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ECO Sains and Green Entrepreneurship in Secondary Education: Character Development, Business Competencies, and Sustainable Product Innovation

Lustia Bekti Rohayati[1]*, Deny Hadi Siswanto[2], Alfi Uswatul Husna[3], Tarso[4]
[1]Muhammadiyah Piyungan Senior High School, Indonesia
[2]Muhammadiyah Mlati Senior High School, Indonesia
[3]Ahmad Dahlan University, Indonesia
[4]Widya Dharma University, Indonesia
Correspondence: lustia.bekti24@admin.sma.belajar.id

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ABSTRACT

This qualitative case study investigates the integration of the ECO Sains and entrepreneurship programs through aloe vera-based dishwashing soap production at SMA Muhammadiyah Piyungan, highlighting its impact on student character development and business competencies. Primary data were gathered through in-depth interviews, participatory observations, and document analyses involving school leaders, teachers, parents, and students, supplemented by descriptive quantitative assessments of student growth indicators. The findings demonstrate that students systematically carried out extraction and formulation processes according to safety standards while actively internalizing Al-Islam and Kemuhammadiyahan (AIK) values, such as environmental stewardship, honesty, and Sharia-compliant business ethics. Furthermore, students mastered end-to-end business operations, including Cost of Goods Sold (COGS) calculations, eco-friendly packaging design, and social media digital marketing. Incubation support from the "Saudagar Muda Muhammadiyah" program served as a pivotal accelerator, enabling students to refine their product from a laboratory-scale experiment into a market-ready innovation. The program yielded measurable transformative improvements across student scientific knowledge, practical skills, creativity, responsibility, and personal independence both at school and home. In conclusion, synthesizing ecological science, religious ethics, and entrepreneurial incubation provides a highly effective holistic framework for modern secondary education.

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INTRODUCTION

Upper secondary education in the modern era is required not only to transfer theoretical academic knowledge, but also to equip students with practical skills and ecological awareness relevant to global challenges (Yang et al., 2016). The phenomenon of environmental degradation and the moral decay of the younger generation have become central issues requiring a holistic learning approach in faith-based educational institutions (Vinokur et al., 2024). Vocational secondary schools and faith-based high schools hold immense potential to serve as hubs of educational innovation that synthesize applied science with Islamic character education (Susetyawati et al., 2026). In this context, SMA Muhammadiyah Piyungan developed its flagship program, ECO Sains, as a means to connect scientific theory with tangible environmental conservation efforts through local resources surrounding the school.

The selection of a local commodity such as aloe vera (*Aloe vera*) represents a strategic step in facilitating student scientific experiments that are safe, applicable, and environmentally conscious.

The integration of ecological science and Al-Islam Kemuhammadiyahan (AIK) values serves as a vital foundation in building environmentally conscious leadership character within students (Beger et al., 2022). Through the concept of *khalifah fil 'ardh*, students are taught that the utilization of natural resources for human needs must be balanced with the ethics of maintaining ecosystem equilibrium (Giovannella & Roccasalva, 2025). Laboratory activities, such as manufacturing aloe vera-based dishwashing soap, not only train scientific literacy and compliance with Standard Operating Procedures (SOP), but also instill honesty, precision in measurement, and worship discipline (Pisriwati et al., 2024; Purwanto et al., 2026). This Islamic value-based character education acts as a main pillar to ensure that science-based innovation remains firmly anchored within moral frameworks and spiritual awareness.

Beyond strengthening character and ecological literacy, current workplace challenges demand that the younger generation possess an entrepreneurial mindset and mature business acumen from an early age (Astiwi et al., 2024; Hidayati et al., 2026). Many high school graduates struggle to adapt to digital economy dynamics because classroom entrepreneurship education is often conceptual and lacks field practice (Jarwanto et al., 2026; Pisriwati et al., 2026). Therefore, SMA Muhammadiyah Piyungan combines ECO Sains research outcomes with practical business management, in which students are trained to manage the entire business chain holistically. This process encompasses calculating the Cost of Goods Sold (COGS), designing eco-friendly packaging, formulating digital marketing strategies, and establishing fair profit margins.

Accelerating student research product innovations requires adequate incubation space so they can transform from mere classroom final assignments into marketable products in the real economy (Hanama et al., 2024; Roviyanty, et al., 2026). Student participation in the "Saudagar Muda Muhammadiyah" incubation program serves as a key accelerator bridging ECO Sains laboratory outputs with commercial quality standards. Through practitioner mentorship and business competency assessments, students receive critical feedback regarding material efficiency, product standardization, and business plan pitching techniques before a board of judges. This incubation program is proven to foster a growth mindset and boldness in students to navigate competitive business market dynamics.

The synergy between ECO Sains learning, Islamic value habituation, and entrepreneurship incubation yields measurable transformative impacts across five primary student dimensions: knowledge, skills, responsibility, creativity, and independence. Periodic evaluations and behavioral observations reveal that students experience significant improvements in problem-solving capabilities as well as financial and social independence. This positive shift extends even to the household environment, where students demonstrate heightened concern for household waste management and the ethics of seeking *halal* and *thayyiib* sustenance. This confirms that an environmental action-based learning model integrated with Sharia business can generate sustainable transformative learning (Urmetzer et al., 2020).

Based on this background, an in-depth investigation into the implementation of the ECO Sains program at SMA Muhammadiyah Piyungan is crucial to evaluate the effectiveness of this research- and business-based learning approach. The novelty of this research lies in its synthesis of ecological science, Sharia business ethics, and entrepreneurial incubation within a single upper secondary education ecosystem. The findings of this study are expected to provide theoretical and practical contributions as a reference for innovative curriculum models capable of producing academically excellent, Islamically grounded, and economically independent graduates.

RESEARCH METHODS

This research employs a qualitative approach with a case study design to thoroughly explore the implementation of the ECO Sains program and its impact on character building and entrepreneurial skills among students at SMA Muhammadiyah Piyungan. Informants were selected using a purposive sampling technique, encompassing the school principal, ECO Sains advisor teachers, Al-Islam Kemuhammadiyahan (AIK) teachers, the entrepreneurship coordinator, parents, and students actively

involved in the production of aloe vera-based dishwashing soap. Data collection was conducted through three primary techniques: in-depth interviews to capture perceptions and the integration of Islamic values and entrepreneurship; participatory observation to monitor laboratory formulation processes, SOP compliance, and group work dynamics; and documentation studies covering practical modules, Cost of Goods Sold (COGS) financial reports, Saudagar Muda Muhammadiyah business proposals, worship control sheets, and student competency assessment records (Miles & Huberman, 1994).

All collected qualitative data were analyzed using an interactive data analysis model consisting of data reduction, data display in comprehensive narrative forms, and conclusion drawing or verification (Naufal et al., 2025). To ensure the trustworthiness and validity of the research findings, the researcher applied technical triangulation (cross-verifying results from interviews, observations, and documentation) as well as source triangulation to verify information consistency across different key stakeholders. Furthermore, supporting quantitative data derived from pre-test and post-test scores alongside soft skills assessment rubrics were processed using simple descriptive analysis to objectively demonstrate student growth in knowledge, skills, and independence prior to and following the program (Arikunto, 2017).

RESULTS AND DISCUSSION

1. Product Development Process of Aloe Vera-Based Dishwashing Soap

The research findings indicate that the processing of aloe vera into dishwashing soap by students at SMA Muhammadiyah Piyungan follows a systematic phase of research and execution. Based on interviews with the ECO Sains advisor teachers and student team representatives, the process begins with the extraction of aloe vera gel harvested directly from the school garden or the surrounding environment. Students conduct formulation experiments to blend the aloe vera extract with eco-friendly foaming agents and degreasing agents. Aloe vera was selected due to its natural antibacterial properties and its gentler effect on the skin compared to pure synthetic chemical dishwashing soaps.

Through direct observation in the school laboratory, students were seen carefully carrying out the formulation and soap-making processes. Students applied material processing in accordance with Standard Operating Procedures (SOP) for occupational safety, ranging from peeling the aloe vera skin, washing the slime to remove irritation-inducing aloin compounds, homogenous mixing under controlled heating temperatures, to testing viscosity and acidity (pH) levels. The division of labor among group members ran in a highly orderly manner; some students focused on measuring raw materials, testing product quality, up to the aging or settling phase before the formulation was ready for packaging.

Research documentation, including ECO Sains practical modules, daily product formulation journals, and photographs of the extraction stages, reinforces the evidence of this innovation's success. Student experimental records show multiple trials of material ratios to achieve optimal degreasing power while remaining safe and environmentally friendly. Photo documentation records the students' precision in measuring aloe vera extract concentrations as well as the results of product washability tests on various types of kitchenware, proving that this school-scale manufacturing process proceeds scientifically and structurally.

2. Integration of Character Education and Islamic Values in the Production Process

Based on interviews with school guardians and Al-Islam/Kemuhammadiyahan (AIK) teachers, the production of this dishwashing soap integratively instills Islamic values and Sharia business ethics in the students. Learning does not merely highlight technical and profit aspects, but emphasizes the importance of work intentions as part of worship (*thalabul 'ilmi* and *amal saleh*). In these interviews, it was revealed that students are taught the concept of honesty in using raw materials, precision in measurements (avoiding fraud in weights/ measures), and a commitment to producing *thayyiib* goods (good, clean, and beneficial to society).

Observations during the production process and group work demonstrate a religious culture and Islamic ethics closely embedded in student activities. Before commencing activities in the laboratory or production room, students routinely recite prayers together and read relevant Qur'anic verses regarding environmental conservation and cleanliness. Upon entering the obligatory prayer (*Fardh*) times, all production activities are decorously halted to perform congregational prayers in the school

prayer room. Attitudes of mutual respect, mutual cooperation (gotong royong), and patience when facing formulation failures also reflect *akhlakul karimah* values that are applied practically within group dynamics.

Documentation data in the form of worship habituation control sheets, Islamic value-based laboratory rules, and character assessment rubrics supplement these findings. In the student competency analysis document, evaluation indicators include honesty in recording experimental results, cleanliness of the work area as part of faith, and responsibility for disposing of production waste to avoid damaging the ecosystem. This documentation confirms that the ECO Sains program successfully turns the aloe vera dishwashing soap production activity into an effective medium for practically embodying Al-Islam and Kemuhammadiyahan values.

3. Development of Student Entrepreneurship Skills and Business Management

The research results identify that students gain direct experience in managing the business chain holistically, from packaging to marketing strategies. Based on interviews with the school entrepreneurship coordinator and students, students receive in-depth guidance on designing aesthetic, informative, and eco-friendly packaging. They learn to compose product labels containing material ingredients, usage instructions, expiration dates, as well as authorization or product claim advantages. In addition, students are equipped with basic accounting knowledge to calculate the Cost of Goods Sold (COGS), account for overheads, and determine competitive selling prices in the market.

Through observations during business simulation sessions and school bazaars, students demonstrated exceptional ability in practicing entrepreneurial skills. During the packaging stage, students appeared adept at using refillable packaging and applying brand stickers designed by their own groups. In price-setting and marketing sessions, students actively discussed determining rational profit margins. They also practiced direct selling techniques and digital marketing through social media, persuasively explaining the advantages of their aloe vera soap product to prospective buyers within the school environment and parents.

Research documentation, including Operational Cost and COGS analysis sheets, brand sticker design sheets, social media promotion portfolios, and product sales logbooks, serves as tangible evidence of mastering these business aspects. Student financial bookkeeping records neat cash flow entries, covering initial capital, raw material costs, down to the net profit obtained from each production batch. These documents show that the ECO Sains learning process successfully converts science research ideas into high-value economic products managed professionally by students.

4. The Role and Support of the "Saudagar Muda Muhammadiyah" Program for Student Innovation

The study found that student participation in the "Saudagar Muda Muhammadiyah" program served as a primary accelerator in transforming the ECO Sains project from a laboratory scale into a market-ready product innovation. Interviews with the school principal and advisory teachers revealed that the Saudagar Muda Muhammadiyah event provided a business incubation space, intensive training, and mentoring from business practitioners. Through this program, students received critical feedback regarding product standardization, material efficiency, and production scaling-up strategies so that their aloe vera dishwashing soap could maintain strong competitiveness.

Observations during the preparation and implementation of the Saudagar Muda Muhammadiyah competition showed high enthusiasm and hard work from the student teams. Students were actively involved in business pitch presentations, assembling attractive pitch decks, and demonstrating product samples before the board of judges and business mentors. The experience of interacting with participants from other schools and listening to evaluations from experts encouraged students to engage in continuous improvement regarding their soap formula, bottle design, and marketing messaging.

Documentation data consisting of Saudagar Muda Muhammadiyah business proposals, certificates of participation and awards, as well as mentor evaluation sheets reinforce these findings. Documented proposal files indicate significant business idea progression, evolving from a mere course final assignment into a mature business model with financial projections and marketing plans. Photo documentation capturing students receiving feedback from judges alongside championship certificates

serves as authentic proof that the Saudagar Muda Muhammadiyah program contributed greatly to shaping a young innovator mindset in students.

5. Learning Impact on Changes in Student Knowledge, Skills, and Independence

Research evidence proves that integrating the ECO Sains and entrepreneurship programs delivers a measurable transformative impact across five main student dimensions: knowledge, skills, responsibility, creativity, and independence. Based on interviews with teachers and parents, there was a drastic increase in students' understanding of ecological science and business insights. Parents also confirmed behavioral changes at home, where students became more independent, showed greater appreciation for earning a living, and developed a high awareness of cleanliness and household waste management.

Periodic observations show the evolution of students' attitudes and technical capabilities throughout the program. In terms of skills and creativity, students who were initially passive became highly skilled at operating laboratory equipment, manufacturing soap, and generating innovative marketing design ideas. Regarding responsibility and independence, students were able to organize production schedules, manage group finances, and resolve technical obstacles (such as material blending failures) independently without relying fully on guidance from advisor teachers.

This positive impact is comparatively proven through documentation data in the form of pre-test and post-test scores for science/entrepreneurship competencies, soft skills assessment rubrics, and individual student progress portfolios. Quantitative data shows a significant increase in students' average knowledge and practical skill scores following the program. Furthermore, self-assessment sheets and peer-assessments recorded score improvements in discipline, leadership, and independence indicators, legitimately confirming the program's success in cultivating an excellent, character-driven, and entrepreneurial young Muhammadiyah generation

6. Discussion

The research findings regarding the development of aloe vera-based dishwashing soap by students of SMA Muhammadiyah Piyungan demonstrate that science learning packaged in structured experimentation significantly enhances students' conceptual understanding and practical skills. The processing steps, from gel extraction to testing acidity (pH) and viscosity levels, prove that a contextual approach based on local potential effectively facilitates students' comprehension of applied chemistry and biology topics. This finding aligns with previous studies by Fatmala et al. (2023), Sari et al. (2025) and Sudirman (2025), which revealed that utilizing local natural resources such as Aloe vera in secondary school science projects not only increases learning engagement but also strengthens student science knowledge retention through hands-on learning experiences. Furthermore, the implementation of laboratory occupational safety Standard Operating Procedures (SOP) applied by the students supports research by Alam et al. (2025), Limori et al. (2025) and Nabila & Kamaludin (2023), which emphasized that project-based STEM learning consistently builds scientific literacy awareness and scientific method discipline among learners.

The application of Al-Islam and Kemuhammadiyahan (AIK) values across all production stages reinforces the argument that science education must not be detached from spiritual character building and Islamic ethnoscience ethics. The habituation of worship, honesty in ingredient measurements, and responsibility toward waste management indicate an internalization of the khalifah fil 'ardh principle and the thayyiib business concept. This strengthens research findings from Adha & Prawironegoro (2024), Rambe et al. (2025) and Tarso et al. (2025) , who stated that integrating Islamic values into science and entrepreneurship curricula in Muhammadiyah schools successfully creates a balance between academic achievements (intellectual quotient) and ethical-spiritual awareness (spiritual quotient). Previous research underscores that when production activities are correlated with worship values and Sharia ethics, students tend to display higher levels of integrity, strong academic honesty, and a greater sense of social responsibility toward surrounding environmental preservation.

From the aspect of entrepreneurship development, the finding that students mastered the holistic business chain ranging from Cost of Goods Sold (COGS) analysis and eco-friendly packaging design to digital marketing strategies explains the importance of project-based entrepreneurship education at

the secondary school level. These results support studies by Pulungan et al. (2026), Sternad et al. (2022) and Wijesundara (2020) , which posited that research learning integrated with business simulations can bridge the gap between academic theory and real-world workplace needs. Accurate pricing and the utilization of social media by students to distribute refillable products align with research by (Afandi et al., 2024; Banthia & Dey, 2022; Tarso, Koswara, et al., 2026), which highlighted that young generations equipped with basic financial literacy and digital marketing skills from an early age possess significantly more mature business readiness and market adaptability compared to students who only receive theoretical entrepreneurship instruction in the classroom.

The role of the "Saudagar Muda Muhammadiyah" program as a school business incubator proved to be a key accelerator in transforming laboratory-scale products into high-value market innovations. The involvement of practitioners, product standardization testing, and business competition events provided space for students to undergo objective evaluation processes and continuous improvement. The findings of this study confirm school business incubation theories researched by Konak et al. (2025), Purwaningrum & Muhid (2026) and Wu et al. (2025), who found that partnerships between educational institutions and entrepreneurship incubators or external association networks drastically enhance the quality of Student Product Innovation (SPI). Pitching sessions and feedback from expert judges fostered a growth mindset in students, wherein formulation failures or packaging critiques were received as constructive opportunities to refine the product's competitive advantage.

Overall, the measurable positive impacts on increasing student knowledge, skills, responsibility, creativity, and independence prove the effectiveness of integrating ECO Sains and entrepreneurship as a contemporary learning model. Behavioral changes that carried over to students' homes such as independence and heightened concern for household waste management support longitudinal research by Daskova et al. (2020), Pisriwati et al. (2025) and Suryani et al. (2025). These previous studies concluded that environmental action-based learning combined with productive economic activities generates transformative learning, resulting in long-lasting shifts in students' mindsets and behaviors. Thus, the research findings at SMA Muhammadiyah Piyungan revalidate that the synergy among ecological science, religious values, and incubation-based entrepreneurship offers a holistic formulation that successfully yields excellent, character-driven, and economically independent graduates.

CONCLUSION

This study concludes that integrating the ECO Sains and entrepreneurship programs through the production of aloe vera-based dishwashing soap at SMA Muhammadiyah Piyungan successfully transforms science learning into a holistic, scientific, and economically valuable experience. Through the implementation of systematic standard operating procedures, the habituation of Al-Islam and Kemuhammadiyahan (AIK) values, the mastery of basic business management, and incubation support from the Saudagar Muda Muhammadiyah program, students not only master academic competencies and ecological science but also demonstrate significant improvements in character, creativity, responsibility, and independence. Based on these findings, it is recommended that the school expand the product's licensing and distribution reach by obtaining official permits and broader standardization so that this innovation can be marketed commercially beyond the school environment, while also serving as a reference for future researchers to examine the long-term impact of this learning model on the sustainability of students' entrepreneurial intention on a larger production scale.

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