

Robotics Training and RoboRoarZ Competition as a STEM-Based Community Service Program for Enhancing STEM Competencies of Senior High School Students in Kepulauan Riau

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Abstract— The low adoption of STEM (Science, Technology, Engineering, and Mathematics) education in senior high schools (SMA/SMK) across Kepulauan Riau Province, Indonesia, has been identified as a critical gap in preparing students for Industry 4.0 and Society 5.0. To address this challenge, Politeknik Negeri Batam conducted a community service program entitled Robotics Training and RoboRoarZ Competition for Enhancing STEM Competencies of Senior High School Students in Kepulauan Riau. The program involved 200 students from 22 schools organized into 25 competing teams and was implemented over two days on 12–13 August 2025. Participants received hands-on training using the SMORPHI modular reconfigurable robot, covering hardware assembly, programming, and autonomous navigation. A robotics competition, RoboRoarZ Indonesia 2025, was subsequently held featuring two categories: Autonomous Challenge (line-follower) and Imaginary Challenge (a browser-based robotics simulation). Pre-test and post-test assessments completed by a subset of participants revealed a substantial improvement in robotics knowledge, with the average score rising from 68.0 to 87.0. Questionnaire data further confirmed high positive response rates across indicators of interest, motivation, and career aspiration in robotics, consistently exceeding 88%. As a form of program sustainability, Politeknik Negeri Batam continues to conduct non-club robotics training sessions for schools in Kepulauan Riau and is in the process of establishing a dedicated robotics club to provide continued mentoring beyond the competition. The findings demonstrate that competition-based STEM learning combining workshop instruction with project-based and problem-solving activities is an effective and scalable model for improving STEM competencies among secondary school students in underserved regions.

Keywords—STEM education; robotics training; RoboRoarZ; SMORPHI robot; community service; senior high school; Kepulauan Riau

Abstrak— Rendahnya penerapan pendidikan STEM (Science, Technology, Engineering, and Mathematics) di sekolah menengah atas (SMA/SMK) di Provinsi Kepulauan Riau, Indonesia, telah diidentifikasi sebagai kesenjangan kritis dalam mempersiapkan siswa menghadapi era Industri 4.0 dan Society 5.0. Untuk menjawab tantangan tersebut, Politeknik Negeri Batam melaksanakan program pengabdian kepada masyarakat berjudul Pelatihan Robotika dan Kompetisi RoboRoarZ untuk Meningkatkan Kompetensi STEM Siswa Sekolah Menengah Atas di Kepulauan Riau. Program ini melibatkan 200 siswa dari 22 sekolah yang terbagi dalam 25 tim peserta, dan dilaksanakan selama dua hari pada 12–13 Agustus 2025. Peserta menerima pelatihan langsung menggunakan robot modular reconfigurable SMORPHI, meliputi perakitan perangkat keras, pemrograman, dan navigasi otonom. Kompetisi robotika RoboRoarZ Indonesia 2025 kemudian diselenggarakan dengan dua kategori: Autonomous Challenge (line-follower) dan Imaginary Challenge (simulasi robotika berbasis peramban). Hasil pre-test dan post-test yang diisi oleh sebagian peserta menunjukkan peningkatan yang cukup besar pada pengetahuan robotika, dengan rata-rata skor meningkat dari 68,0 menjadi 87,0. Data kuesioner juga menunjukkan tingkat respons positif yang tinggi pada indikator minat, motivasi, dan aspirasi karier di bidang robotika, yang secara konsisten melebihi 88%. Sebagai bentuk keberlanjutan program, Politeknik Negeri Batam terus melaksanakan pelatihan robotika non-klub bagi sekolah-sekolah di Kepulauan Riau dan sedang dalam proses pembentukan klub robotika untuk memberikan pendampingan lanjutan pasca-kompetisi. Temuan ini menunjukkan bahwa pembelajaran STEM berbasis kompetisi yang menggabungkan instruksi workshop dengan kegiatan berbasis proyek dan pemecahan masalah merupakan model yang efektif dan dapat direplikasi untuk meningkatkan kompetensi STEM siswa sekolah menengah di wilayah yang kurang terlayani.

Kata Kunci—pendidikan STEM; pelatihan robotika; RoboRoarZ; robot SMORPHI; pengabdian kepada masyarakat; sekolah menengah atas; Kepulauan Riau

I. INTRODUCTION

The Indonesian Ministry of Industry has designated Batam as one of the national pilot cities for Industry 4.0 implementation [1]. As the global economy transitions into the Society 5.0 era, the ability to think critically and creatively particularly in science, technology, engineering, and mathematics (STEM) has become indispensable. Demonstrates that STEM-based educational approaches significantly enhance students' critical thinking skills required for navigating Industry 4.0 complexities [2].

Despite growing international recognition, STEM education remains insufficiently integrated into Indonesia's secondary school curriculum, especially in provinces beyond Java. A scoping review shows that only a small number of Indonesian provinces have systematically adopted STEM education, while the majority including Kepulauan Riau still lag behind [5]. In Kepulauan Riau, including Batam, most schools continue to adopt Teacher-Centered Learning (TCL) without meaningful integration across the science, technology, engineering, and mathematics disciplines. Field observations and discussions with local educators confirmed the absence of accessible STEM learning media and limited teacher familiarity with integrated STEM instructional models such as case method and Problem-Based Learning (PBL) [3].

This gap becomes even more critical considering that STEM-based community service activities should ideally not end with a single event, but should instead be directed toward sustainable impact for the schools and students being served. Prior community service activities conducted by Polibatam, such as robotics training at an Islamic boarding school in Batam [11], indicate that robotics-based service programs need to be accompanied by follow-up mechanisms so that their benefits do not stop once the activity concludes. This consideration underlies the design of the Robotics Training and RoboRoarZ Competition program not merely as a two-day event, but as the starting point of an ongoing robotics mentoring initiative for schools in Kepulauan Riau, as further described in Section IV.F.

Robotics has been widely recognized in the literature as an effective medium for delivering STEM education in engaging project-based formats. Studies have demonstrated that robotics training improves students' engineering design skills by up to 98% and fosters analytical competence [8]. Furthermore, competitive robotics events have been shown to strengthen intrinsic motivation and sustain engagement in STEM learning over time [3]. Platforms such as the SMORPHI modular robot developed by Singapore University of Technology and Design (SUTD) offer a reconfigurable, accessible framework for introducing robotics concepts to students with no prior background.

In response to these challenges, Politeknik Negeri Batam (Polibatam), through its Bachelor of Applied Science in Robotics Engineering Technology Study Program, implemented a

community service program combining intensive hands-on robotics workshops with a national-level robotics competition, RoboRoarZ Indonesia 2025. This program was designed with the following objectives: (1) to introduce STEM-integrated learning to SMA/SMK students and teachers in Kepulauan Riau through hands-on robotics workshops based on the SMORPHI modular robotic platform; (2) to improve participants' technical skills (hardskills) in robot design, programming, and autonomous operation, as well as non-technical skills (softskills) including teamwork, communication, and problem-solving; (3) to provide teachers with practical exposure to case-method and Project-Based Learning (PBL) strategies applicable to robotics-based STEM instruction; (4) to create an evaluative and motivational competition environment through the RoboRoarZ Indonesia 2025 competition; and (5) to lay the foundation for program sustainability through continued robotics training and the establishment of a school robotics community in Kepulauan Riau. This paper reports the design, implementation, and outcomes of the program, including pre- and post-test assessment results, competition outcomes, participant questionnaire data, and the program's follow-up plan, in order to evaluate its effectiveness as a STEM community outreach model for secondary school students in Kepulauan Riau.

II. LITERATURE REVIEW

STEM education integrates science, technology, engineering, and mathematics into a single cohesive learning framework and has been widely adopted in both developed and developing countries as a strategy to prepare younger generations for the challenges of the 21st century [4]. In Indonesia, research on STEM implementation in schools has grown rapidly since 2015 [5], although equitable distribution across provinces remains a challenge, with several provinces — including Kepulauan Riau yet to fully adopt this approach systematically.

Teachers' perceptions and understanding of STEM education are important components supporting the equitable distribution of STEM education in Indonesia. Nugroho et al. [6] found that some science teachers in Indonesia still have a limited understanding of STEM education and face constraints related to infrastructure and supporting facilities. On the other hand, found that from the students' perspective, STEM learning tends to be perceived as enjoyable, particularly in the context of project-based learning that encourages students to actively generate ideas [7].

Robotics in particular has been widely recognized in the literature as an effective medium for delivering STEM education through engaging project-based formats. Asri [8] found that robotics training can improve students' robot design capability by up to 98% in the engineering aspect, while also improving their ability to analyze graphical data. A systematic further

confirms that robotics-based STEM education is consistently associated with improvements in problem-solving skills, computational thinking, and student motivation across educational levels [12]. Similarly, a meta-analysis shows that the integration of educational robotics into STEM learning generally produces positive effects on student learning outcomes compared to conventional methods [13].

Beyond technical skill development, robotics competitions have also been shown to strengthen intrinsic motivation and sustain student engagement in STEM learning over time [3]. Implementing robotics within STEM education requires an accessible robot platform. Besides commercial robot kits such as LEGO Mindstorms commonly used in schools, several domestic researchers have developed their own educational robot kits, such as Logarithmus [9] and a line-follower-based educational robot kit [10]. The SMORPHI modular robot used in this program complements this range of platforms by offering a flexible reconfigurable form factor along with a block-based programming interface, making it suitable for students without prior robotics experience.

Regarding the sustainability of robotics-based community service programs, Polibatam's experience in delivering robotics training for Islamic boarding school students in Batam [11] indicates that training impact tends to be stronger when accompanied by follow-up mentoring, rather than remaining a one-off event. This finding is one of the main considerations in designing the follow-up mechanism for the RoboRoarZ Indonesia 2025 program, as discussed in Section IV.

2.1 Program Objectives

The program was designed with the following primary objectives:

1. To introduce STEM-integrated learning to SMA/SMK students and teachers in Kepulauan Riau through hands-on robotics workshops based on the SMORPHI modular robotic platform.
2. To improve participants' technical skills (hardskills) in robot design, programming, and autonomous operation, as well as non-technical skills (softskills) including teamwork, communication, and problem-solving.
3. To provide teachers with practical exposure to case-method and Project-Based Learning (PBL) strategies applicable in robotics-based STEM instruction.
4. To create an evaluative and motivational competition environment through the RoboRoarZ Indonesia 2025 competition, enabling students to apply their learning in a real-world context.

2.2 Methods

2.2.1 Program Design and Participants

This community service program was conducted by Politeknik Negeri Batam on 12–13 August 2025 at the Batam campus, involving 200 students from 22 schools in Kepulauan Riau Province (and one international school from Turkey) organized into 25 competing teams. Participant selection was limited by the available number of SMORPHI robot units (25 units, one per team). Schools were invited through formal coordination with local education networks.

2.2.2 Implementation Stages

The program was executed in four structured stages:

Stage 1 — Preparation (July 23 – August 10, 2025). This stage involved coordination meetings with SUTD for SMORPHI kit procurement, an online Training of Trainers (ToT) session (August 1), competition rule development, and field construction.

Stage 2 — Workshop (Day 1, August 12, 2025). Participants attended a technical brief followed by parallel workshop sessions covering: (a) SMORPHI hardware familiarization (sensors, motors, wiring), (b) programming using block-based coding, and (c) imaginary simulation practice using the Wefaa Robotics Imaginary Challenge platform. Lecturers and student mentors from Polibatam facilitated each session.

Stage 3 — RoboRoarZ Competition (Day 2, August 13, 2025). The competition featured two categories: (a) *Autonomous Challenge*— a physical line-follower robot race in which each robot uses infrared or optical sensors mounted on its underside to detect a contrasting line on the track and automatically adjusts its motors to stay on course, without any human input during the run, and (b) *Imaginary Challenge*—a software simulation competition. Scoring incorporated both technical criteria (design accuracy, programming efficiency) and non-technical criteria (teamwork, creativity, strategic thinking).

Stage 4 — Evaluation (Post-event). Evaluation data were collected through three instruments: (a) pre-test and post-test knowledge assessments administered to all participants, (b) a structured questionnaire covering interest, motivation, and career aspiration indicators, and (c) observation records from the competition.

2.2.3 Assessment Instruments

Knowledge gain was measured using a pre-test administered prior to the Day 1 workshop and a post-test administered after the Day 2 competition. Both tests assessed participants' conceptual understanding of robotics hardware, programming fundamentals, and autonomous navigation principles. Both tests were optional, and not all participants completed both — a common occurrence in large-scale, activity-based assessments, since some participants left sessions early

due to school obligations or their team's match schedule, meaning that the number of pre-test and post-test respondents analyzed does not always match the total number of participants. The questionnaire comprised nine Likert-scale items addressing prior knowledge, interest development, career aspiration, and perceived learning outcomes.

2.2.4 Imaginary Challenge Platform

The Imaginary Challenge category used the Smorphi Imaginary simulation platform developed by Wefaa Robotics, the official commercial partner of SUTD for the SMORPHI robot. The platform is browser-based and provides a virtual environment that replicates real-world robot navigation challenges, allowing participants to program robot movement using block-based coding without requiring a physical robot unit. Programming is carried out through a block-based logic interface similar to physical SMORPHI programming, covering motion control, object detection, and real-time maze navigation within the simulator. This characteristic makes the platform relatively easy to replicate at other institutions with limited resources, as it does not require ownership of a physical robot unit a computer with browser access is sufficient to run a robotics training session or simulation competition.

III. RESULTS AND DISCUSSION

3.1 Program Implementation

Table 1 presents the detailed timeline of the program activities from preparation to final reporting.

Table 1. RoboRoarZ Indonesia 2025 Program Activity Schedule

No.	Date	Activity	Person in Charge
1	23/07/2025	Initial meeting with SUTD regarding RoboRoarZ Indonesia 2025	Team Leader
2	27/07/2025	Collection of SMORPHI robots from SUTD for ToT preparation	Workshop Team
3	30/07/2025	Follow-up meeting with SUTD on event logistics and ToT agenda	Team Leader
4	01/08/2025	Training of Trainers (ToT) by SUTD (online) — SMORPHI kit introduction and competition simulation	Workshop Team
5	02/08/2025	Formulation of competition rules and field design	Competition & Field Team
6	10/08/2025	Construction of competition field and furniture	Competition & Field Team
7	12/08/2025	Day 1 — Technical brief + Workshop: SMORPHI hardware, software, and imaginary simulation training	Event Team
8	13/08/2025	Day 2 — RoboRoarZ competition: autonomous line-follower and imaginary challenge	Event Team
9	15/08/2025	Post-event review meeting	Team Leader
10	21/11/2025	Final report submission	Team Leader

The SMORPHI robot is a modular, reconfigurable robotic platform developed by SUTD and commercialized globally by Wefaa Robotics, capable of adopting multiple locomotion configurations. Its accessibility and block-based programmability made it well-suited for secondary school participants with no prior robotics experience. For the imaginary simulation category, teams competed using the Smorphi Imaginary platform from Wefaa Robotics as described in Section III.D, which provides a browser-based virtual environment replicating real-world robotic challenges.

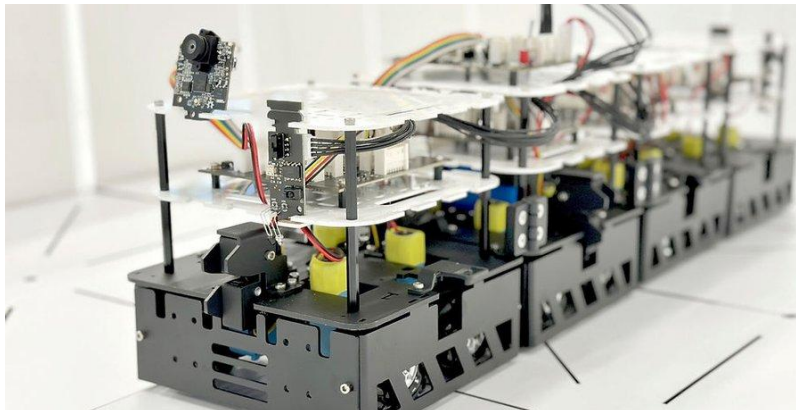


Figure 1. The SMORPHI Robot

Try Smorphi Imaginary!

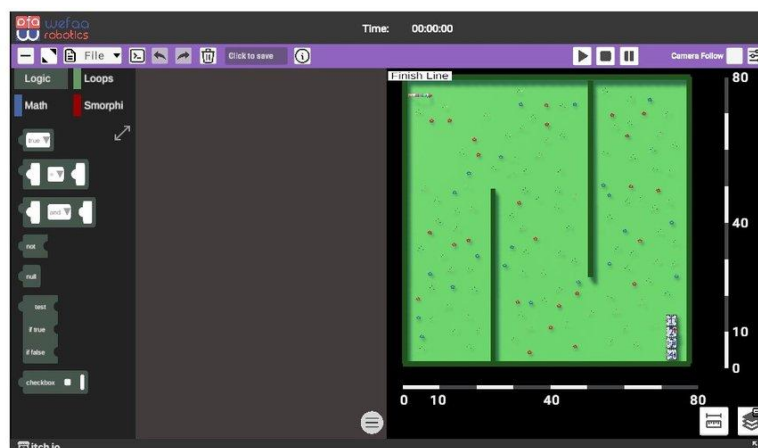


Figure 2. Interface of the SMORPHI Imaginary Challenge Platform (WEFAA Robotics)

On Day 1, the workshop was structured into two parallel tracks running simultaneously. Participants rotated between the SMORPHI hardware track and the imaginary simulation track, guided by Polibatam faculty and student mentors. On Day 2, teams competed in a group-stage format (25 teams divided into 8 groups) before advancing to finals, with sessions running throughout the day for both competition categories.

3.2 Competition Results

Table 2 presents the competition award recipients across both categories.

Table 2. RoboRoarZ Indonesia 2025 Competition Results

Category	Rank	Team Name	School
Imaginary Challenge	1st Place	KARTINI STEM NEXUS LABS	SMA KARTINI
	2nd Place	IO/OI	SMKN 1 BINTAN UTARA
	3rd Place	GEN_IUS	SMA AL KAHFI ISLAMIC SCHOOL BATAM
	Best Spirit	ROBOCEN 2	MAN IC BATAM
	Best Strategy	MB TECH	MAN 1 BATAM
Autonomous Challenge	1st Place	TAT BOT	SMKN 3 BATAM
	2nd Place	CIA TEAM 2	GRANADA INTERNASIONAL ISLAMIC BOARD SCHOOL
	3rd Place	ZAFER	ULUSLARASI PROF. DR. MUHAMMED HAMIDULLAH ANADOLU IMAM HATIP LISESI (Turkey)
	Best Spirit	TIM ROBOTIK SMKN 3 TPI	SMKN 3 TJ. PINANG
	Best Strategy	CASTOR	SMAN 3 BATAM

The winning teams reflected a broad geographic distribution across Kepulauan Riau. Notably, international participation was evident in the Autonomous Challenge, with a team from Turkey (Uluslarasi Prof. Dr. Muhammed Hamidullah Anadolu Imam Hatip Lisesi) achieving third place, underscoring the cross-cultural appeal and transferability of the SMORPHI-based robotics framework. The inclusion of special awards for Best Spirit and Best Strategy acknowledged non-technical competencies—teamwork and tactical thinking—consistent with the program’s holistic STEM development objectives.

3.3 Knowledge Assessment: Pre-Test and Post-Test

To measure participants knowledge gain, a pre-test was conducted before the Day 1 workshop and a post-test after the Day 2 competition. As explained in Section III.C, not all participants completed both tests, so the number of pre-test and post-test respondents analyzed differs from the total of 200 program participants (153 pre-test respondents and 137 post-test respondents). Table 3 summarizes the pre-test and post-test results based on recorded respondents. Table 3 summarizes the pre-test and post-test results across all 200 participants.

Table 3. Pre-Test and Post-Test Knowledge Assessment Results

Metric	Pre-Test	Post-Test	Improvement
Average Score	68.0	87.0	+19.0 pts
Number of Test Respondents	153 students	137 students	—

The results demonstrate a substantial gain in robotics knowledge following the program. The average score increased from 68.0 (pre-test) to 87.0 (post-test). The score distribution across ranges also shows a consistent shift, with the proportion of participants in the high-score range

(above 80) increasing sharply in the post-test compared to the pre-test, while the proportion in the low-score range decreased. These findings are consistent with prior studies documenting the effectiveness of hands-on robotics training in improving measurable STEM learning outcomes [8, 3].

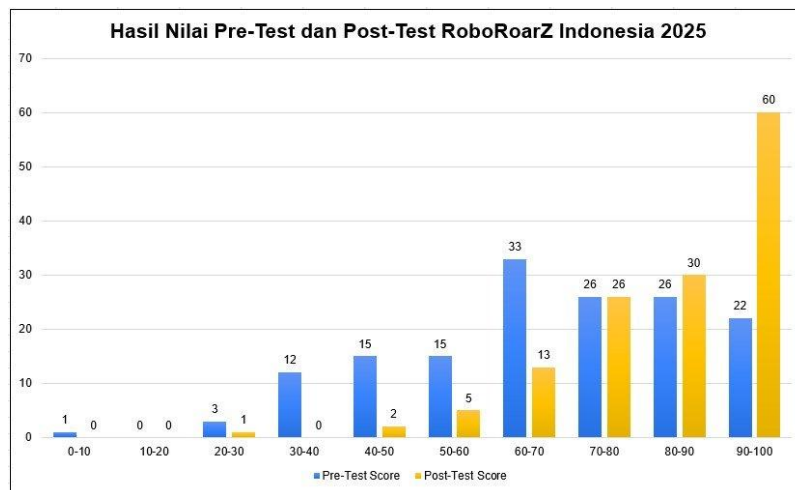


Figure 3. Distribution of Pre-Test and Post-Test Score, RoboRoarZ 2025

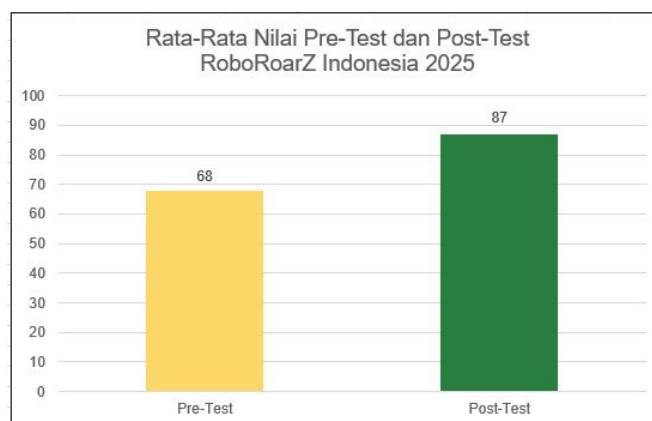


Figure 4. Average Pre-Test and Post Test Scores, RoboRoarZ 2025

The test instrument used in this program was not designed to separate achievement by individual STEM aspect (Science, Technology, Engineering, Mathematics); instead, it measured participants' conceptual understanding in an integrated manner covering robotics hardware, programming fundamentals, and autonomous navigation principles. Consequently, an analysis of which STEM aspect showed the greatest improvement cannot yet be presented in this report, and is noted as a limitation of the study to be addressed in future program iterations through the design of test instruments that explicitly map each item to its respective S, T, E, or M aspect.

The magnitude of this improvement is particularly noteworthy given the constrained two-day format, suggesting that structured, competition-integrated training — combining instruction,

guided practice, and immediate application in a competitive setting — produces accelerated learning gains relative to conventional classroom approaches.

3.4 Participant Questionnaire Results

Table 4 presents the summary of questionnaire responses across nine items.

Table 4. Participant Questionnaire Results — RoboRoarZ Indonesia 2025

No.	Question Item	Positive Response Rate
Q1	Prior knowledge of robotics before RoboRoarZ	Strongly Agree / Agree: 78%
Q2	RoboRoarZ increased interest in robotics	Strongly Agree / Agree: 94%
Q3	Became more curious about how robots work	Strongly Agree / Agree: 96%
Q4	Can envision building or programming robots in the future	Strongly Agree / Agree: 91%
Q5	Workshop helped discover new interest in robotics technology	Strongly Agree / Agree: 93%
Q6	Desire to explore more workshops, clubs, or competitions	Strongly Agree / Agree: 92%
Q7	Considering studying robotics or engineering in the future	Strongly Agree / Agree: 88%
Q8	Now understands how robotics is applied in real-world careers	Strongly Agree / Agree: 89%
Q9	RoboRoarZ helped think about contributing to solving real-life problems via technology	Strongly Agree / Agree: 93%

Questionnaire results were overwhelmingly positive. Positive response rates (Strongly Agree + Agree) exceeded 88% for all nine items. The highest responses were recorded for Q3 (“I am now more curious about how robots work” — 96%) and Q2 (“RoboRoarZ increased my interest in robotics” — 94%), indicating that the competition successfully stimulated intrinsic curiosity and enthusiasm.

Career-aspiration items (Q4, Q7) also yielded high positive rates (91% and 88%, respectively), suggesting that the program meaningfully influenced participants’ perceptions of robotics and engineering as viable future pathways. This aligns with national STEM education goals of cultivating a technically skilled generation for Industry 4.0 [1, 2].

The results of Q1 (prior robotics knowledge, 78% positive) indicate that while a substantial portion of students had some familiarity with robotics prior to the event, the remaining participants entered with limited baseline knowledge—reinforcing the need for structured outreach programs of this nature in underserved provinces such as Kepulauan Riau.

3.5 Activity Documentation

The workshop and competition were comprehensively documented by the service team as part of the program's accountability process. Documentation covers the Day 1 workshop sessions on SMORPHI hardware familiarization and programming, directly guided by lecturers and assisted by students from the Robotics Engineering Technology Study Program, as well as the Day 2 Autonomous Challenge and Imaginary Challenge competitions, from the group stage through the final round. Photo and video

documentation also form part of the mandatory outputs of this community service program and are used as supporting material for the institution's final report.



Figure 5. Workshop Atmosphere on the First Day



Figure 6. Students Mentoring of Workshop Participants



Figure 7. RoboRoarZ Competition on the Second Day



Figure 8. Participants During the Autonomous Challenge Session

3.6 Program Sustainability

Unlike community service activities that conclude with the competition itself, this program was designed with post-event sustainability in mind. As a follow-up measure, the Polibatam service team currently conducts regular non-club robotics training sessions for schools in Kepulauan Riau, serving as a bridge for enriching robotics material outside the RoboRoarZ schedule. In addition, the team is in the process of forming a robotics club that will serve as a more structured and sustainable mentoring platform for students and schools in Kepulauan Riau, building on the enthusiasm shown by participants in questionnaire Item 6 (92% expressed a desire to explore more robotics workshops, clubs, or competitions).

These follow-up training activities are run by lecturers and students from the Bachelor of Applied Science in Robotics Engineering Technology Study Program at Polibatam, targeting schools across the Kepulauan Riau region generally, not limited to teams that performed well in the RoboRoarZ Indonesia 2025 competition. This approach was chosen so that the program's benefits can be felt more evenly by schools that have historically had limited access to robotics-based STEM learning media, consistent with the program's aim of serving as a replicable bridge intervention rather than merely an annual ceremonial event.

3.7 Discussion

The findings collectively confirm that a competition-integrated, workshop-based STEM outreach model is effective for secondary school populations in Kepulauan Riau. Three key insights emerge from this study:

First, structured two-day formats combining instruction and competition can generate measurable knowledge gains equivalent to longer training programs when content is well-scaffolded and immediately applied. The SMORPHI platform's modular simplicity enabled even novice participants to achieve functional robot operation within a half-day workshop session.

Second, competition as a pedagogical mechanism reinforces motivation and sustains engagement, consistent with prior research by Chung et al. [3]. The competitive environment created a goal-oriented context that gave immediate purpose to the workshop content.

Third, the program revealed persistent structural gaps in STEM education access across Kepulauan Riau. Fewer than 50% of Indonesia's provinces have implemented STEM education, and Kepulauan Riau is among those lagging behind [5]. University-led community service programs of this type can serve as scalable bridge interventions to accelerate STEM adoption in secondary schools.

Fourth, the sustainability of robotics-based service programs should not be treated as an optional add-on, but as a core component of the program design itself. This program's experience through the non-club robotics training already running and the robotics club currently being established shows that sustainability efforts can begin even before a single service cycle is formally completed, so that the impact on partner schools does not stop once the competition ends.

IV. CONCLUSION

This paper reported the design, implementation, and outcomes of the Robotics Training and RoboRoarZ Competition 2025, a community service program conducted by Politeknik Negeri Batam targeting secondary school students in Kepulauan Riau Province. The program engaged

200 students from 22 schools across two days of hands-on SMORPHI robotics workshops and a two-category competition.

Quantitative evaluation demonstrated meaningful effectiveness: average test scores among respondents who completed both the pre-test and post-test improved from 68.0 to 87.0. Questionnaire data confirmed high levels of positive impact across interest, motivation, and career aspiration indicators, with all items exceeding 88% positive response rates. As a form of sustainability, the program has produced an ongoing non-club robotics training initiative as well as an in-progress robotics club for schools in Kepulauan Riau.

These results affirm that competition-based, hands-on STEM workshops represent a replicable and scalable model for university-led community outreach in regions with limited STEM education infrastructure. Future iterations of this program should expand school participation beyond Kepulauan Riau, deepen longitudinal tracking of participant outcomes, design test instruments capable of mapping achievement by individual STEM aspect, and explore integration with formal curriculum frameworks to sustain impact beyond the event itself.

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