

IN THE FUTURE ENERGY OF INDONESIA: STUDENT VOICES ON NUCLEAR ENERGY

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Abstract

Research on students' multidimensional perspectives on nuclear energy is essential for Indonesia's inevitable transition from fossil to nuclear energy, given that students are future decision-makers. This research focused on students in Bandung, Padang, Yogyakarta, Surabaya, and Jakarta, a densely populated city with the potential for an energy crisis. A total of 360 students, aged 20-25, were involved. The majority of respondents had moderate knowledge about energy, environmental care, and technology understanding. The results showed that students' attitudes towards nuclear energy were influenced by factors such as gender, level of knowledge, and technical training. Despite the general outlook being optimistic, concerns regarding safety and waste management remain. This study suggests implementing educational initiatives to increase understanding and foster positive attitudes toward nuclear energy. Despite these limitations, these findings contribute to the ongoing discussion on energy policy and highlight the importance of students in shaping a sustainable future.

Keywords: Energy transition, Perspectives on nuclear energy, Public acceptance, Students preferences.

1. Introduction

The role of nuclear energy as a future energy source is increasingly relevant and significant. An evaluation of nuclear energy's role should consider various aspects, including environmental, social, and economic factors [1, 2]. Nuclear energy is regarded as a more environmentally friendly and sustainable solution, as it produces lower carbon emissions than fossil energy sources. Furthermore, nuclear energy does not produce environmentally damaging waste and can help reduce the impacts of climate change [3, 4]. Although nuclear energy has significant environmental impacts from radioactive waste and the risk of nuclear disasters, it has advantages in terms of capacity and a more stable and reliable energy supply [5]. Although the development of renewable energy sources is continuously increasing with more affordable prices, the initial infrastructure construction costs remain high [6]. Meanwhile, nuclear energy sources face high production and maintenance costs and require significant investment in security and oversight [6]. Outside of technological, environmental, and economic issues, citizens' knowledge and beliefs about nuclear energy often determine their attitudes. Previous studies have shown that public perception of nuclear energy contributes to the desired changes in policy attitudes by decision-makers [7-9].

Previous studies have revealed that perceptions of corporate social responsibility (CSR) programs from electricity companies and perceptions of legal responsibility have a positive effect on public acceptance of nuclear power [10]. Apart from that, there are publicity methods that can increase the acceptance of nuclear power plants by the surrounding community, such as popularizing knowledge, holding site visits, and socializing through online media [11]. However, other studies show that people who are more economically established, have higher cognitive abilities, and are in the mature age group tend to be more open to switching to using new energy sources [12, 13]. To gain public support for nuclear energy, countries need to support consumer-friendly energy prices and the growth of the energy business [14, 15]. Environmental concern and belief in future energy shortages are also important factors in determining public acceptance and psychological perception [16, 17]. Trust in local authorities, knowledge of the development of new energy technologies, and level of education are also important factors in supporting new energy policies [18]. However, resistance to nuclear energy development often occurs due to impacts on land use and transmission lines [19]. Therefore, there is a need for effective handling of these impacts to increase public acceptance of new energy development.

In the context of nuclear energy, the debate about the benefits and risks of different views between experts and the public is still ongoing. So far, research on public acceptance of nuclear energy has mostly focused on the differences in views between the government as policymakers and the public, and the results have always failed to produce a meeting point that satisfies both parties. The transition from fossil energy to nuclear energy is an inevitability that must be chosen for the future of Indonesia, and currently there is no research that collects students' views in a multidimensional manner. Considering that students are potential decision-makers in the future, it is necessary to conduct research that identifies the factors that influence these differences in views, including students' understanding and views regarding nuclear energy. By gaining a deeper and more comprehensive understanding, students will be able to produce policies and regulations that are more appropriate and in favour of the public interest. The views of science and

engineering students are also very important to consider, considering the special and in-depth educational background they have in the fields of technology and science. With a more accurate understanding of the benefits and risks of nuclear energy, as well as their important role in developing environmentally friendly and sustainable energy technology, the opinions of science and engineering students can become an influential factor in decision-making and the development of energy technology in the future. Therefore, it is important to explore their views in research on public acceptance of nuclear energy.

2. Research Methods

2.1. Research design

This study explores the multidimensional perspectives of science and engineering students in Indonesian higher education on nuclear energy as a future energy source. Recognizing the urgent need for sustainable alternatives due to dwindling fossil fuels and environmental concerns, this research targets students as future leaders who can influence energy policies and technologies. Conducted over four months (July-October 2023), the study employed an online questionnaire divided into six sections covering demographics, nuclear energy preferences, benefits and risks, factors influencing preferences, student contributions, public acceptance, and infrastructure development.

2.2. Respondents

The study involved 360 students from Bandung, Padang, Yogyakarta, Surabaya, and Jakarta, reflecting the energy crisis potential in densely populated areas. The sample consisted of 48.2% male and 51.2% female respondents, aged 20-25, with 48.2% studying natural sciences and 51.8% engineering. Respondents included first- to fourth-year students with varying levels of energy knowledge, environmental concern, and technology understanding. Questionnaires were distributed via lecturer networks and WhatsApp groups. The majority of respondents felt they had knowledge about energy at a moderate level (86.1%), cared about the environment (74%), and perceived they understood technology at a moderate level (67.6%) (see Fig. 1).

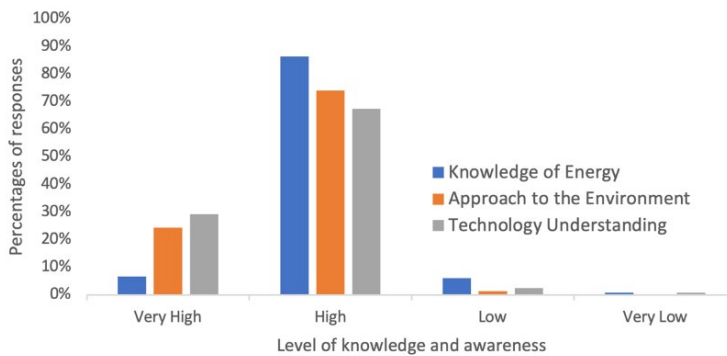


Fig. 1. The level of knowledge of respondents regarding energy, environment, and technology.

2.3. Measurements

Following are measuring tools administered in this study:

- **Preferences on Nuclear Energy Sources:** Eight questions assessed support for nuclear energy, confidence in its contribution, environmental risk assessment, potential benefits, importance of environmentally friendly sources, influence of nuclear knowledge, specific concerns, and the importance of nuclear education.
- **Preferences on Benefits and Risks:** Ten questions used a Likert scale to gauge views on nuclear energy's sustainability potential and associated risks like disasters and waste.
- **Factors Influencing Preferences:** Eight questions explored influences such as information availability, personal beliefs, media experiences, and perceptions of technology and energy needs.
- **Student Contribution:** Six questions evaluated students' perceived roles in developing sustainable nuclear technology and their willingness to collaborate with industry and government.
- **Public Acceptance:** Seven questions measured support for nuclear energy, belief in its benefits, and readiness to accept nuclear plants locally.
- **Preference for Infrastructure Development:** Five questions assessed support for nuclear energy infrastructure, investment, and long-term benefits using a Likert scale.

3. Results

Using this descriptive analysis as a foundation (Table 1), it is evident that the preferences of Indonesian students concerning nuclear energy exhibit substantial variability. The average preference score is approximately 133.32, while the most frequently occurring score is roughly 141. The distribution of these preferences is skewed towards lower values, and there is notable diversity in the scores, ranging from 44 to 176. This dataset can serve as a valuable resource for subsequent statistical investigations or for making informed decisions related to nuclear energy in Indonesia.

Table 1. Descriptive analysis.

Descriptive Analysis	Score
Mean	133,3157895
Standard Error	1,042583622
Median	136
Mode	141
Standard Deviation	19,80908882
Sample Variance	392,4
Kurtosis	0,943510726
Skewness	-0,530554179
Range	132
Minimum	44
Maximum	176
Sum	48127
Count	361

Figure 2 reveals students' views on nuclear energy's pros and cons, with a majority agreeing that it could provide a sustainable energy source. However, the

study also found a significant disparity between Natural Science Students (NSS) and Engineering Students (ES) regarding the advantages and drawbacks of nuclear energy. ES students had a greater inclination towards nuclear energy, while NSS students had a greater inclination towards fossil fuel use. The gender analysis showed no significant differences in preferences, but women had a marginal inclination towards a more critical perspective on nuclear energy's advantages.

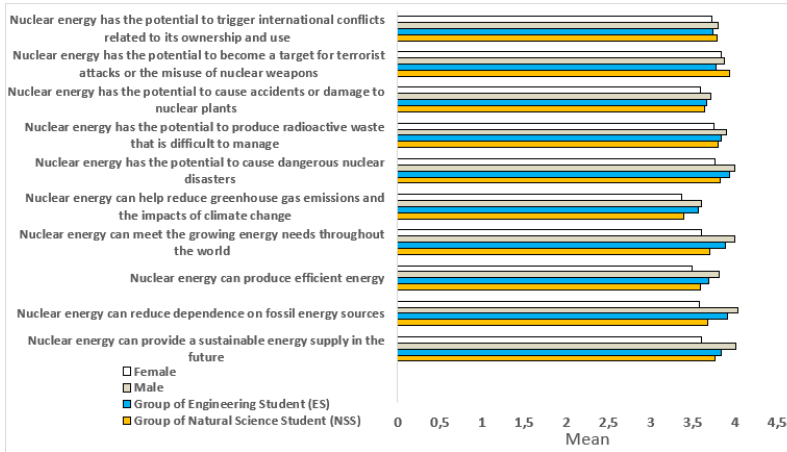


Fig. 2. Histogram of preferences for the benefits and risks of nuclear, differentiated by gender and study program background energy.

Figure 3 shows students' views on advancing ecologically sustainable nuclear energy technology. Overall, students felt involved in advancing environmentally sustainable nuclear energy technology. This element was widely rated high, with no significant differences between NSS and ES groups or genders. ES students are also more likely to actively improve nuclear energy technology, particularly efficiency and safety. Male and female pupils showed no significant differences.

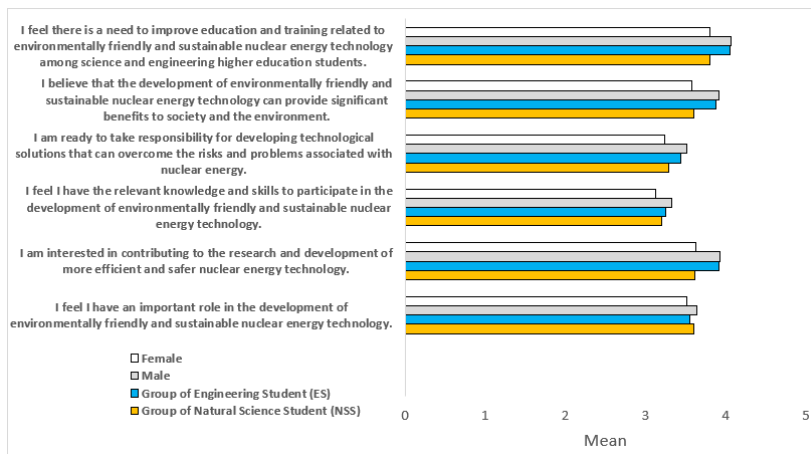


Fig. 3. Histogram student contributions to the development of environmentally friendly and sustainable nuclear energy technology, differentiated by gender and study program background.

Students believe they have the expertise and skills to advance environmentally sustainable nuclear energy technology. This component had a high average rating, with no significant differences between NSS and ES groups or genders. Additionally, ES students were better prepared to mitigate nuclear energy threats and obstacles. In this sense, male and female students do not differ much. The continuously high average assessment for this element showed that students saw the potential societal and environmental benefits of environmentally sustainable nuclear energy technology. The ratings of ES students were higher than those of NSS students. However, male and female student assessments were not statistically different. ES students acknowledge the need to improve science and engineering education and training in environmentally sustainable nuclear energy technology. Note that gender differences were negligible.

Figure 4 shows students' views on future nuclear energy infrastructure. Students generally supported nuclear energy infrastructure development, with engineering students (ES) scoring higher than natural science students (NSS). Also, male students average a higher ranking than female students. They also believed nuclear energy may be trustworthy in the future, with engineering students (ES) again scoring higher than natural science students. Additionally, male students had a higher average rating than female pupils. Engineering students (ES) again had a higher average rating than natural science students (NSS) in believing that nuclear energy might help satisfy energy needs efficiently. Male pupils also rate higher than female students. Engineering students (ES) support nuclear energy technology development more than natural science students (NSS). Again, male students score more than female students. Finally, engineering students (ES) had better mean ratings than natural science students (NSS) because they believed nuclear energy infrastructure would have long-term benefits. Male pupils also rate higher than female students.

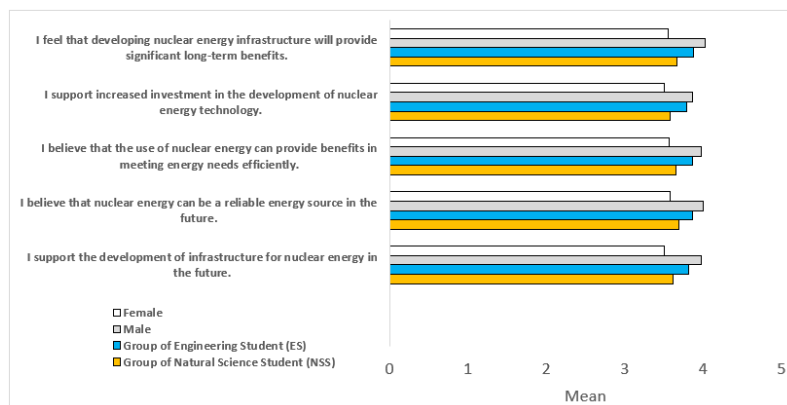


Fig. 4. Preference for nuclear energy infrastructure development.

4. Discussion

Research on the multidimensional evaluation of the future role of nuclear energy sources based on the preferences of higher education science and engineering students in Indonesia is very important for academic study. Despite nuclear energy not currently being designated as the primary energy source in Indonesia, its role

remains crucial during this transitional phase in the energy landscape. Nuclear power plants (NPP) can function as a vital energy buffer, bridging the gap until solar and wind energy capacities are optimized. This means that NPP either works at a low level when renewable energy sources like solar and wind power are at their peak, or it acts as a backup source of energy when wind and solar power aren't available as much [20]. Recognized as a source of electricity capable of meeting escalating energy demands while maintaining environmental sustainability [21, 22], nuclear energy assumes a pivotal role in the future energy mix. Contemporary students play a crucial role in shaping a sustainable and environmentally friendly energy future [23, 24]. As a highly educated cohort, they possess the capacity to comprehend and apply cutting-edge energy technologies, acquiring knowledge about the benefits and risks associated with diverse energy sources. They might be able to actively help with the research and development of better nuclear energy technologies, which could influence how better energy policies are made. Leveraging their skills and knowledge, students can disseminate accurate and reliable information about nuclear energy to the public.

According to the poll, science and engineering students have diverse views on nuclear energy. Despite the diverse array of opinions among them, a prevalent trend emerges, revealing a cautious stance toward the utilization of nuclear energy. This diversity in viewpoints is considered reasonable, given that these students have yet to acquire a comprehensive understanding of the full spectrum of benefits and risks associated with nuclear energy. Realizing this knowledge gap, it's clear that giving students unbiased and thorough information about all the different parts of nuclear energy can be very important in making people more open to and optimistic about nuclear energy options [25]. Additionally, it's crucial to acknowledge that the lack of precise information about the risks posed by nuclear energy to the public can significantly impact individual perceptions. Despite this, a broader understanding of nuclear energy's intricacies is recognized as a key factor contributing to an overall positive acceptance of this energy [26].

In conclusion, these findings underscore the importance of targeted educational efforts to enhance students' comprehension and contribute to more informed and positive attitudes toward nuclear energy. Although the public generally acknowledges the benefits of nuclear energy, the majority does not support the construction of NPPs in their countries, primarily due to a lack of accurate information from the government. Cultural and political differences play a crucial role in shaping public attitudes toward nuclear energy [27]. Factors such as public knowledge, perceived benefits, perceived risks, and community involvement all significantly impact the public's acceptance of nuclear energy [28]. Cross-cultural disparities between countries or regions can create differences in perceptions regarding the benefits, risks, and acceptance of nuclear energy, viewed from geographical and cultural perspectives [29]. In the context of perceptions of risks and benefits associated with NPPs, trust and influence play a central role, with a strong relationship between these two concepts. While trust directly influences risk perceptions, it may have a smaller direct impact on perceived benefits [30].

This study reveals that both Engineering Students (ES) and Natural Science Students (NSS) agree that nuclear energy holds the potential to provide a sustainable energy source but also acknowledge potential drawbacks such as accidents and the possibility of conflicts. Issues related to waste management,

proliferation safety, operational safety, economic competitiveness, and public acceptance are persistently associated with the utilization of nuclear energy [31].

This study also examines gender disparities and preferences between the ES and NSS groups in the context of nuclear energy. The findings indicate similar average scores between the two groups in terms of information accessibility, knowledge of risks and benefits, family and peer influence, and personal attitudes towards environmentally friendly energy sources. However, female students tend to rate nuclear technology and safety slightly lower than their male counterparts, contributing significantly to the formulation of more inclusive energy policies. Despite a consistent trend among female groups rejecting the use of nuclear energy over time, their primary focus of rejection lies in health and safety risks [32]. Conversely, students, regardless of NSS or ES classification and gender, generally hold a positive view of environmentally friendly nuclear energy technology. They believe in possessing the skills to advance this technology and feel more prepared to mitigate potential threats.

ES students tend to actively engage in efforts to enhance efficiency and safety, acknowledging the importance of increased science and engineering education in this field. These findings offer further insights into gender dynamics and preferences in the nuclear energy environment, shaping more accurate policy and educational strategies. Moreover, previous research highlighting the influence of knowledge levels on public understanding of the benefits and risks of nuclear energy underscores the importance of strengthening public understanding of these concepts [33, 34]. Lastly, the current developments emphasizing the urgency of enhancing nuclear knowledge, raising public awareness of nuclear energy technology, and introducing its economic and social benefits provide a strong foundation to support increased public acceptance of nuclear energy for societal well-being [35-37].

Engineering students (ES) exhibit stronger support for nuclear energy as a future energy source, reflected in higher average scores compared to natural science students (NSS). They believe nuclear technology may be safer and more environmentally friendly. However, there is no significant difference in the responses between male and female students. This pattern can be explained by the general tendency of engineering students to show higher acceptance of nuclear technology, attributed to their deeper education, technical training, field experiences, and emphasis on practical applications [38, 39]. Their positive outlook on technological advancements and culture within engineering programs also influences their perception of nuclear technology as a significant economic opportunity and a potential source of employment. On the other hand, the public tends to accept the potential damages associated with nuclear energy if substantial benefits are involved. This neutral stance appears to stem from a cost-benefit analysis, where the public weighs potential negative impacts against perceived benefits such as energy production, economic growth, or job opportunities [40, 41]. Public attitudes towards nuclear issues are highly complex and diverse, influenced by factors such as information, education, and awareness [42, 43].

The outcomes of this study reveal that there are considerable discrepancies in the opinions that students have on the future infrastructure of nuclear energy, notably between students majoring in engineering and students majoring in natural sciences. The fact that engineering students scored better than other

students suggests that the education, technical training, and focus on practical applications that students get in engineering schools may give a more in-depth and constructive knowledge of nuclear energy. Students of engineering who have faith that nuclear power will one day be able to provide dependable power are also likely to have faith in the reliability of this technology's safety measures and its potential for long-term sustainability [44-47]. In addition, the disparity in results between male and female students sheds light on the fact that there is a spectrum of opinions held by men and women on nuclear power, with male students having a tendency to have more optimistic views. It's possible that this is due to the social and cultural aspects that are involved in the process of influencing students' perspectives on nuclear power [48-50]. The potential contributions of engineering specialists to the development of more sustainable energy sources may be seen in the support that engineering students have shown for the advancement of nuclear energy technology as well as their conviction in the advantages that it will bring in the long run. These results may be used as a foundation for the development of improved policies on education and information in order to improve the knowledge of nuclear energy and its advantages and disadvantages among students and the general public.

This study contains a number of limitations, any or all of which might be addressed in further research. To begin, the questionnaire did not include a number of subjects that are known to have an effect on respondents' perspectives on nuclear energy. These include concerns about nuclear proliferation and the management of nuclear waste. Second, the type of data collecting that was used in this investigation depended entirely on questionnaire surveys, which is a methodology that is generally acknowledged for its failure to adequately portray the genuine preferences of respondents. Thirdly, the sample that was employed in this research was a convenience sample rather than a random sample, which hinders its potential to accurately reflect the total population. Last but not least, the results cannot easily be generalized to a larger population since the poll was only carried out among students in five main cities in Indonesia.

5. Conclusion

This study highlights the crucial need to understand Indonesian science and engineering students' perspectives on nuclear energy. Nuclear energy is essential in Indonesia's energy transition until renewable sources are fully developed. The research finds that students, as future leaders, show cautious optimism towards sustainable nuclear technology but have concerns about safety and waste management. Gender differences influence these views, with female students being more cautious. Both engineering and natural science students support nuclear energy's potential. The study suggests focused education to improve understanding and attitudes towards nuclear energy. Despite limitations, the findings contribute to energy policy discussions and emphasize students' roles in a sustainable energy future. Further research should include diverse samples, qualitative methods, and explore the impact of digital media on opinions.

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