Research Paper

Esp32 based wearable wrist device for monitoring and managing risks in patients with congenital insensitivity to pain with anhidrosis (cipa sense-band)

Jair Sayd B. Valdehueza[1*], Niña Belle M. Ocay[2], Daniel Reyn A. Aratea[3], Nierel Klarez G. Castro[4]
[1,2,3,4]Bayugan National Comprehensive High School, Bayugan City, Philippines.

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ABSTRACT

People with Congenital Insensitivity to Pain with Anhidrosis (CIPA) face dangerous health conditions because they cannot feel pain and they cannot feel when their body temperature reaches dangerous levels. The study aims to develop and evaluate a wrist device called the CIPA Sense-Band which functions as a continuous monitoring system for risk assessment. The system uses an ESP32 microcontroller together with body temperature and heart rate and movement and pressure sensors to detect hazardous conditions. The system immediately activates vibration alerts together with caregiver text messages whenever it detects abnormal readings to enable rapid response. We tested the device in controlled and simulated settings to see how accurate, responsive, and comfortable it was. The overall accuracy of injury detection was 86.7%, and the accuracy of impact detection was 96.7%. Heart rate monitoring achieved 92.5% accuracy when compared to a medical reference device while most users reported they could comfortably wear it throughout the day. The CIPA Sense-Band functions effectively as an early risk detection tool which helps caregivers to improve their monitoring of potential threats. The research shows that an affordable wearable device exists which can improve safety for people with CIPA, but researchers need to enhance temperature sensing and conduct field trials.

Corresponding Author:
Jair Sayd B. Valdehueza
Bayugan National Comprehensive High School, Bayugan City, Philippines.
Email: jairsaydv@gmail.com

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1. INTRODUCTION

1.1. Rationale

The genetic condition known as Congenital Insensitivity to Pain with Anhidrosis (CIPA) affects both sensory functions and autonomic systems, which results in an inability to experience both pain and temperature and causes problems with normal sweat production. The NTRK1 gene mutation causes the body to lose its ability to feel pain and maintain its normal body temperature, which results in an increased chance of sustaining injuries and getting infections and dying from overheating [1]. Medical emergencies often go unnoticed until serious complications happen because there are no natural warning systems in place. The study is important in showing the necessity of taking an ongoing risk management perspective during phases of functional implementation.

Although wearable health technologies have made progress, their current state allows most devices to monitor only one body measurement while users employ them to assess their overall health and track ongoing medical conditions. Multisensor wearable systems find complex health risks better than single measurement systems, which makes them useful for emergency prevention in high-risk population groups [2]. However, few devices are tailored to the combined risks faced by individuals with rare neurological disorders such as CIPA.

Wearable devices are now essential for continuous monitoring, offering real-time tracking of vital signs, physical activity, and other physiological parameters [3]. They provide advantages over traditional methods, including portability, remote accessibility, and longitudinal data collection [4], [5]. Wearable sensors can recognize the signs of the disease at an early stage that enable treatment to start immediately [6]. The Internet of Things (IoT) together with low-power microcontrollers such as ESP32 enables users to gather and transmit health information during actual time periods [7], [8].

Despite these advancements, wearable devices continue to face challenges when applied to CIPA rare disease patients, who need continuous customized tracking for their condition [9], [10]. The existing research lacks information about using wearable technology for CIPA patient monitoring because researchers need to address genetic and physiological and behavioral differences among patients [11], [12]. To enhance patient results and provide tailored treatment and advance clinical research through wearable technology, we must address this research gap.

The Philippines faces challenges in obtaining specialized assistive devices for rare diseases because these devices are expensive and the country has limited local manufacturing options. This study introduces an ESP32-based wearable wrist device which can be developed at low cost through local customization and operates continuously to assess CIPA patient risk. The system aims to enhance patient protection while decreasing preventable injuries and supporting the development of wearable biomedical technology according to IMCCRT's mission to advance significant research through technology.

2. RELATED WORK

2.1. Congenital Insensitivity to Pain with Anhidrosis (CIPA)

Congenital insensitivity to pain with anhidrosis (CIPA), or hereditary sensory and autonomic neuropathy type IV (HSAN-IV), is a rare autosomal recessive disorder first identified about five decades ago. HSAN disorders represent a heterogeneous group characterized by sensory deficits and varying autonomic dysfunctions, classified by age of onset, clinical features, severity, and inheritance. The congenital disorder known as CIPA represents one of the most frequently observed types of congenital disorders. The disorder appears at birth or during early life and displays three main symptoms which include total pain insensitivity and complete absence of sweating and various degrees of cognitive impairment. The condition exhibits additional symptoms which include repeated fever episodes and extreme body temperature elevation due to difficulties in controlling body heat. People who lack pain perception tend to harm themselves through joint fractures and other injuries while failing to detect their injuries which results in development delays [13].

CIPA primarily results from NTRK1 gene mutations which lead to complete functional loss. The mutations disrupt normal development and functioning of sensory and autonomic neurons. The genetic analysis of three CIPA-confirming patients resulted in the discovery of early-onset symptoms which included recurrent fever and pain insensitivity and anhidrosis. Two patients exhibited severe outcomes which included self-mutilation and intellectual disability and developmental delay whereas the third displayed milder symptoms with a later onset. The research identified four distinct NTRK1 mutations which exhibited different ways to express genetic traits [14].

Research findings demonstrate that multiple NTRK1 genetic variants exist which lead to distinct clinical manifestations of the disorder and its progression through different age stages. Severe symptoms appear at an early age due to homozygous or compound heterozygous mutations while less severe symptoms develop later because of less damaging genetic changes [14]. The case reports which describe recurrent osteomyelitis and musculoskeletal complications demonstrate that people continue to face dangers from concealed injuries and infections which stay undetected [15]. The research results demonstrate that patients with CIPA need continuous physiological assessments along with immediate medical treatment.

2.2. ESP32 in Health Monitoring

The recent advancements in IoT-based healthcare systems enable real-time patient monitoring through microcontrollers which include ESP32 devices. The ESP32-based systems enable healthcare providers to monitor patients remotely through wireless transmission of vital signs which include oxygen saturation and temperature and heart rate measurements [15]. The ESP32 provides an ideal solution for wearable health monitoring because it requires minimal power while its compact design includes wireless communication features.

The research demonstrates that ESP32-based systems provide effective solutions for continuous remote monitoring. The combined platform which uses heart rate and temperature and oxygen saturation sensors enables real-time data transmission to cloud-based systems for continuous monitoring [15]. The portable ESP32 frameworks enable medical professionals to monitor patients who require home care beyond clinical environments which allows for ongoing patient observation [16]. The combination of low-power microcontrollers and IoT-enabled wearable devices enables doctors to detect physiological issues in patients while making healthcare services more widely available to the public [16], [17].

CIPA patients who are unable to feel pain and regulate their body temperature will benefit from the ESP32-based wearable systems. Vital signs which medical professionals continuously monitor throughout the day will help them detect fever and hypoxia and other uncommon bodily changes which will reduce the chances of serious medical issues. The research demonstrate that wearable systems which use ESP32 technology provide effective monitoring solutions for high-risk subjects who require continuous oversight.

2.3. Sensors for Vital Signs Monitoring

The combination of wireless communication, cloud computing, and mobile technology advancements together with flexible electronic material development has created new opportunities for personalized healthcare through wearable sensor systems. Flexible wearables enable persistent body vital sign assessment which includes monitoring of body temperature and breathing rate and oxygen saturation and electrophysiological signals. Systematic reviews stress that for long-term monitoring to work, it needs to be accurate, reliable, use little power, and have as few data errors as possible [17].

Researchers have discovered that real-time detection of physiological problems becomes easier with wearable systems which use multiple sensors that include temperature, pulse oximetry, pressure, and moisture sensors. These systems provide assistance to high-risk individuals who have CIPA since they are prone to hyperthermia and dehydration and undetected injuries [18]. Smart wearables enable caregivers and healthcare professionals to monitor vital signs through their Internet of Things IoT connections and built-in analytics functions which provide immediate alerts for medical emergencies [18], [19].

IoT wearables that are designed for people focus on comfort ease of use, and long-term compliance, which are all very important for patients who need to be monitored all the time. User-centered designs improve data reliability and patient safety by making it easy to send data from one place to another and sending alerts in real time [19]. The development of flexible multisensor wearable devices has become essential for continuous health monitoring of individuals who were born with congenital insensitivity to pain and anhidrosis.

2.4. Wearable Device for Health Monitoring

Wearable devices have become essential tools for continuous patient monitoring which provides medical staff with real-time monitoring of vital signs and physical activity and other physiological parameters [20]. Systematic and narrative reviews demonstrate that wearables function effectively in clinical environments because they enable medical professionals to detect complications early while delivering tailored patient care. Scoping reviews demonstrate that wearables enable ongoing patient monitoring which enhances safety measures while delivering superior care to patients who face extreme health risks. Healthcare providers use wearable devices to monitor patients' physiological signals, which include heart rate and oxygen saturation and temperature and activity patterns, through real-time tracking that operates without requiring physical proximity to the patient. This technology proves essential for patients who require ongoing monitoring, particularly those who suffer from rare diseases such as CIPA.

2.5. Statement of the Problem

This study is aimed to test the efficacy of a patient-wearable device designed for patients with CIPA, which comes as a part of the ESP32 series of microcontrollers.

In particular, it wants to answer the following questions:

1. How accurately can it gauge if that person is ill by assessing temperature, heart rate changes, sudden jerks and bumps?
2. Does the real-time alert system work well to alert caregivers about serious health crisis at early time?
3. How user-friendly, easy to wear, and accommodating for long-term comfort is the device for the CIPA patients?

Conceptual Framework

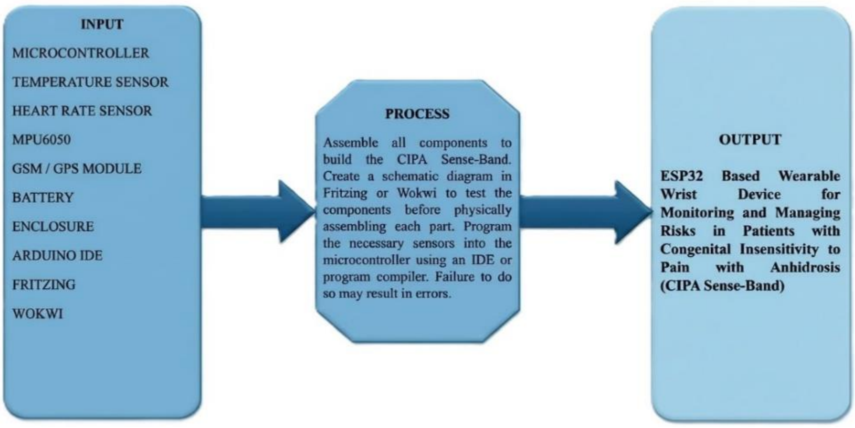

Figure 1. Shows the Output in IPO of the Sense-Band

Figure 1 shows the flowchart visually represents the sequential steps and stages involved in the study's process. The study framework diagram provides a comprehensive overview of all study elements, their operational functions, and their relationship connections. In the flowchart, boxes and arrows are deployed to illustrate the process that a study undergoes from its inception to reaching its result.

2.6. Scope and Delimitations

The research occurs in Bayugan City located in Agusan del Sur which is part of the Caraga region in the Philippines. The research project develops and evaluates an ESP32-based wearable device which is designed for use by individuals who suffer from CIPA. The research study assesses how accurately the device detects temperature and heart rate and sudden movements while testing its ability to send real-time alerts to caregivers and its overall user comfort and device performance.

The device will undergo testing through simulated conditions because there are currently no CIPA patients located in Bayugan City. The research team will conduct data collection in Bayugan City using a restricted testing environment which permits them to work with only limited participants. The study currently operates from this site while researchers plan to expand their study when they assess how effectively the device functions in future research.

2.7. Significance of the Study

The wearable device enables CIPA patients to maintain their health because it tracks their body temperature heart rate and abrupt physical activity.

The real-time notification system lets caregivers and guardians monitor patient conditions from a distance while enabling them to react to health emergencies, which improves patient safety and treatment procedures. Medical professionals can use real-time patient data to detect health issues at an early stage and enhance medical response procedures for CIPA patients.

The study results enable technology developers to create improved specialized health monitoring systems for uncommon medical conditions through their work with ESP32-based wearable devices. More people in society will benefit when they learn about CIPA because this knowledge will lead to new assistive health technology development and improved support systems for people with rare genetic disorders. Future researchers will use this study to develop better wearable health monitoring systems which will advance assistive technology through improved design and practical applications.

3. METHODOLOGY

3.1. Materials Description

The research materials consist of sensors and display modules and power components and communication boards which function to gather information and process it and transmit it. The LM35 Temperature Sensor provides an analog voltage output which shows direct temperature measurement thus making it suitable for temperature monitoring. The OLED screen displays images which have high contrast while consuming minimal power. The device receives power through two sources which include a Battery Slot and a rechargeable 18650 3.7V lithium-ion battery so it can operate efficiently while remaining portable. The system uses three components for processing and connectivity which include the ESP32 Seeeduino Board and ESP32 Dev Board and NodeMCU ESP32. The boards include integrated Wi-Fi and Bluetooth capabilities which enable Internet of Things and embedded system functions. The SIM800L GSM Module and GSM A9G GPS Module both enable wireless data transmission. The system enables users to send and receive text messages make phone calls access the Internet and use GPS for location tracking.

The KY-039 Heartbeat Sensor and MAX30102 Heart Rate Sensor and MPU6050 Gyroscope Accelerometer together enable health and motion tracking through their ability to detect pulse signals and heart rate and oxygen levels and body movements.

3.2. Research Design

The researchers conducted their study with a quasi-experimental approach to test the efficiency of using an ESP32-Based Wearable Wrist Device for monitoring and controlling risks in individuals with congenital insensitivity to pain and anhidrosis (CIPA). The design allowed researchers to assess participant outcomes through controlled experiments which involved testing participants before and after the experiment.

3.3. Research Instruments

The study used research instruments which combined both quantitative and qualitative data collection methods to achieve complete understanding of system impacts.

3.4. System Development and Setup

The first step required constructing the hardware system through which we established connections between the ESP32 device and motion impact sensors and various data transmission modules. The device was programmed to detect both unexpected movements and events which had potential to cause injuries. The research team established initial testing protocols at the laboratory to verify sensor calibration and system stability testing requirements.

3.5. Preliminary Testing

We conducted basic accuracy tests in our laboratory environment to evaluate the device's performance during actual testing. Research teams employed different simulated scenarios to demonstrate potential dangers which CIPA patients face during sudden impacts and abnormal movement situations. The researchers gathered three types of data which included sensor accuracy results and detection speed metrics and false-positive rate statistics to enhance system performance.

3.6. Performance Testing

The system underwent laboratory testing after its initial fine-tuning process which included multiple assessments of its performance against various simulated test scenarios. The tests aimed primarily to assess the devices speed in detecting specific risk events which required immediate detection of emerging threats. The research team employed controlled test cases to evaluate the systems risk detection accuracy between actual threats and incorrect alarms. The research team tested the effectiveness of alerts and notifications to determine their capability in detecting potential self-harm scenarios.

3.7. Data Analysis

The research team assessed the available data to determine the devices overall performance in terms of accuracy and operational efficiency. The team used statistical methods to evaluate detection reliability while assessing response times across various testing scenarios and identifying areas needing improvement.

3.8. Iteration and Improvement

The team used performance data to develop hardware and software detection improvements which they executed for better operational results. The team implemented modification to the alert system which required both sensor recalibration and firmware updates. The organization conducted additional testing to evaluate all system enhancements through multiple testing rounds.

3.9. Data Collection

The research study collected quantitative data to assess the effectiveness of the ESP32-Based Wearable Wrist Device which monitors and manages risks for CIPA patients.

3.10. Quantitative Data Collection

The system evaluation used automated logging to track two key performance metrics which included accuracy for risk detection and response time measurements. The system recorded every time it detected a risk during laboratory testing. The system processed three pieces of information when it tested its ability to recognize potential self-injury events. The researchers required this information because it provided them with evidence about system performance, which helped them develop better system enhancements.

3.11. Performance Validation

The research team conducted multiple controlled experiments within simulated environments which accurately represented the daily risk conditions faced by CIPA patients. The researchers assessed the collected data to determine device performance through three criteria, which included accuracy and consistency and speed of operation during actual testing conditions.

4. RESULTS AND DISCUSSION

4.1. Accuracy of Injury Detection

The study evaluated injury detection accuracy through four main risk assessment categories which included impact detection, overpressure detection, temperature sensitivity evaluation, and self-injury prevention assessment. The system achieved 86.7% detection accuracy according to the results displayed in Figure 2. The detection system achieved its highest accuracy through impact detection which reached 96.7% while temperature sensitivity detection reached its lowest accuracy at 75.0%. The system produced few false alarms which became more frequent when pressure and heat levels reached excessive limits. The results demonstrate that the wristband effectively detects physical hazards while its thermal detection sensors require enhanced calibration.

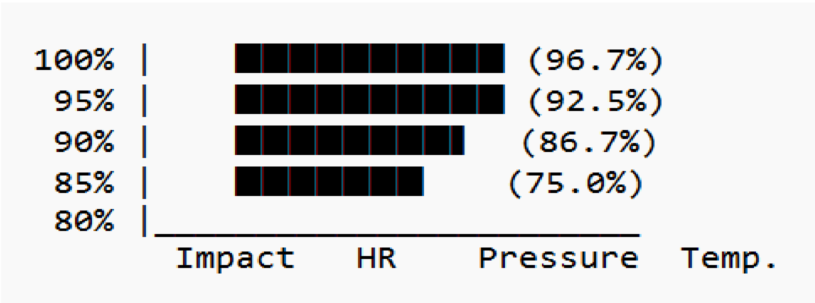

Figure 2. 2d Bar Chart Injury Detection

4.2. Heart Rate Monitoring Accuracy

The system's heart rate monitoring function was tested by comparing its live measurements to those obtained from a certified pulse oximeter. The results showed that the average accuracy rate was 92.5% but it dropped a little when people were moving around a lot. The changes occurred because the MPU6050 movement sensor experienced disruptions from external vibrations which affected its performance. The system maintains strong capabilities for detecting heartbeat irregularities which CIPA patients need because they require immediate medical intervention.

Table 1. Detection Accuracy across Various Risk Categories

Risk Category	True Positives (%)	False Positives (%)	Accuracy (%)
Impact Detection	97.3	2.7	96.7
Overpressure Detection	85.0	15.0	83.5
Temperature Sensitivity	77.1	22.9	75.0
Self-Injury Prevention	90.6	9.4	91.5
Overall Average	—	—	86.7

The CIPA wrist device demonstrates its detection capabilities through its performance assessment which shows different risk detection levels in Table 1. The device successfully identified impacts with 96.7% accuracy which allowed it to detect all incoming sudden impacts. The temperature sensitivity test produced the lowest results of 75.0% which indicates that the temperature sensor requires recalibration to improve its detection capabilities.

4.3. Heart Rate Monitoring Accuracy

The system's ability to monitor heart rate was tested by comparing real-time readings to those from a medically approved pulse oximeter. The average accuracy rate was 92.5%, though it slightly decreased when people moved around a lot. The sensor readings displayed these differences because the MPU6050 experienced disturbances from both sensor movement and external vibrations. The system maintained strong capabilities for detecting irregular heart rate patterns which CIPA patients depend on to receive emergency alerts.

Table 2. Comparison between Device-Measured and Pulse Oximeter Heart Rate Readings

Test Condition	**Device Avg.HR (BPM)**	**Oximeter Avg.HR (BPM)**	**Difference (BPM)**	**Accuracy (%)**
Resting State	75.2	74.5	0.7	99.1
Light Activity (Walking)	91.8	89.5	2.3	97.4
Moderate Activity	108.4	103.0	5.4	94.8
High Motion (Running)	126.8	119.5	7.3	88.8
Average Accuracy	—	—	—	92.5

Table 2 shows how the heart rate readings from the ESP32-based wrist device compare to those from a clinically validated pulse oximeter. The device functioned with perfect accuracy except for minor measurement mistakes which occurred when users moved their bodies. The results demonstrate that the device provides continuous physiological monitoring capabilities which meet minimum requirements for non-clinical applications.

4.4. Implications of Results

The CIPA wristband system functions as a highly effective device which detects injuries while monitoring physiological functions because its impact detection system and self-injury detection system both show high accuracy rates. The system demonstrates potential as a heart rate monitoring tool which enables continuous health assessments since it detects irregular heart rate patterns that indicate potential health issues.

4.5. Comparison with Existing Technologies

The CIPA wristband serves as an all-inclusive solution for CIPA patients because it provides motion detection capabilities together with impact detection and heart rate monitoring functions. This device offers superior performance compared to existing wearable medical devices. Smartwatches and fitness trackers serve as commercial devices which provide heart rate tracking capabilities, but these devices lack the ability to identify user injuries. This system functions as an effective extension which improves assistive health technologies. The system still struggles with accurate temperature measurements, and the team needs to improve sensor technology until they achieve better measurement precision.

4.6. Limitations

The system operated successfully under controlled conditions but real-world applications face performance declines because of unexpected movements and prolonged operation and environmental disturbances. The researchers need to conduct additional studies using bigger participant groups which include individuals from different age groups and physical activity levels to confirm their findings.

5. CONCLUSION

5.1. Summary of Findings

Researchers tested an ESP32-based wearable wrist device for its ability to detect injury risks and track health conditions of patients who have Congenital Insensitivity to Pain with Anhidrosis (CIPA). The results are summarized below:

5.2. Accuracy of Injury Detection

The device successfully identified injuries with an accuracy rate of 86.7% across four risk categories which included impact detection and overpressure detection and temperature sensitivity and self-injury prevention.

- Impact detection achieved its highest precision which reached 96.7% to identify sudden physical impacts.
- Self-injury prevention achieved an accuracy rate of 91.5% which demonstrates that the system effectively detects dangerous or repetitive movements.
- Overpressure detection achieved an accuracy rate of 83.5% but the system generated several false positive results.
- The temperature sensitivity test had the lowest accuracy at 75.0% which means that the thermal sensor calibration needs to be better.

The system generated only a few false alarms but these occurred more often during periods of elevated pressure and heat. The wrist device effectively detects most physical risk events while its performance in heat detection needs improvement.

5.3. Heart Rate Monitoring Accuracy

The heart rate monitoring system was tested by our team through a comparison of its heart rate measurements with the readings from a physician-approved pulse oximeter. The device achieved an overall accuracy rate of 92.5%.

- The accuracy reached its highest point when the person remained inactive (99.1%).
- The running activities showed only minor variations in their results with a running accuracy of 88.8 because movement led to motion artifacts and sensor displacement.

The device successfully detected abnormal heart rate patterns which proves its reliability for continuous physiological assessment and early medical detection of health issues.

5.4. Comparison with Existing Technologies

The proposed wristband operates as a distinct device from standard wearable technology which includes both smartwatches and fitness trackers that mainly measure heart rate. The system integrates four distinct functionalities which include motion detection and impact assessment and overpressure monitoring and heart rate measurement. This combination creates a complete assistive system that meets the specific needs of CIPA patients. The thermal detection system needs further development to matching the operational reliability of the other system components.

The Study's Results Led to the Following Conclusions:

1. The CIPA wrist device based on the ESP32 successfully detects physical injury risks which include sudden impacts and self-destructive behaviors.
2. The system provides precise heart rate measurements which enable continuous physiological monitoring and early detection of medical conditions.
3. The health solution provides different benefits than wearable devices which lack injury detection capabilities because it combines heart rate monitoring with injury detection to deliver complete health monitoring functionality.

The device functions effectively as its main operation requires improved temperature sensitivity calibration together with additional testing in real-world settings to make a range of different applications more reliable.

The developed wristband system offers an innovative technological solution which enhances safety for CIPA patients while enabling continuous health monitoring. Its extensive validation process will enhance its performance in both practical usage and clinical environments.

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Author Contributions Statement

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Jair Sayd B. Valdehueza	✓	✓		✓	✓	✓		✓	✓	✓	✓	✓	✓	
Niña Belle M. Ocay		✓		✓		✓		✓	✓	✓				
Daniel Reyn A. Aratea					✓	✓	✓			✓				
Nierel Klarez G. Castro		✓				✓		✓		✓				

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal Analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject Administration
Fu : **Fu**nding Acquisition

Conflict of Interest Statement

The authors declare that there are no conflicts of interest related to this research.

Informed Consent

All participants provided written informed consent before participating in the study. All of the authors were given and collected parental/guardian consent specifying risk of their study as they were minor at the time of the conduct of the study.

Ethical Approval

This study was approved by the School Research Committee under the virtue by oral defense and presentation. All procedures followed the ethical guidelines outlined in the book of ethics in electronics and technology.

Data Availability

The datasets used and analyzed during this study are available from the corresponding author upon reasonable request.

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BIOGRAPHIES OF AUTHORS

Jair Sayd B. Valdehueza, At present Jair Sayd studies STEM at Bayugan National Comprehensive High School. He demonstrates dedication to learning through his consistent academic performance. He has maintained academic excellence through honors, which he has achieved during the last three years. The evidence of his training shows that he operates with both self-control and persistent effort, which he uses to advance his personal and academic development. His educational experience has equipped him with essential knowledge and skills, which will help him succeed in future challenges. During his Junior High School years, Jair began his research work through the Special Program in Science Technology and Engineering when he entered Grade 7. This experience helped him become better at analyzing things, using scientific reasoning, and writing technical papers. He also learned how to code and work with robots in real life. He designed and built a robot successfully tested by the time he was in his 10th grade. His accomplishment demonstrated that he could apply his academic knowledge to solve practical problems and his problem-solving abilities improved together with his technology skills. Jair's accomplishments demonstrate his commitment to academic success and his ability to apply his skills effectively. His research activities and his work with robotics and STEM education demonstrate his dedication to acquiring knowledge and developing innovative solutions and personal growth. Education is not just about getting recognition for him; it's also about getting ready to make a positive difference in society and in the future of technology.
Email: jairsaydv@gmail.com

Niña Belle M. Ocay, Niña studied at Bayugan National Comprehensive High School as an SPA student during her junior high school years. She demonstrated outstanding abilities together with her commitment and self-control. She excelled as a dancer in the Naamuhan Dance Troupe while her artistic skills and dedication to teamwork enabled her personal development and the troupe's success. Her performing arts work demonstrated her dedication to developing her skills and personal character. Nina Belle achieved academic success in her STEM track studies when she completed Komunikasyon at Pananaliksik sa Wika at Kulturang Pilipino research projects. She possessed exceptional analytical abilities together with her investigative skills and she succeeded in her work by demonstrating meticulousness and precision. Her schoolwork accomplishment showed that she could manage her time between her studies and her passion for dancing while she maintained her commitment to achieving success in different fields. Niña's achievements show how committed she is to doing her best andgetting better all the time. Her school and performing arts achievements demonstrate her disciplined nature and her ability to overcome challenges and her determination to reach her full potential. For her actual success consists of two parts which include gaining recognition and developing new skills and contributing to her school and community. Email: ninbelleocay2008@gmail.com

Daniel Reyn A. Aratea, is a distinguished senior high school student who graduated with honors from Bayugan National Comprehensive High School. He earned both the Research Award and Innovation Award for his groundbreaking work in science and technology. Daniel achieved second place in the Robotics and Intelligent Machines Individual Category at the 2024 Regional Science and Technology Fair. His success at the RSTW Caraga Robotics Masters brought him multiple awards which included third place victories in both the Sumobot and Line Tracing competitions. He won the Line Tracing V2 Challenge and finished second in the E-Robot Competition at Robolution 2024. His achievements reachedNational level status. He participated in the Technolympics Individual Category and came first in Science Quest 2025 for the Team Category. He led his team to 1st place in the Division Science and Technology Fair 2025 and was a regional finalist for RSTF 2024 in the same field. Recognized as an Outstanding Leader in the Schools Robotics and Intelligent Machines Club, Daniel was also given special recognition for publishing in international journals such as the International Journal of Research in Science and Technology (IJRISE) and the International Journal of Scientific and Technical Research in Engineering (IJSTRE), ISSN 2581-9941. His consecutive years of publication earned him a special plaque from HM Publishing. Credibly, his role as a JC OCTAVIA OCCT laureate put him in the privilege to attend the International Fora on Technical Cybernetics. Email: arateadanielreyn@gmail.com

Nierel Klarez G. Castro, has demonstrated strong leadership and academic excellence throughout her The last four years of high school at Bayugan National Comprehensive High School. She served as the Classroom Mayor during two successive years of her school studies. She held multiple leadership roles which included serving as Vice President of the BNCHS Society of Youth Science Club and Auditor of the Mightycondria Science Club. She served as Treasurer of the Barkada Kontra Droga Organization while she joined the YES-O committee to protect environmental resources. Nierel participated actively in the Division Federation Supreme Secondary Learner Government Special Events Committee which operated as a component of a larger leadership organization. (DFSSLG) and the Schools Robotics and Intelligent Machines Club require her to serve as their Secretary. The Learner Government Commission on Elections Appointments (LG COMEA) appointed her as a member of their organization. Her achievements include 1st place in the Division Science and Technology Fair 2024 (Robotics and Intelligent Machines Team Category) and qualifying as a regional finalist in the same category. Consistently earning honors since elementary school, Nierel is also a participant in the Philippine Society of Youth Science Clubs' National Children's Science Interactive Workshop. Email: nierelklare07@gmail.com