Medical Students as Agents of Change: Experiential Learning through Sustainability Innovation in Agricultural Waste Management

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ABSTRACT

Background: Medical education increasingly incorporates experiential learning and sustainability to prepare future physicians to address environmental and community health challenges aligned with the Sustainable Development Goals (SDGs). Rice husk (RH), an abundant agricultural biomass waste in Malaysia, remains underutilized despite its environmental and economic potential. This study evaluated a structured community-based experiential learning project in which medical students identified RH waste as a societal issue and developed sustainable solutions.

Methods: This qualitative exploratory study involved six Year 2 preclinical medical students from Universiti Teknologi MARA (UiTM), Malaysia, during a four-week elective project. Participation was voluntary, and students had no prior formal training in sustainability innovation. Students conducted field observations at a rice mill and performed a structured literature review (ScienceDirect and MDPI; 2015–2025). Data from field notes, observation logs, and discussion transcripts were analysed using Braun and Clarke's six-phase thematic analysis. Two researchers independently coded the data, followed by consensus discussions. Trustworthiness was ensured through peer debriefing, audit trails, and reflexive documentation. Students then developed eco-friendly prototypes and conducted knowledge-sharing sessions with peers and farmers.

Results: Five themes were identified: storage practices, disposal methods, reuse potential, environmental and health implications, and innovation opportunities. Observations revealed partial reuse of RH as boiler fuel but also open storage and burning practices contributing to pollution and health risks. Students developed eco-paper and biodegradable deodorizer prototypes, demonstrating feasibility. Knowledge transfer to farmers highlighted the potential for value-added RH utilization to generate supplementary income while reducing environmental health risks.

Conclusion: Structured experiential learning enabled medical students to address real-world sustainability challenges while developing transferable professional skills. Rice husk innovation represents a feasible, low-cost strategy for improving environmental health and community resilience and provides a replicable model for integrating sustainability-focused innovation into medical education.

Keywords: experiential learning, medical education, sustainability, environmental health, rice husk

INTRODUCTION

Higher education institutions have a pivotal responsibility not only to impart disciplinary knowledge but also to equip students with the competencies necessary to address real-world challenges affecting individuals and communities. In the 21st century, rapid urbanization, environmental degradation, widening socioeconomic disparities, and emerging public health threats have intensified the need for graduates who are not only academically competent but also socially responsible and solution-oriented (United Nations, 2015; World Health Organization [WHO], 2021). Traditional didactic teaching methods, which emphasize theoretical knowledge and examination performance, may not adequately prepare students to address complex community issues requiring critical thinking, interdisciplinary collaboration, and practical problem-solving skills (Frenk et al., 2010). Experiential learning theory emphasizes that knowledge is created through the transformation of experience, highlighting the importance of engaging students in real-world contexts (Kolb, 1984). Therefore, integrating community engagement into higher education enables students to apply theoretical knowledge in meaningful contexts while fostering social accountability and professional development.

The global call for educational transformation is reinforced by the United Nations Sustainable Development Goals (SDGs), particularly SDG 4, which promotes inclusive and equitable quality education and lifelong learning opportunities (United Nations, 2015). Education is recognized as a key driver for achieving multiple SDGs, including SDG 3 (Good Health and Well-Being), SDG 11 (Sustainable Cities and Communities), and SDG 12 (Responsible Consumption and Production). Education for Sustainable Development (ESD) emphasizes learner-centred approaches such as problem-based learning, service learning, and community-based research to empower students to address sustainability challenges (Tilbury, 2011; Leal Filho et al., 2019). These approaches enable students to develop critical competencies, including systems thinking, innovation, and collaborative problem-solving, which are essential for addressing environmental and public health challenges.

Engaging medical students in solving community problems is particularly important, as many health outcomes are influenced by environmental, social, and economic determinants (WHO, 2021). Community-based medical education has been shown to enhance students' clinical competence, social accountability, and understanding of public health issues (Loyola et al., 2020). Experiential learning opportunities strengthen essential transferable skills such as communication, teamwork, leadership, and ethical decision-making (Kolb, 1984; Frenk et al., 2010). Furthermore, participation in community-focused activities enhances students' sense of purpose, motivation, and professional identity, preparing them to become socially responsible physicians capable of addressing broader determinants of health (Frenk et al., 2010).

Despite its recognized importance, integration of sustainability-focused, community-based learning into medical curricula remains inconsistent. Barriers include limited institutional support, lack of structured frameworks, and insufficient opportunities for experiential learning (Leal Filho et al., 2019). Therefore, there is a need for structured educational initiatives that enable medical students to identify and address real-world environmental and community health challenges. One of the ways to integrate this is by developing a project in elective weeks for preclinical students before embarking into clinical years. This manuscript describes an experiential learning project in which Year 2 medical students identified rice husk waste as an environmental and economic issue and developed innovative, sustainable solutions aligned with the SDGs.

METHODOLOGY

Study Design and Educational Framework

This study employed a qualitative exploratory design embedded within a community-based medical education framework to evaluate medical students' ability to identify and address real societal challenges in alignment with the Sustainable Development Goals (SDGs). Qualitative exploratory approaches are particularly suitable for understanding complex social, environmental, and educational phenomena within real-world contexts (Creswell & Creswell, 2018). The activity involved six Year 2 preclinical medical students from Universiti Teknologi MARA (UiTM), Malaysia. None had prior formal coursework in sustainability or environmental innovation. They were given autonomy to identify a community issue and propose an innovative and

sustainable solution during their 4 weeks of elective program. Participation was voluntary and not linked to course grading. The educational framework was based on experiential learning and problem-based learning principles, which emphasize learning through direct experience, reflection, and application (Kolb, 1984; Frenk et al., 2010). This approach also aligns with Education for Sustainable Development (ESD), which promotes student engagement in solving real-world sustainability challenges (Leal Filho et al., 2019). Students reported motivation to join due to interest in community engagement and practical learning.

Problem Identification and Field Observation

Students conducted field observations and environmental scanning to identify relevant societal and environmental issues affecting community health. Field-based learning enables students to develop contextual understanding of environmental determinants of health and enhances their problem-solving capabilities (WHO, 2021). Through this process, students identified rice husk (RH) waste as a major underutilized agricultural byproduct in Malaysia. Improper biomass waste management has been associated with environmental pollution and adverse public health outcomes, particularly due to particulate emissions from open burning (WHO, 2021). The identified problem was contextualized within SDG 3 (Good Health and Well-Being), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), and SDG 13 (Climate Action) (United Nations, 2015).

LITERATURE REVIEW AND EVIDENCE GATHERING

Students conducted a structured literature review using ScienceDirect and MDPI databases to identify existing research on rice husk utilization, sustainability, and environmental health impacts. Literature reviews are essential for evidence-based problem-solving and innovation development in both medical and environmental education (Frenk et al., 2010). Keywords included “rice husk utilization,” “biomass waste,” and “environmental health.” Studies published between 2015 and 2025 were screened based on relevance, scientific quality, and applicability.

Thematic Analysis

In this study, thematic analysis (TA) was employed as the primary method to systematically analyse both field observation data and relevant literature regarding rice husk (RHs) management, environmental challenges, and potential applications. The analysis followed the six-phase framework proposed by Braun and Clarke (2006), which provides a rigorous yet flexible approach to identify, analyse, and interpret patterns of meaning in qualitative data.

Firstly, students began with familiarization with the data, where all field notes, interview transcripts, and literature findings were read and re-read multiple times to ensure a thorough understanding of the content. During this stage, preliminary observations and interesting ideas were noted, which allowed the research team to gain an overall perspective on the patterns present in the data. For instance, the repeated observations of open piles of RHs at the mill, closed storage practices, and instances of burning in paddy fields highlighted initial areas of concern and potential opportunities for sustainable interventions.

The second phase involved generating initial codes, whereby meaningful data segments were highlighted and systematically labelled with descriptive codes. Codes such as open storage, closed burning, partial reuse, soil conditioner, and air pollution were developed to capture the essence of observed practices and reported information from both the field and literature. Coding allowed for the organization of the data into smaller, manageable units, ensuring that significant details were retained for subsequent analysis.

Following this, the search for themes was conducted by examining the initial codes to identify broader patterns or recurring topics that could provide insight into RHs management and utilization. Codes that shared conceptual similarities were grouped together under higher-order themes, which reflected the underlying issues and potential applications. For example, codes related to storage and disposal practices were organized under the themes Storage Practice and Disposal Practice, while codes reflecting reuse and recycling were combined under Reuse Practice. Similarly, literature codes describing RHs properties, environmental problems, and

industrial potential were grouped into corresponding themes such as RHs Properties, Environmental Problems, and Potential Applications.

The fourth phase, reviewing themes, involved assessing whether the identified themes accurately represented the data and whether they captured all relevant patterns without redundancy. During this phase, overlapping codes and themes were refined and merged where appropriate, ensuring coherence and clarity. For instance, small-scale agricultural reuse observed at the farm site was integrated under the broader theme of 'Reuse Practice' to provide a comprehensive perspective on how RHs are being utilized across different contexts.

Next, defining and naming themes entailed providing clear, concise, and descriptive labels for each theme, along with a detailed explanation of what each theme represented in relation to RHs management. Themes were labelled to reflect their content precisely, such as 'Storage Practice' to represent different storage methods, 'Disposal Practice' to describe burning or disposal approaches, 'Reuse Practice' to capture any form of RH utilization, and 'Environmental Issues' to highlight dust, air pollution, and health impacts. This step ensured that each theme conveyed a meaningful message and linked directly to the research objectives.

Finally, the writing of the report involved presenting the identified themes in a structured manner using tables and descriptive interpretations. Tables were used to clearly summarize observations, literature findings, and the qualitative interpretations associated with each theme, providing transparency and facilitating the understanding of the results. Importantly, the insights derived from the thematic analysis directly informed the development of proof-of-concept prototypes, including eco-paper and deodorizer products, as the analysis highlighted underutilization, environmental challenges, and the potential for higher-value applications of RHs.

Proposal Development and Approval

Based on field observations and literature findings, students developed a structured proposal outlining their problem statement, proposed solution, sustainability impact, and alignment with SDGs. Proposal-based learning encourages critical thinking, innovation, and application of scientific knowledge (Kolb, 1984; Frenk et al., 2010). The proposal was reviewed and approved by panels appointed by the faculty to ensure scientific validity, feasibility, and educational relevance.

Prototype Development and Implementation

Students were given three weeks to develop functional prototypes using locally available materials. Experiential learning activities such as prototype development enhance student innovation skills and promote deeper understanding of sustainability challenges (Leal Filho et al., 2019). Faculty supervision ensured appropriate guidance and feasibility throughout the process.

Community Knowledge Transfer and Economic Potential

Students presented their findings and prototypes to faculty members, peers, and community stakeholders including the farmers. During presentation, assessment was made based on slide presentation, clarity of speech, originality and innovative idea, and ability to answer questions by panels. Community knowledge transfer is a key component of sustainable education and promotes community empowerment and economic resilience (United Nations, 2015). This stage allowed students to develop communication skills and reinforce their role in promoting community health and sustainability.

RESULTS

Problem Identification and Environmental Context

Field observations identified rice husk waste as a significant environmental issue with potential health implications. Although rice husks were partially reused as boiler fuel, large quantities were stored in open piles and exposed to environmental elements. Open burning of agricultural biomass was also observed, contributing to dust pollution and potential respiratory health risks. Exposure to particulate matter from biomass burning

has been associated with adverse respiratory and cardiovascular health effects (WHO, 2021). These findings highlight the importance of improving agricultural waste management to protect environmental and community health.

Thematic Analysis Findings

Thematic analysis identified five key themes: storage practices, disposal methods, reuse potential, environmental and health implications, and innovation opportunities. Current reuse practices were limited primarily to energy generation, indicating underutilization of rice husk waste. Previous studies have demonstrated that rice husks contain high silica content and possess favourable physical properties, including porosity and absorbent capacity, which support their use in value-added applications (Ashraf et al., 2021; Mohajerani et al., 2019). These findings confirmed the potential for sustainable reuse and innovation.

Prototype Development and Feasibility

Students successfully developed functional prototypes, including eco-paper and biodegradable deodorizer products derived from rice husks. These prototypes demonstrated the feasibility of converting agricultural waste into environmentally friendly products using simple and locally accessible materials. The successful prototype development provided proof-of-concept evidence supporting the potential for community-level innovation.

Eco-Paper Production from Rice Husk

Rice husk–based paper was produced using a simple mechanical pulping and drying technique. Rice husks were first soaked in water to soften the fibres and facilitate blending. The hydrated husks were then blended with water until a homogeneous slurry was obtained. The slurry was transferred into a clean container and stirred thoroughly to ensure uniform fibre distribution. The mixture was subsequently poured into a square frame mould measuring approximately 4 × 4 cm to shape the sheet. The moulded slurry was left to dry under direct sunlight until completely dehydrated and structurally stable, producing a thin sheet of eco-paper suitable for handling and basic use.

Biodegradable Deodorizer Sachet from Rice Husk

Rice husks were first completely dried to remove residual moisture. A small quantity of fragrance oil was added and mixed thoroughly to allow uniform scent absorption. The scented husks were then placed into breathable mesh or net fabric and tied securely to form sachets. These sachets were positioned in enclosed or semi-enclosed spaces (e.g., room corners or near windows) to function as natural deodorizers.

Community Knowledge Transfer and Economic Potential

Students shared their innovation and technical knowledge with local farmers, demonstrating how rice husks could be converted into eco-paper and biodegradable deodorizer products. Knowledge transfer is an essential component of sustainable development and community empowerment (United Nations, 2015). Farmers expressed interest in the innovation, recognizing its potential to create value-added products and generate supplementary income. Sustainable agricultural waste utilization has been shown to provide economic and environmental benefits for rural communities (Leal Filho et al., 2019).

Educational Outcomes

The project demonstrated that students were able to apply experiential learning principles to address real-world sustainability challenges. Students developed critical thinking, innovation, communication, and problem-solving skills, consistent with the goals of modern medical education (Frenk et al., 2010). This experience enhanced students' understanding of environmental determinants of health and reinforced their role as socially accountable future healthcare professionals. All 6 students reported that real-world exposure was the most influential learning component.

DISCUSSION

This study demonstrates the effectiveness of experiential, problem-based learning in enabling medical students to address real-world environmental and community health challenges. Through field observation, literature review, thematic analysis, and prototype development, students identified rice husk waste as an underutilized agricultural byproduct with environmental and health implications. Improper biomass waste management, including open storage and burning, contributes to air pollution and increases the risk of respiratory and environmental health problems (WHO, 2021). These findings highlight the importance of sustainable agricultural waste management in promoting environmental health and community well-being.

The literature review confirmed that rice husks possess favourable physicochemical properties, including high silica content, porosity, and lightweight characteristics, making them suitable for conversion into value-added products such as eco-paper and biodegradable materials (Ashraf et al., 2021; Mohajerani et al., 2019). Similar studies have shown that rice husk biomass can be used to develop sustainable and biodegradable products (Ashraf et al., 2021). The successful development of eco-paper and biodegradable deodorizer prototypes demonstrates the feasibility of transforming agricultural waste into sustainable products using locally available resources. This approach aligns with circular economy principles, which emphasize resource efficiency and waste reduction to promote environmental sustainability (Leal Filho et al., 2019).

This innovation also aligns with SDG 3 (Good Health and Well-Being) by addressing environmental determinants of health. Reducing open burning and improving waste utilization can contribute to cleaner air and reduced exposure to harmful pollutants (United Nations, 2015; WHO, 2021). Furthermore, knowledge transfer to farmers regarding the conversion of rice husks into value-added products has the potential to generate additional income streams and enhance economic resilience in agricultural communities. This supports SDG 11 (Sustainable Cities and Communities) and SDG 12 (Responsible Consumption and Production), highlighting the interconnected relationship between environmental sustainability, economic development, and health (United Nations, 2015).

From an educational perspective, this project illustrates the value of experiential learning in medical education. Experiential learning enables students to connect theoretical knowledge with real-world applications, enhancing critical thinking, problem-solving, and innovation skills (Kolb, 1984). Community-based learning has also been shown to improve students' social accountability and understanding of public health issues (Loyola et al., 2020). By engaging in sustainability innovation and community knowledge transfer, students developed competencies essential for future physicians, including leadership, communication, and social responsibility (Frenk et al., 2010).

Despite these positive outcomes, several limitations should be acknowledged. The small sample size and single-institution setting limit generalizability. Additionally, the prototypes developed were proof-of-concept models and were not subjected to rigorous experimental or economic validation. Future studies should include larger student cohorts, interdisciplinary collaboration, and experimental evaluation of prototype performance and economic feasibility. Long-term studies evaluating community adoption and economic impact would also strengthen the evidence base.

Nevertheless, this project provides a scalable model for integrating sustainability innovation into medical education. By engaging students in addressing real-world environmental challenges, higher education institutions can contribute to sustainable development while preparing future physicians to address environmental determinants of health. Such initiatives support the development of socially accountable healthcare professionals and contribute to the achievement of the Sustainable Development Goals (United Nations, 2015). Despite growing recognition of sustainability education, implementation barriers persist, including curricular overload, limited faculty expertise, and lack of assessment frameworks. This model addresses these challenges by embedding sustainability within elective or project-based modules rather than adding standalone courses.

Limitations

Despite its promising outcomes, this study was limited by the absence of laboratory validation, economic analysis, and long-term community impact assessment. Future research should incorporate laboratory testing to evaluate product performance and safety, cost–benefit analysis to assess economic feasibility, durability testing to determine product reliability, and scalability evaluation to support wider community adoption and commercialization potential. Expanding interdisciplinary collaboration and involving industry stakeholders may further enhance innovation and implementation.

CONCLUSION

This project illustrates the effectiveness of integrating sustainability innovation into medical education. By engaging in real-world problem identification, evidence-based research, and community knowledge sharing, students were able to apply theoretical knowledge to practical environmental health challenges. This experiential learning approach enhanced students' critical thinking, innovation, and social accountability while reinforcing their role as future physicians in addressing environmental determinants of health. The innovation aligns with Sustainable Development Goal 3 (Good Health and Well-Being) by promoting cleaner environments and reducing pollution-related health risks. Furthermore, the development of value-added RH products offers potential economic benefits for farmers by creating supplementary income opportunities, thereby supporting broader sustainability goals including SDGs 11, 12, and 13.

Overall, this study provides a scalable and practical model for integrating sustainability-focused innovation into higher education curricula. By empowering students to address real-world environmental challenges and engage with communities, higher education institutions can contribute to sustainable development while preparing socially responsible healthcare professionals capable of improving environmental and public health outcomes.

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Conflict Of Interest

The authors declare that they have no conflicts of interest.

REFERENCES

1. Ashraf, M., et al. (2021). Rice husk utilization in sustainable materials. *Journal of Cleaner Production, 312*, 127745. https://doi.org/10.1016/j.jclepro.2021.127745
2. Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa
3. Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

4. Frenk, J., et al. (2010). Health professionals for a new century: Transforming education to strengthen health systems in an interdependent world. *The Lancet, 376*(9756), 1923–1958. https://doi.org/10.1016/S0140-6736(10)61854-5
5. Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Prentice Hall.
6. Leal Filho, W., et al. (2019). Sustainable development in higher education: Reviewing needs. *Journal of Cleaner Production, 232*, 285–294.
7. Mohajerani, A., et al. (2019). Rice husk ash in sustainable materials. *Journal of Cleaner Production, 237*, 117851. https://doi.org/10.1016/j.jclepro.2019.117851
8. Tilbury, D. (2011). Higher education for sustainability: a global overview of commitment and progress. Higher education in the world, 4(1), 18-28.
9. United Nations. (2015). *Transforming our world: The 2030 agenda for sustainable development.*
10. World Health Organization. (2021). *Health and environment: Managing the linkages.*