world constraints, these AI personas were programmed as busy professionals, offering only limited time for interviews. This scenario was designed to challenge students to effectively gather essential information and apply their understanding of AHP to recommend the optimal decision. The AI personas were designed without any understanding of AHP or technical knowledge. Their role was solely to assist with comparisons within their specific areas of expertise. In preparation, students were provided with lecture material and attended two in-person lectures covering the concepts of AHP. Additionally, they were required to work through AHP consistency calculations. To support their learning, a separate AI tutor persona—familiar with the lecture content—was made available to answer questions related to theory and calculations.

The primary objective of the assignment was to assess students' ability to comprehend and apply the concept of pairwise comparisons within AHP. Students needed to understand how to conduct these comparisons, use the 1–9 preference scale provided in their textbook (Taylor, 2013), and effectively interview non-technical individuals to gather the necessary input for constructing comparison matrices. They also had to recognize the importance of performing AHP consistency checks on the scores obtained.

To ensure individual engagement, students were assigned randomly to different instances of the company, each featuring the same AI personas but with slightly varied comparison scores. This variation led to different recommended bakery locations across instances. Furthermore, in each instance, two of the AI personas—the CEO and either the marketing research analyst or the distribution manager—provided comparisons that resulted in AHP inconsistency scores. This design element was intended to challenge students to identify and address inconsistencies in their analyses.

Students were required to construct the comparison matrices, calculate the AHP consistency scores, and return to the individual AI personas whose input resulted in inconsistencies, requesting them to review and revise their choices. The AI personas were programmed to adjust one pairwise comparison—specifically the one causing inconsistency—when prompted by the student, thereby ensuring a consistent matrix. Any change made by the CEO in response to such a prompt would lead to a different location emerging as the top-scoring alternative. To minimize confusion, AI personas who initially provided consistent scores were not assigned alternative responses. This design choice emphasized the importance of students thoroughly completing their calculations before requesting score revisions, discouraging arbitrary re-interviews with all personas.

3.4 Reflection by Lecturer 1

Prior to the assignment, most students expressed enthusiasm and a positive outlook toward engaging with the AI personas to gather the required data. They were advised not to expect uniform responses from all personas, which successfully encouraged students to interact with all assigned personas in their individual company instances. The rate of plagiarism was low, indicating that most students completed the assignment independently and submitted original calculations. This also suggests that students felt confident in their understanding of the material. However, a significant portion of the cohort struggled with fully grasping the concept of pairwise comparisons. Rather than prompting the AI personas for step-by-step pairwise evaluations, many students requested general summaries or direct comparisons of all locations at once. This approach reflects a misunderstanding of Saaty's key principle of moving away from simultaneous weighted scoring of multiple alternatives, toward focused pairwise evaluations to reduce bias. Many students appeared eager to obtain quick answers, opting for summarised information rather than guiding the AI personas through proper pairwise comparison procedures.

Another common misconception among students was a lack of understanding regarding Saaty's non-linear 1–9 preference scale. Although the AI personas were programmed to provide preference descriptions aligned with the correct scale, many students bypassed these cues and instead asked the personas to assign a numerical value between 1 and 9 directly. In 26% of submissions, students failed to properly introduce the scale to the AI personas and neglected to verify the precise phrasing provided in double quotes. As a result, they accepted numeric values that did not align with Saaty's scale. In some instances, students insisted on receiving a numerical rating without considering the qualitative meaning behind the values, leading AI personas to respond with values based on a linear interpretation, thus distorting the intended scoring.

Additionally, in 15% of cases, students failed to perform AHP consistency checks on their pairwise comparison matrices. These students had minimal interaction with the AI personas—averaging only seven exchanges—and did not follow up to clarify or correct inconsistencies. While 21% of students correctly identified inconsistencies, 15% of them did not prompt the AI personas to revise their scores, even after inconsistencies were detected.

The use of AI personas was a valuable tool for teaching students how to engage with individuals to obtain information necessary for applying theoretical concepts. However, the results highlight the need for a shift in mindset. Many students approached the interactions with the AI personas as merely a different way to obtain data for calculations, rather than as an opportunity to develop real-world skills in information gathering and critical thinking. This could further enhance their skills in GA 6 (Professional & Technical Communication) as well as their skills to consult with experts and contribution to teamwork needed in GA 8 (Individual, Teamwork & Multidisciplinary Collaboration). For future assignments, additional emphasis may be needed to reinforce that the core learning outcome is not just about deriving the correct numerical result, but about effectively interacting, interpreting, and applying theoretical knowledge in a practical context.

4 Case Study 2: Environmental Science

4.1 Background and Assessment Outcome

The Applied Geography third-year module at North-West University (NWU) is specifically designed to cultivate a deep understanding of sustainable practices, environmental management, and policy frameworks, thereby significantly enhancing students' graduate attributes. One of the central learning outcomes of the module requires students to articulate and critically reflect upon their environmental worldview, particularly within the South African context. To achieve this, an assignment was created based on Shume's conceptual framework from the chapter "Mapping Conceptions of Wolf Hunting onto an Ecological Worldview Conceptual Framework" (Shume, 2017), which identifies four distinct ecological worldviews: technocentric, ecocentric, egocentric, and resiliocentric.

The assignment tasked students with writing a reflective essay mapping their personal stance on climate change within South Africa. Students were expected to clearly articulate their perspectives by referencing specific examples of climate change impacts or policies, such as droughts, floods, and energy transition initiatives. Through this process, the students were encouraged to deepen their critical thinking skills and clearly communicate their positions in a structured and informed manner. The explicit goal was for students to not only understand the conceptual underpinnings of these worldviews but also to clearly express how their own views aligned or differed from these theoretical constructs.

4.2 Selection and Creation of Personas

The four personas were carefully constructed based on Shume's (2017) adapted ecological worldview conceptual framework, reflecting distinct beliefs regarding the human-nature relationship. Each persona encapsulates one of the four ecological worldviews—Egocentric, Technocentric, Ecocentric, and Resiliocentric—providing diverse and realistic perspectives for students to engage with.

Egocentric (Us vs. Nature): In this worldview, nature is considered something that needs to be controlled or subdued to safeguard human livelihoods. Thabo van der Merwe, a farmer from a traditional farming family in Limpopo, personifies this perspective. His upbringing in rural farming has shaped his strong belief in managing wildlife, particularly predators, to protect agricultural interests.

Technocentric (Us over Nature): This dimension emphasises technological innovation and human ingenuity as solutions to environmental problems, prioritising human benefit and resource optimisation. Mandla Mthembu, a recent graduate in environmental engineering from Johannesburg, embodies this worldview. His approach involves developing advanced technologies to address major South African issues like water scarcity and energy shortages.

Ecocentric (Us in Nature): The ecocentric view recognises nature's intrinsic value, advocating for minimal human interference and preserving ecosystems for their own sake. Zandile Mkhize, an environmental science student from the Eastern Cape with deep ties to nature, represents this dimension. Her passion for biodiversity and conservation stems from her personal and cultural connection to the natural world.

Resiliocentric (Us within Nature): This perspective acknowledges the intertwined relationship between humans and ecosystems, advocating for resilience and adaptability to environmental changes. Sibongile Nkosi, studying environmental policy at the University of Cape Town, personifies this worldview. Her analytical approach focuses on creating adaptive systems to address climate change and ecological shifts sustainably.

Students interacted with these personas through prompts designed to foster engaging, realistic conversations about various topics, including scientific issues, environmental management, political considerations, and even entertainment. The AI-driven personas did not explicitly state their worldview but demonstrated their ecological perspective implicitly through their responses and interactions. This methodology provided students with a nuanced understanding of diverse environmental worldviews and promoted critical thinking and reflective dialogue.

The AI prompts for each of these personas can be provided by authors.

4.3 Engagement Process

The engagement process entailed structured interactions between students and the AI-driven personas, encouraging exploration and debate around various environmental and socio-political issues pertinent to South Africa. Students could freely interact with each persona, posing questions or engaging in discussions that revealed underlying worldview assumptions. Through iterative engagements, students contrasted the personas' responses, gaining firsthand insights into how these worldviews differently shaped attitudes towards sustainability, climate change responses, resource management, and environmental ethics.

This interactive method effectively prompted students to articulate their views clearly by comparing and contrasting their own thoughts with those expressed by the personas. For instance, a student exploring drought management might engage Mandla's technocentric solutions emphasising technological interventions like desalination, Zandile's ecocentric advocacy for ecosystem preservation, Thabo's egocentric focus on protecting agricultural interests, and Sibongile's resiliocentric emphasis on adaptive strategies integrating both ecological and social dimensions. By experiencing these differing perspectives, students were better positioned to reflect critically on their own beliefs, enriching their reflective essays with nuanced understanding and well-supported arguments. The dialogue with personas encouraged deeper, more holistic reflections, moving beyond superficial analysis to genuine introspection about environmental challenges and potential solutions in the South African context.

4.4 Reflection by Lecturer 2

The integration of AI personas profoundly enhanced student engagement and learning outcomes, as noted by the lecturer overseeing the module. Students demonstrated significantly increased enthusiasm and critical depth compared to previous iterations of the module without AI interaction. Observations revealed a marked improvement in both the quality and analytical depth of the essays submitted.Notably, conversations after the assignment revealed students' high levels of enjoyment and intellectual stimulation derived from persona interactions. Many students described these exchanges as transformative, expressing that their discussions with the personas helped them to remember the complex paradigms and apply these insights effectively during examinations. The interactive format provided students with a "safe space," enabling even those who identified as introverts to freely engage in debates without fearing judgment or ridicule. Several students explicitly noted that the personas allowed them to ask questions they might have otherwise hesitated to raise, deepening their understanding and appreciation of diverse environmental viewpoints.

From the lecturer's perspective, using AI personas represented a groundbreaking educational strategy, substantially enriching classroom dynamics and fostering an inclusive, participatory learning environment. The nuanced dialogue facilitated by AI allowed students to explore challenging concepts interactively, prompting richer reflection on the broader ethical, societal, and practical implications of their engineering decisions. The lecturer emphasised the value of quantifiable engagement metrics provided by the MindJoy platform, which supported the qualitative observations of enhanced student involvement and deeper critical reflection.

5 Conclusion

It is concluded that AI personas across multiple disciplines can potentially enhance STEM students' critical thinking, engagement, and professional skills, provided their use is paired with structured methodological guidance and real-time instructional support. The Decision Science case study revealed particular pedagogical areas that required further development despite the positive results. Students incorrectly understood AHP methodological principles by misunderstanding pairwise comparison procedures and Saaty's non-linear scale implementation. Educators should implement direct instructional guidance to present AI personas as practical tools for skill development instead of information sources. Students need structured guidance toward complete theoretical comprehension while learning methodical application methods to prevent shortcut behaviours. The Enivironmental Science case study conclude that, the AI persona strategy demonstrated a compelling potential to advance student learning outcomes significantly. It successfully promoted critical thinking, deeper engagement with complex sustainability issues, and clearer articulation of students' environmental worldviews, thus substantially fulfilling the module's educational objectives and contributing to the achievement.

The educational advantages of MindJoy are enhanced through its utilisation of an advanced platform. MindJoy enables lecturers to monitor student engagement levels and conceptual understanding through real-time metrics while helping detect learning difficulties and misconceptions. Educators gain actionable insights that allow them to deliver targeted support to critical areas while refining their instructional methods dynamically and addressing learning gaps proactively. Real-time analytics enable lecturers to make immediate educational adjustments, which leads to better results for individual students and their entire class.

The deployment of AI personas from multiple disciplines stimulates substantial growth in critical thinking, reflective practice, and professional communication skills among STEM students. These interactive AI-driven experiences benefit students by connecting academic theory with real-world practice while preparing for complex multidisciplinary professional environments. Students showed remarkable progress in executing structured interviews and combining multiple perspectives while effectively explaining their analytical steps. The AI persona interactions significantly boosted student engagement, which became evident through both survey results and the enhanced quality of their assignment submissions. Students felt comfortable in the AI personas' virtual environment, enabling them to develop intellectual curiosity while openly engaging with advanced concepts even when introverted. Student engagement at this level proved transformative because it improved their understanding and retention of theoretical paradigms and led to academic benefits.

6 Future Work

As this was an exploratory study relying primarily on lecturer reflection, future research should explicitly incorporate student perspectives, assess long-term impacts on graduate attribute development, and test the approach across a broader range of disciplines to refine best practices for integrating AI personas into pedagogy.

The prompts used in the case studies are provided as addendums, and a valuable extension of this work would be to analyze the different approaches used in each case study to develop these prompts and compare them with best practices documented in the literature. Such an analysis could provide insights into optimizing prompt engineering for AI-driven tutoring in STEM education. A follow-up study could also gather student feedback to evaluate the effectiveness of the AI Persona and assess the extent to which it supports the development of the targeted Graduate Attributes. This could be achieved through surveys as well as by using the data analytics available within the Mindjoy platform, although ethical clearance would be required before such data could be collected and analyzed. Furthermore, the Mindjoy platform's embedded AI-driven analytics offer potential for deeper insights into student engagement, learning patterns, and areas for improvement. Future work could explore how these analytics can be leveraged to enhance tutorbot interactions and refine AI-driven pedagogical strategies. These directions will contribute to refining the role of AI Personas in engineering education, ensuring alignment with pedagogical best practices and improving student learning outcomes.

References

ECSA, Engineering Council of South Africa. (2023). E-02-PE: Qualification standard for Bachelor of Science in Engineering / Bachelor of Engineering NQF Level 8 (Rev. 7, 24 August 2023). Engineering Council of South Africa. https://www.ecsa.co.za/ECSADocuments/

Nguyen, H. (2023). Role design considerations of conversational agents to facilitate discussion and systems thinking. Computers & Education, 192, 104661.

Saaty, T. L. (2001, August). Deriving the AHP 1-9 scale from first principles. In Proceedings of the 6th International Symposium on the Analytic Hierarchy Process (ISAHP) (pp. 397–402). Berna, Switzerland.

Saaty, T. L. (2008). Decision making with the Analytic Hierarchy Process. International Journal of Services Sciences, 1(1), 83–98.

Shume, T. J. (2017). Mapping Conceptions of Wolf Hunting onto an Ecological Worldview Conceptual Framework—Hunting for a Worldview Theory. In M. P. Mueller, D. J. Tippins, & A. J. Stewart (Eds.), Animals and Science Education : Ethics, Curriculum and Pedagogy (Vol. 2, pp. 221–241). New York : Springer.

Taylor, B. W. (2013). Introduction to management science (11th ed.). Pearson.

Vaidya, O. S., & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. European Journal of Operational Research, 169(1), 1–29.