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ASSESSING THE TECHNICAL COMPETENCE OF ADMINISTRATORS AND TEACHERS IN ARDUINO ROBOTICS IN SECONDARY SCHOOLS IN CANDON CITY

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ABSTRACT

This study examined the demographic profiles and technical competence of school administrators and teachers in Arduino Robotics in secondary schools in Candon City, Ilocos Sur. A descriptive quantitative research design was employed. A total of 86 respondents, comprising seven school administrators and 79 teachers, were included using total enumeration sampling. Data gathered through a validated survey tool were analyzed using frequency distributions, percentage calculations, and weighted mean computations. The results revealed that the preponderance of administrators were within the 40–49-year age range, were female, married, and had accrued more than 10 years of teaching experience. In contrast, most teachers were between 30 and 39 years old, mostly female, and held the Teacher III position. Their main subjects were Science and TLE/TVL.

Findings further showed that the overall level of technical competence of the respondents in Arduino Robotics was slightly competent (grand mean = 1.83), with relatively higher competence in electronics fundamentals and Arduino programming, but lower competence in embedded systems, sensor integration, IoT communication, robotics assembly, and project development.

Keywords: *Arduino robotics, competence, readiness, secondary schools, STEM education*

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I. INTRODUCTION

Educational robotics has increasingly become an important component of modern Science, Technology, Engineering, and Mathematics (STEM) education because of its capacity to enhance technological literacy, computational thinking, and problem-solving skills among learners. According to Yuldashevna and Khurana (2024), robotics-based learning environments enable students to apply theoretical STEM concepts in practical contexts by designing, constructing, and programming robotic systems. Similarly, Aliyu et al. (2025) emphasized that robotics activities enable learners to develop critical thinking and analytical skills through hands-on technological experimentation. Rahman (2021) further explained that robotics education promotes creativity and innovation by allowing students to explore multiple approaches to solving real-world problems through collaborative and inquiry-based learning.

Educational robotics also contributes significantly to the development of essential twenty-first-century competencies. Gratani and Giannandrea (2022) noted that robotics-based learning environments encourage the development of communication, collaboration, creativity, and critical thinking skills, which are widely recognized as fundamental competencies for future-ready learners. Through project-based and experiential learning activities, students are encouraged to design, test, and refine technological solutions, allowing them to translate abstract STEM concepts into practical applications.

The worldwide proliferation of robotics education reflects a growing recognition of its importance in equipping students for societies increasingly shaped by technology. Grand View Research (2024) indicates that the global educational robotics market has experienced consistent expansion, driven by heightened investments in STEM education and digital learning tools. Correspondingly, Global Growth Insights (2025) documented a persistent increase in demand for educational robotics platforms as educational institutions seek to incorporate novel technologies into their pedagogical practices.

Wolniak (2023) explained that the growing influence of automation and artificial intelligence in modern industries has increased the need for educational systems to equip learners with advanced technological competencies. The World Economic Forum (2025) likewise emphasized that future labor markets will increasingly require skills related to programming, automation, and digital technologies.

Southeast Asian governments are increasingly advocating for the incorporation of advanced technologies within educational frameworks, aligning with wider developmental objectives. ASEAN.org (2024) emphasized the crucial role of technological innovation in promoting sustainable urban and educational progress across the region. In a similar vein, the ASEAN Smart Cities Network (2024) highlighted the importance of improving citizens' digital and technological skills to support innovation-led economies. Furthermore, the growing global interest in robotics education is demonstrated by the proliferation of robotics competitions and international learning initiatives.

Specifically, FIRST Robotics (2023) and the World Robot Olympiad (2024) offer international platforms where students can utilize engineering design and programming expertise to solve practical technological problems.

Among the platforms used for robotics instruction, the Arduino microcontroller system has gained significant popularity in educational settings. Arduino's widespread adoption in educational settings is attributed to its open-source design, ease of use, and adaptability for both electronics and programming endeavors (Arduino, 2023; Arduino, 2025). Marín et al. (2024) elucidated that robotics activities using Arduino facilitate student engagement in the design and implementation of interactive

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systems that incorporate sensors, actuators, and programmable microcontrollers. Likewise, Zadorozhnii (2023) underscored Arduino's capacity to cultivate fundamental skills in embedded systems and electronics through practical experimentation. Furthermore, Dat et al. (2024) highlighted that Arduino-based projects foster inquiry-based STEM learning, thereby motivating students to conceive, construct, and assess technological solutions.

Notwithstanding these benefits, numerous educational institutions continue to face obstacles in the adoption of robotics-based learning initiatives. Phokoye and colleagues (2024) found that educators frequently encounter difficulties in incorporating robotics into their teaching practices, primarily stemming from a lack of technical training and inadequate access to necessary learning materials. Similarly, Gonzales et al. (2021) noted that insufficient professional development opportunities constitute a considerable impediment to the successful integration of educational robotics within school settings. Consequently, in the absence of sufficient technical preparation and institutional backing, teachers may find it challenging to provide students with enriching robotics learning experiences, thereby hindering the comprehensive development of their technological proficiencies.

In the Philippines, students' performance in STEM fields has highlighted the need for more robust technology-based learning programs.

Data from Education GPS (2024) reveal that Filipino students consistently face difficulties on international science and mathematics assessments. These observations emphasize the need to enhance STEM education through novel pedagogical strategies, including robotics-based learning. Nevertheless, the efficacy of these initiatives is significantly contingent upon the proficiency and readiness of the educators tasked with delivering technology-integrated instruction.

In Candon City, Ilocos Sur, several secondary schools have begun introducing Arduino robotics as part of efforts to strengthen STEM-related instruction and promote technological innovation in education. However, differences in educators' demographic characteristics, professional backgrounds, and levels of technical competence may influence how robotics instruction is implemented across schools. Examining these characteristics is therefore essential for understanding administrators' and teachers' readiness to support robotics-based learning initiatives and for identifying areas that may require further capacity development.

Research Questions

This study examined the demographic profiles and technical competence of school administrators and teachers in Arduino Robotics in secondary schools in Candon City. Specifically, the study sought to answer the following research questions:

What are the demographic and professional profiles of administrators and teachers in terms of age, sex, civil status, years in teaching, academic rank, major field of specialization, highest educational attainment, and Arduino Robotics training?

What is the level of technical competence of administrators and teachers in Arduino Robotics?

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METHODOLOGY

Research Design

This study employed a quantitative descriptive research design to examine the demographic profiles and technical competence of school administrators and teachers in Arduino Robotics. Descriptive research is appropriate for investigations that aim to systematically document existing conditions and characteristics of a population without manipulating variables. Through this design, the researcher was able to gather factual, measurable information on respondents' demographic and professional characteristics, as well as their level of technical competence across key domains of Arduino Robotics. By utilizing this approach, the study provided an objective assessment of educators' competencies and identified prevailing conditions that may influence the implementation of robotics-based instruction in secondary schools.

Respondents

The respondents in the study comprised 86 educators from seven secondary schools in Candon City, Ilocos Sur, including both public and private institutions. The participants comprised 79 teachers and 7 school administrators. Among the teachers, 41 were Science teachers, while 38 were Technology and Livelihood Education/Technical-Vocational-Livelihood (TLE/TVL) teachers, representing subject areas closely associated with robotics-related instruction. The participating schools included five public secondary schools and two private institutions within the division.

A total enumeration sampling technique was utilized to include all administrators and teachers directly involved in Science and TLE/TVL instruction in the identified schools. This sampling approach ensured a comprehensive representation of educators most likely to integrate or support robotics-related learning activities, thereby providing a more accurate assessment of the demographic characteristics and technical competencies relevant to the implementation of Arduino robotics in secondary education.

Candon City was selected as the study locale because of its increasing Engagement in STEM-related initiatives and the introduction of Arduino Robotics in selected secondary schools. The city, therefore, provided a relevant educational setting for examining the demographic characteristics and technical competence of educators involved in robotics-based instruction.

Instrument

A structured survey questionnaire was employed to gather the necessary data for this investigation, specifically designed to evaluate the demographic profiles and technical proficiency of school administrators and teachers in Arduino Robotics. The instrument's design drew inspiration from Brian O. Rilloraza's (2019) research on competencies in Bread and Pastry Production. Although the instrument's overarching structure was informed by the framework established in the cited study, the questionnaire items were meticulously formulated and adapted to the particular context of Arduino Robotics and the specific aims of the current research.

The instrument was divided into two sections. The initial section collected data on respondents' demographic and professional backgrounds. This encompassed age, sex, marital status, years of teaching experience, academic rank, primary field of specialization, highest level of education attained, and involvement in Arduino Robotics-related training. These variables were used to classify respondents by their individual and professional attributes.

The second part assessed respondents' technical competence in Arduino Robotics. This section covered eight competency domains: electronics fundamentals, Arduino programming, embedded systems and microcontroller applications, robotic mechanics and design, sensor integration and automation, wireless communication and Internet of Things (IoT) integration, robotics assembly and

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testing, and project development and prototyping. The items in this section were measured using a five-point rating scale to determine the respondents' level of technical competence.

To establish the instrument's validity, expert validation was conducted by three specialists with expertise in robotics and STEM education. These experts evaluated the instrument to determine the relevance, clarity, and suitability of the questionnaire items concerning the study's aims. Their suggestions were integrated to refine the instrument's content and structure before it was distributed to participants.

Ethical Considerations

Ethical principles were strictly observed throughout the study. Before data collection, permission was obtained from the school authorities of the participating secondary schools. The respondents were provided with a letter of informed consent explaining the purpose of the research, the procedures involved, and the voluntary nature of their participation.

Participation in the study was entirely voluntary, and respondents were informed that they could decline or withdraw at any time without consequences. The anonymity and confidentiality of the respondents were strictly maintained. No identifying information was included in the questionnaire responses, and all collected data were treated with strict confidentiality.

All completed questionnaires and related research documents were stored securely and were accessible only to the researcher. The collected data were used solely for academic and research purposes to ensure the ethical integrity of the study.

Data Gathering Procedure

Before starting the research, the investigator obtained permission from the Schools Division Superintendent of Candon City to distribute the survey questionnaire in the chosen secondary schools. After receiving approval from the Schools Division Office, the researcher then sought permission from the school administrators of the participating schools to begin the data collection.

After receiving the necessary approvals, the researcher worked with administrators and teachers to establish the schedule and procedures for distributing the questionnaire. The survey questionnaires were then physically distributed to the selected participants at their schools.

Before the administration of the questionnaire, the researcher elucidated the study's objectives and furnished explicit directions for instrument completion. The participants were apprised of the voluntary nature of their involvement, and assurances were given that all responses would be handled with the utmost confidentiality.

The participants were given enough time to complete the questionnaire, which usually took about five to ten minutes. The researcher was available throughout the survey to answer any questions or clarify anything the participants needed. After the questionnaires were finished, they were collected right away. This was done to ensure all the answers were complete and to prepare the data for later analysis.

Data Analysis

The gathered data underwent organization, tabulation, and subsequent analysis employing descriptive statistical methods, thereby facilitating a thorough synthesis of the observed results. Initially, the survey questionnaire responses were aggregated and encoded to guarantee both precision and comprehensiveness prior to the analytical phase.

Demographic and professional characteristics of the participants were delineated through descriptive statistics, encompassing frequency counts and percentages. These statistics encompassed age, sex, marital status, years of teaching experience, academic rank, primary field of specialization, highest level of education achieved, and prior participation in Arduino Robotics training.

To assess respondents' level of technical competence

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in Arduino Robotics, a weighted mean was used. The computed mean scores were used to determine the overall competence level across the identified competency domains.

The interpretation of the mean scores followed a five-point rating scale with the following descriptive equivalents: 4.20–5.00 (Very Competent), 3.40–4.19 (Competent), 2.60–3.39 (Moderately Competent), 1.80–2.59 (Slightly Competent), and 1.00–1.79 (Not Competent).

RESULTS AND DISCUSSION

The study's findings are presented and discussed in relation to the profiles and technical competencies of school administrators and teachers in Arduino Robotics.

Profile of Administrators and Teachers

Table 1. Profile of Respondents

Socio-Demographic Profile	Administrators (f)	Administrators (%)	Teachers (f)	Teachers (%)
Age				
29 years old and below	–	–	17	21.50
30–39 years old	–	–	32	40.50
40–49 years old	5	71.40	22	27.80
50–59 years old	2	28.60	8	10.10
Total	7	100.00	79	100.00
Sex				
Female	4	57.10	52	65.80
Male	3	42.90	27	34.20
Total	7	100.00	79	100.00
Civil Status				
Single	2	28.60	28	35.40
Married	5	71.40	51	64.60
Total	7	100.00	79	100.00
Years in Teaching				

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1–3 years	–	–	23	29.10
4–6 years	–	–	15	19.00
7–9 years	1	14.30	18	22.80
10 or more years	6	85.70	23	29.10
Total	7	100.00	79	100.00
Academic Rank				
Teacher I	–	–	19	24.10
Teacher II	–	–	9	11.40
Teacher III	–	–	45	57.00
Master Teacher I	2	28.60	4	5.10
Master Teacher II	–	–	1	1.30
Master Teacher III	1	14.30	1	1.30
School Principal I	1	14.30	–	–
School Principal III	1	14.30	–	–
School Principal IV	2	28.60	–	–
Total	7	100.00	79	100.00
Major Field of Specialization				
English	–	–	2	2.50
Filipino	–	–	1	1.30
Science	5	71.40	42	53.20
Mathematics	2	28.60	3	3.80
Social	–	–	1	1.30

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Science				
MAPEH	–	–	2	2.50
TLE/TVL	–	–	28	35.40
Total	7	100.00	79	100.00
Educational Attainment				
College Graduate	–	–	38	48.10
With MA/MS Units	–	–	11	13.90
MA/MS Graduate	3	42.90	22	27.80
With PhD Units	1	14.30	4	5.10
PhD Graduate	3	42.90	4	5.10
Total	7	100.00	79	100.00

Age

The age distribution of the respondents shows that most administrators were in the 40–49 age bracket (5 or 71.4%), while the remaining two (2) administrators, or 28.6%, were aged 50–59. This indicates that most administrators are in the mid- to late stages of their professional careers. Among teachers, the largest proportion belonged to the 30–39 age group (32 or 40.5%), followed by those aged 40–49 (22 or 27.8%). Teachers aged 29 years and below accounted for 17 respondents (21.5%), while only 8 (8) or 10.1% were in the 50–59 age bracket. These findings suggest that the teaching workforce in the participating schools is composed largely of early- to mid-career educators, while more experienced individuals predominantly hold administrative positions.

Sex

In terms of sex, female respondents comprised most of both administrators and teachers. Among administrators, 4 (57.1%) were female, while 3 (42.9%) were male. Similarly, female teachers accounted for 52 respondents, or 65.8% of the total, while male teachers accounted for 27 respondents, or 34.2%. This distribution indicates a higher representation of females in both teaching and administrative positions within the participating schools, reflecting the broader trend of female predominance in the education sector.

Civil Status

About civil status, most administrators were married, with five (5) or 71.4% reporting this status, while two (2) or 28.6% were single. A similar pattern was observed among teachers: 51 respondents, or 64.6%, were married, and 28, or 35.4%, were single. These results indicate that a significant proportion of both administrators and teachers are married, which may reflect the

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relatively mature professional profile of educators in the participating schools.

Years in Teaching

Regarding teaching experience, most administrators reported extensive experience in the profession. Six (6) administrators, or 85.7%, had ten or more years of teaching experience, while only one (1) administrator, or 14.3%, had between seven and nine years of teaching experience. Among teachers, the distribution of teaching experience was more varied. Twenty-three (23) teachers or 29.1% had between one and three years of teaching experience, while another 23 teachers (29.1%) had ten or more years of experience. Eighteen teachers (22.8%) reported seven to nine years of teaching experience, while fifteen teachers (19.0%) had four to six years of experience. This distribution suggests that the teaching workforce consists of both newly hired and experienced educators.

Academic Rank

The academic ranks of administrators and teachers reflect their respective professional responsibilities within the schools. Among administrators, the largest proportions held positions as Master Teacher I (2, or 28.6%) and School Principal IV (2, or 28.6%). Other administrative positions included Master Teacher III (14.3%), School Principal I (14.3%), and School Principal III (14.3%). For teachers, the majority held the rank of Teacher III (45 or 57.0%), followed by Teacher I (19 or 24.1%) and Teacher II (9 or 11.4%). A smaller number of teachers held higher ranks such as Master Teacher I (4 or 5.1%), Master Teacher II (1 or 1.3%), and Master Teacher III (1 or 1.3%). These results indicate that most teachers occupy mid-level teaching positions, while administrators hold leadership roles within the school structure.

Major Field of Specialization

Regarding specialization, most administrators had academic backgrounds in Science, with five (5) respondents or 71.4%, while two (2) administrators, or 28.6%, specialized in Mathematics. Among teachers, the largest group specialized in Science (42 or 53.2%), followed by those in Technology and Livelihood Education/Technical-Vocational-Livelihood (TLE/TVL) with 28 respondents or 35.4%. Smaller proportions of teachers specialized in English (2 or 2.5%), Filipino (1 or 1.3%), Mathematics (3 or 3.8%), Social Science (1 or 1.3%), and MAPEH (2 or 2.5%). This distribution indicates that a substantial proportion of respondents have academic backgrounds in STEM and technical fields.

Educational Attainment

In terms of educational attainment, administrators generally possessed advanced academic qualifications. Three (3) administrators, or 42.9%, were MA/MS graduates; another three (3), or 42.9%, had already completed a doctoral degree; and one (1) administrator, or 14.3%, had earned doctoral units. Among teachers, the majority were college graduates (38 or 48.1%), followed by those with MA/MS degrees (22 or 27.8%). Eleven teachers (13.9%) reported having MA/MS units, while four (4) teachers, or 5.1%, had doctoral units, and another four (4), or 5.1%, had already completed doctoral degrees. These findings suggest that while many teachers hold undergraduate degrees, a considerable number have pursued graduate studies to further their professional qualifications.

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Table 2. Training Attended in Arduino Robotics by Administrators and Teachers

Level of Training	Administrators (Days Attended) f (%)	Administrators (Hours Attended) f (%)	Teachers (Days Attended) f (%)	Teachers (Hours Attended) f (%)
International				
With Training	0 (0.00)	0 (0.00)	1 (1.27)	1 (1.27)
No Training	7 (100.00)	7 (100.00)	78 (98.73)	78 (98.73)
Total	7 (100.00)	7 (100.00)	79 (100.00)	79 (100.00)
National				
With Training	0 (0.00)	0 (0.00)	4 (5.06)	3 (3.80)
No Training	7 (100.00)	7 (100.00)	75 (94.94)	76 (96.20)
Total	7 (100.00)	7 (100.00)	79 (100.00)	79 (100.00)
Regional				
With Training	0 (0.00)	0 (0.00)	6 (7.59)	4 (5.06)
No Training	7 (100.00)	7 (100.00)	73 (92.41)	75 (94.94)
Total	7 (100.00)	7 (100.00)	79 (100.00)	79 (100.00)
Division				
With Training	0 (0.00)	0 (0.00)	4 (5.06)	4 (5.06)
No Training	7 (100.00)	7 (100.00)	75 (94.94)	75 (94.94)
Total	7 (100.00)	7 (100.00)	79 (100.00)	79 (100.00)
District				
With Training	0 (0.00)	0 (0.00)	2 (2.53)	3 (3.80)

Level of Training	Administrators (Days Attended) f (%)	Administrators (Hours Attended) f (%)	Teachers (Days Attended) f (%)	Teachers (Hours Attended) f (%)
No Training	7 (100.00)	7 (100.00)	77 (97.47)	76 (96.20)
Total	7 (100.00)	7 (100.00)	79 (100.00)	79 (100.00)
School-Based				
With Training	1 (14.29)	0 (0.00)	9 (11.39)	8 (10.13)
No Training	6 (85.71)	7 (100.00)	70 (88.61)	71 (89.87)
Total	7 (100.00)	7 (100.00)	79 (100.00)	79 (100.00)

Training Attended in Arduino Robotics

The training exposure of administrators and teachers in Arduino Robotics across different levels is presented in Table 2. The results indicate that none of the administrators had attended robotics-related training at the international, national, regional, divisional, or district levels. All seven administrators (100%) reported having no training at these levels, in terms of both the number of days and the number of hours attended. Only one administrator (14.29%) reported attending a school-based training activity, but no training hours were recorded. This finding suggests that administrators generally have limited formal exposure to Arduino Robotics training.

Similarly, the results show that the majority of teachers had not participated in robotics-related training across most levels. At the international level, only one teacher (1.27%) reported having attended training, while 98.73% had no training exposure. At the national level, four teachers (5.06%) reported attending training in terms of days, while three teachers (3.8%) reported training hours. Slightly higher participation was observed at the regional level, where six teachers (7.59%) attended training in terms of days and four teachers (5.06%) in terms of hours. Participation at the division and district levels remained low, with only a small proportion of teachers reporting attendance at training.

Across the different levels, school-based training recorded the highest participation among teachers, with 9 teachers (11.39%) reporting attendance in days and 8 teachers (10.13%) in hours. Nevertheless, the majority of teachers (88.61% and 89.87%) still reported no participation in school-based robotics training. Overall, these findings indicate that both administrators and teachers have limited exposure to formal Arduino Robotics training, suggesting a potential gap in professional development opportunities related to robotics-based instruction.

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Level of Technical Competence in Arduino Robotics

Table 3. Technical Competencies of Administrators and Teachers

Competency	Administrators	Teachers	[illegible]	Descriptive Equivalent
Electronics Fundamentals	2.48	1.80	[illegible]	Slightly Competent
Arduino Programming	2.22	1.57	[illegible]	Slightly Competent
Embedded Systems and Microcontroller Applications	2.06	1.50	[illegible]	Not Competent
Robotic Mechanics and Design	2.23	1.53	[illegible]	Slightly Competent
Sensor Integration and Automation	1.95	1.50	[illegible]	Not Competent
Wireless Communication and IoT Integration	2.05	1.49	[illegible]	Not Competent
Robotics Assembly and Testing	2.05	1.46	[illegible]	Not Competent
Project Development and Prototyping	1.97	1.45	[illegible]	Not Competent

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Grand Mean	2.13	1.54	[illegible]	Slightly Competent

Level of Technical Competence in Arduino Robotics

Table 3 presents the level of technical competence of administrators and teachers in Arduino Robotics across eight competency domains. The results show that the overall competence level of the respondents was slightly competent, as indicated by the grand mean of 1.83. Administrators obtained a higher overall mean score (2.13) compared with teachers (1.54), although both groups generally demonstrated limited competence in the different areas of robotics.

Among the competency domains, electronics fundamentals obtained the highest mean score (2.14), interpreted as slightly competent. This was followed by Arduino programming (1.90) and robotic mechanics and design (1.88), which were also interpreted as slightly competent. These findings suggest that respondents have some foundational understanding of basic electronics and introductory robotics concepts.

However, several competency domains were rated not competent, including embedded systems and microcontroller applications (1.78), sensor integration and automation (1.73), wireless communication and IoT integration (1.77), robotics assembly and testing (1.75), and project development and prototyping (1.71). These results indicate that respondents have limited knowledge and practical skills in more advanced aspects of robotics development and system integration.

Overall, the findings suggest that while administrators and teachers possess minimal familiarity with basic robotics concepts, their competence in more complex Arduino robotics applications remains limited. This indicates a need for professional development programs and training opportunities to enhance educators' technical competencies in robotics-based instruction.

CONCLUSIONS

Profile of Administrators and Teachers

The demographic and professional profiles of administrators and teachers do not, on their own, indicate readiness for Arduino Robotics instruction. While variations in age, years of teaching experience, specialization, academic rank, and educational attainment were observed, these characteristics alone do not translate into preparedness for robotics-based teaching. The generally limited exposure of both administrators and teachers to formal Arduino Robotics training suggests that professional experience and academic credentials are insufficient indicators of instructional readiness in robotics education.

Technical Competence in Arduino Robotics

The level of technical competence of administrators and teachers in Arduino Robotics is insufficient to support comprehensive and effective instruction. Although respondents demonstrated slightly higher competence in foundational areas such as electronics fundamentals and basic Arduino programming, overall competence remained low, particularly in advanced domains including embedded systems, sensor integration and automation, wireless communication and IoT integration, robotics assembly and testing, and project development and prototyping. This limited technical competence constrains educators' capacity to facilitate meaningful, hands-on, and problem-based robotics learning experiences in secondary education.

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RECOMMENDATIONS

Based on the findings and conclusions of the study, the following recommendations are proposed:

1. Structured seminars, workshops, and hands-on training activities focusing on Arduino Robotics competencies may help address the identified gaps in technical competence. Emphasis should be placed on both foundational and advanced domains, including programming, system integration, and project development, to strengthen educators' instructional readiness.
2. Teachers may benefit from intensive technical and instructional training. At the same time, administrators may be supported through programs that enhance their understanding of robotics concepts, enabling informed instructional leadership and program supervision.
3. Periodic evaluation may serve as a benchmark to monitor progress, identify persistent gaps, and inform data-driven decisions related to professional development planning and instructional support.
4. Schools may promote peer mentoring, learning action cells, or communities of practice that allow teachers with relatively higher competence to support colleagues with limited robotics experience, thereby fostering continuous skill development through collaborative learning.
5. Subsequent research may examine the relationship between technical competence and instructional practices, student learning outcomes, or program sustainability to provide a more comprehensive understanding of robotics education in secondary schools.

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