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Whiteboard Marker Ink Refiller

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Abstract

This study designed, constructed, and evaluated a Whiteboard Marker Ink Refiller intended to integrate ink storage, monitoring, dispensing, and refilling into a reusable marker system. Anchored in General System Theory and an input-process-output conceptual framework, the study employed a descriptive developmental and quantitative research design. The device was developed using integrated mechanical, structural, and electronic components and was evaluated by 30 respondents comprising Department of Education faculty and staff, University of Southern Mindanao–Kidapawan City Campus faculty and staff, and students. A researcher-made questionnaire validated by panel members and technology experts was used to assess design and functional performance, with data analyzed through frequency count, percentage distribution, and mode. The device obtained a general mode of 4 (Agree) for design and 4 (Functional) for functional performance, demonstrating generally positive acceptance and the ability to meet its defined functional requirements with minimal issues. Identified challenges included airtight cap sealing, ink-level visibility, battery capacity, weight and distribution of internal components, and failure of the refilling mechanism after extensive testing. The study concluded that the Whiteboard Marker Ink Refiller successfully integrated its intended writing and refilling functions, while recommending improvements in cap sealing, battery performance, component positioning, construction strength, and electronic capabilities. The study supports SDG 12 (Responsible Consumption and Production), SDG 9 (Industry, Innovation and Infrastructure), and SDG 4 (Quality Education) through marker reuse, product innovation, and support for classroom instruction. Its sustainability impact lies in promoting resource efficiency, reducing the disposal and repeated purchase of depleted markers, and supporting the continued availability of a practical educational and workplace tool.

Keywords: Digital Ink Monitoring, Functional Performance, Product Innovation, Refillable Marker, Resource Efficiency, Sustainable Consumption, Whiteboard Marker Ink Refiller

1. Introduction

Whiteboard markers are widely used in educational and professional settings because they provide convenient, erasable writing on non-porous surfaces (Suzuki, Yuuko, 2003). However, conventional markers may run out of ink during use, require separately stored refills, and are frequently discarded once depleted. This contributes to inconvenience, recurring costs, and persistent synthetic waste (Slovakia, 2018). These concerns provide the basis for developing a Whiteboard Marker Ink Refiller that integrates convenient ink replenishment, monitoring, and dispensing into the marker system.

Whiteboard markers remain important tools for teaching, presentations, and professional communication, with applications across educational institutions, offices, homes, and creative settings (Wiseguysreport.com, 2025). However, markers may run out quickly, dry when improperly stored, produce irregular ink flow, or become separated from their refill supplies (Yuri Malishenko 2023). Marker usability also depends on its physical and functional characteristics. Weight, size, shape, hand size, and motor activity influence ergonomics and ease of use (Yuri Malishenko 2023). Likewise, effective markers should provide consistent writing and convenient

erasability, while refillable mechanisms can support continued use with fewer interruptions (Stephanie Janolo, 2024). Whiteboard marker ink is specifically formulated for non-porous surfaces, allowing markings to be easily removed without permanently bonding to the surface (Loddie Doddie, 2024).

Whiteboards and dry-erase markers emerged as cleaner alternatives to chalkboards and have continued to develop through innovations such as low-odor formulations (Gapssg 2023). Alternative marker inks have also been explored, including Basella alba (Malabar spinach), which demonstrated good color intensity and a softer odor profile (Rob Walker, 2024). Existing technologies further demonstrate the feasibility of improving marker refilling and dispensing systems. According to the invention of Frank Erwin Schulte, et al. (2010), dispenser pumps can regulate liquid delivery according to desired volumes. Replaceable ink-cartridge technologies have similarly allowed users to replenish whiteboard pens instead of discarding the entire marker. Refillable markers offer potential economic and environmental advantages by reducing repeated marker replacement. Consumers have expressed interest in eco-friendly refillable markers, although disposable markers remain common because of price differences (Young Reporters for the Environment, 2018). Reusable whiteboards and markers also provide economical and environmentally beneficial tools for teaching, brainstorming, project planning, and other activities (Shirley Ya, 2022).

Whiteboard markers continue to be relevant despite advances in digital educational technologies. ICT-based resources can enhance students' interest and learning (Ezziane, 2007), and interactive whiteboards have been adopted in educational institutions (Northcote et al. 2010). However, their use can be restricted by cost and training requirements (Manny-Ikanet et al.,2011), maintaining the practical relevance of conventional whiteboards and markers. The continued demand for whiteboard markers is also associated with their extensive use in educational and professional environments. North America represents a major market because of its educational infrastructure, corporate sector, interactive teaching practices, product innovation, and consumer awareness (Cognitive Market Research, 2024). Whiteboard markers remain effective for presentations, diagrams, explanations, and audience interaction (Luxor Seo, 2024).

The study is anchored in General System Theory (GST), which emphasizes the interrelationship of components within a complete system. The Whiteboard Marker Ink Refiller consists of interconnected components, including the ink reservoir, digital ink view panel, switch, foam wadding, charging port, delivery pin, and refilling mechanism. Their coordinated operation enables ink monitoring, dispensing, storage, and continued writing. The digital ink view panel provides feedback regarding ink levels, allowing users to control refilling and dispensing. This reflects the GST concepts of interaction, feedback, and control. Von Bertalanffy (2021), opined that all phenomena are entangled by the very premise of inter-relatedness and as such, we need to deliberately study this interwoven nature in order to grapple with it holistically. The conceptual framework follows an input-process-output approach. Inputs include ideas, related literature, prior arts, materials, tools, labor, construction procedures, and the questionnaire. These undergo planning, designing, constructing, testing, revising, and evaluating to produce the Whiteboard Marker Ink Refiller.

Despite existing developments in whiteboard markers, liquid dispensing systems, and replaceable cartridges, practical concerns remain. Conventional markers may experience rapid ink depletion, drying, irregular ink flow, and inconvenient refill storage (Yuri Malishenko 2023), while disposable markers contribute to persistent waste (Slovakia, 2018). The study therefore addresses the need for an integrated refillable marker system that combines ink storage, controlled dispensing, ink-level monitoring, and rechargeable operation. It specifically seeks to design and construct a Whiteboard Marker Ink Refiller and evaluate its design and functional performance.

The study primarily supports SDG 12 – Responsible Consumption and Production by promoting marker reuse through ink refilling rather than immediate disposal, potentially reducing waste from disposable writing instruments (Slovakia, 2018). It also relates to SDG 9 – Industry, Innovation and Infrastructure through the development of an integrated refilling and ink-monitoring mechanism. The project further connects with SDG 4 – Quality Education because whiteboard markers remain practical tools for classroom instruction and communication, particularly where more advanced technologies may be constrained by cost and training requirements (Ezziane, 2007) (Northcote et al. 2010) (Manny-Ikanet et al.,2011).

The study contributes to environmental, economic, technological, and educational sustainability. A refillable marker can reduce the disposal of depleted markers and promote more efficient use of materials (Slovakia, 2018). Reusing markers can also reduce repeated purchases while maintaining their usefulness in classrooms and workplaces (Shirley Ya, 2022). Technologically, the project integrates ink storage, digital ink monitoring, controlled dispensing, and rechargeable operation into one system. Educationally, it supports the continued availability of a commonly used teaching and communication tool. Thus, the Whiteboard Marker Ink Refiller combines practical product innovation with resource efficiency and more sustainable use of whiteboard markers.

2. Material and methods

2.1 Research Design

The study employed a descriptive developmental and quantitative research design. The developmental approach was used to design, construct, and test the Whiteboard Marker Ink Refiller, while the quantitative approach was applied to evaluate its design and functional performance. The device consisted of a top cover or lid, internal connector or sensor holder, main enclosure or housing tank, digital ink view panel, marker body with ink reservoir

or foam wadding, felt-tip cover, marker plastic cap, guide plate, drive motor assembly, syringe barrel with detachable delivery pin, plunger head, and rack. These components were integrated to enable ink storage, monitoring, dispensing, and refilling. The digital display and electronic sensor helped regulate ink flow, while the delivery pin transferred ink from the refiller tank to the foam wadding. The materials used in constructing the project included a 3D-printed design, switch, marker ink, drive motor, marker felt tip, colorless nail paint, foam wadding, syringe, internal connector or sensor, mini digital display, lithium polymer batteries, and other necessary materials. The reported material cost was Php2,770.00, while the contracted labor cost was Php5,000.00. Including miscellaneous expenses for visual and audio resources, Arduino IDE, and AutoCAD Civil 2025, the reported total project cost was Php17,770.00. The construction required a 3D printer, electric drill, ruler, marker pen, cutter, glue gun, soldering iron, and pliers. These were used for printing the designed components, creating holes, measuring and marking materials, cutting components, bonding parts, soldering electronic connections, and gripping, bending, or cutting materials during assembly. The development process involved designing the marker body, ink reservoir, and refilling mechanism, preparing the necessary components, assembling the marker and refilling system, and testing its design and functional performance. The construction process lasted 14 weeks, consisting of four weeks for planning and designing, two weeks for preparing materials, three weeks for fabrication, three weeks for testing and revision, and two weeks for evaluation. Adjustments were made during construction when necessary to improve the project design and functionality.

2.2 Locale of the Study

The Whiteboard Marker Ink Refiller was designed and created in Poblacion, Kidapawan City. The study was conducted at Estado High School in Estado, Matalam, Cotabato, and at the University of Southern Mindanao-Kidapawan City Campus.

2.3 Respondents of the Study

The study involved thirty (30) respondents composed of ten (10) Department of Education faculty and staff, ten (10) faculty and staff from the University of Southern Mindanao-Kidapawan City Campus, and ten (10) students. They evaluated the Whiteboard Marker Ink Refiller in terms of design and functional performance.

2.4 Sample and Sampling Procedure

Purposive sampling was used to select the respondents. The researcher selected participants whose profiles were considered appropriate for evaluating the project, particularly those with expertise relevant to the field of technology. The respondents provided their evaluations after observing the actual demonstration of the Whiteboard Marker Ink Refiller.

2.5 Research Instrument

The study used a researcher-made survey questionnaire to evaluate the design and functional performance of the Whiteboard Marker Ink Refiller. The instrument was validated by three (3) panel members and technology experts from the University of Southern Mindanao-Kidapawan City Campus. It obtained a mean validation result of 3.89, indicating that the questionnaire was reliable and may yield objective research data, with an error rate of 11–15%. The study also underwent Ethics Review and document checking before receiving the Certificate to Conduct. The design of the device was evaluated using a five-point Likert scale consisting of 5 for Strongly Agree, 4 for Agree, 3 for Neutral, 2 for Disagree, and 1 for Strongly Disagree. These ratings represented the respondents' levels of confidence and perceptions toward the design elements being evaluated. Functional performance was likewise evaluated using a five-point scale. A rating of 5 represented Fully Functional, indicating that the project consistently exceeded the defined functional requirements and expectations. A rating of 4 represented Functional, indicating that the project met the defined functional requirements with minimal issues. A rating of 3 represented Partially Functional, indicating that the basic functional requirements were met. A rating of 2 represented Barely Functional, indicating noticeable shortcomings and the need for further development, while a rating of 1 represented Not Functional, indicating failure to meet the basic functional requirements and the need for redesign.

2.6 Data Gathering Procedure

Before data collection, the researcher submitted the required documents for Ethics Review and obtained a Certificate to Conduct. A letter requesting permission was sent to the principal of Estado High School. Upon approval, the researcher distributed the evaluation questionnaire to the selected respondents and provided instructions and sufficient time for them to review the instrument. The respondents observed the actual demonstration of the Whiteboard Marker Ink Refiller and evaluated its design and functional performance using the survey questionnaire. The researcher also directly observed the implementation of the device and documented relevant observations and findings. After the evaluation, the completed questionnaires were collected and forwarded to the statistician for computation of the statistical results.

2.7 Data Analysis Techniques

The data gathered from the respondents were analyzed using frequency count, percentage distribution, and mode. A five-point Likert scale was used to quantify the respondents' assessments of the design and functional performance of the Whiteboard Marker Ink Refiller.

3. Results and Discussion

3.1 Design and Construction of the Whiteboard Marker Ink Refiller

3.1.1 Design of the Whiteboard Marker Ink Refiller

The Whiteboard Marker Ink Refiller was developed for use in classrooms, offices, and other settings requiring frequent whiteboard writing. The device incorporated a top cover, sensor holder, main enclosure or housing tank, digital ink display, linear actuator, N20 motor, plunger, rack, syringe barrel, guide plate, marker body, ink reservoir, felt tip, and cap. The refiller stored up to 5 ml of ink, equivalent to 100% capacity, and dispensed approximately 1 ml or 20% during each dispensing cycle. The 3D-printed marker body protected the internal components, while the ink reservoir, delivery system, and electronic components supported ink storage, monitoring, and dispensing. The integration of mechanical and electronic components supported the intended operation of the device. According to Fono-Tamo et al. (2021), the integration of embedded automation systems in institutional environments has increasingly focused on optimizing routine maintenance tasks. The design also used SketchUp Pro 2025, AutoCAD Civil 2025, and Arduino IDE to support technical design and automated operation. The interface among the N20 motor, linear rack-and-pinion assembly, and ink reservoir was designed to support precise operation (Marco et al., 2006; ResearchGate Fluid Systems, 2026). According to E. Brown 2023, developments in technology have also contributed to advances in writing ink and the use of non-permanent whiteboard inks as alternatives to chalkboards.

3.1.2 Construction of the Whiteboard Marker Ink Refiller

The Whiteboard Marker Ink Refiller was constructed through conceptualization, planning, material selection, fabrication, and integration of electronic components. Its construction consisted of four integrated assemblies: the structural chassis, motorized linear actuator, fluid delivery system, and electronic control unit. The 3D-printed chassis housed the internal components, while the N20 geared DC motor and rack-and-pinion mechanism controlled the syringe plunger. The fluid delivery system transferred ink from the reservoir to the marker core, while the Arduino-based electronic system controlled dispensing and plunger movement. A magnetic shaft encoder, digital display, and USB-C interface were incorporated to support operation, monitoring, and power delivery. The construction demonstrated the integration of the physical marker design with an automated refilling mechanism. This conforms by Stephanie Janolo 2024, that the functional performance of a whiteboard marker is determined by how well its ink formulation and physical design work with the whiteboard surface. A high-performing marker provides vibrant, consistent color and can be easily erased, while lower-quality markers may smudge, ghost, or dry out quickly. Having a high-quality refillable marker on hand at all times is a sustainable solution. Easy refill mechanism, changing a cartridge only takes a few seconds, allowing you to continue writing without any hassles.

3.2 Evaluation of the Whiteboard Marker Ink Refiller

3.2.1 Design Evaluation

The design evaluation obtained a general mode of 4, verbally described as Agree. Most respondents positively evaluated the marker's grip, non-slip surface, weight, ergonomic handling, ease of operation, digital display, material suitability, dimensions, and innovative characteristics. The digital status display, suitability of the materials for classroom and workplace environments, and innovative features received particularly positive responses. However, 13% of respondents were neutral regarding ergonomic weight distribution and innovative characteristics, while 10% were neutral regarding the marker's dimensions for writing. These findings indicate generally positive acceptance of the design while identifying weight, dimensions, and balance as areas for further improvement. The results indicate that the design generally accommodated user ergonomics and functional needs for classroom and workplace use. The neutral responses suggest that the size and weight of the 3D-printed enclosure may affect handling for some users because of the internal motor, battery, and other components. Current industrial workflows address these inconsistencies through the use of multi-disciplinary engineering frameworks (Fono-Tamo et al., 2021). As stated by Patel et al. (2018), using linear assemblies powered by direct-current motors enables repeatable and exact physical movement. These results demonstrate that the electronic integration is a perceived functional improvement of Whiteboard Marker Ink Refiller. This conforms the statement of E. Brown 2023, that for many years, in sync with the developments in technology has advanced, as has the development of writing ink drastically to satisfy the public's and the industry. Non permanent whiteboard inks started to take over classrooms in order to replace chalkboards. It was in light of the health hazards that have been raised through dusts of chalk.

3.2.2 Functional Performance Evaluation

The functional performance evaluation obtained a general mode of 4, verbally described as Functional. The device was generally rated functional in minimizing spills during refilling, displaying the ink level, maintaining ink flow at different writing angles, supplying sufficient ink through the foam wadding, preventing leakage from the refill tank, protecting the marker tip from drying, and providing a responsive sensor mechanism. The charging port, continued writing capability during low-battery conditions, and felt-tip resistance to ink leakage received particularly favorable evaluations. However, 37% rated the airtight marker cap criterion as Partially Functional, while 23% rated the visibility of the ink level as Partially Functional. During field testing, the battery was also completely drained and required recharging through a power bank. After extensive respondent testing, the refilling mechanism eventually failed, indicating the need for stronger construction and further revision. The findings indicate that the Whiteboard Marker Ink Refiller generally performed its intended writing and refilling functions despite identified mechanical and interface limitations. Its ability to remain useful for manual writing during low-battery conditions provided continued basic functionality even when the electronic refilling system was unavailable. Overall, the prototype automated the refilling process while maintaining the necessary writing functions, as reflected by the general mode of 4. This conforms with the statement of Stephanie Janolo (2024) which stated "Having a high-quality refillable marker on hand at all times is a sustainable solution. Easy refill mechanism, changing a cartridge only takes a few seconds, allowing you to continue writing without any hassles"

4. Conclusion & Recommendations

The study successfully designed, constructed, and evaluated the Whiteboard Marker Ink Refiller using mechanical, structural, and electronic components, including a 3D-printed housing, drive motor, internal connector or sensor, foam wadding, syringe, digital display, switch, lithium-polymer batteries, marker felt tip, and marker ink. Based on the evaluation, the device obtained a mode of four (4) for both design and functional performance, indicating that respondents had a high level of confidence and positive perception toward its design and that the device met its defined functional requirements and operated with minimal issues.

The Whiteboard Marker Ink Refiller should be checked and refilled during designated preparation periods or at the end of the school day, and markers should be inserted carefully to prevent damage to the internal alignment mechanism. The plastic cap should be redesigned with a double-locking mechanism or silicone gasket to maintain an airtight seal, while lightweight, heavy-duty lithium-polymer batteries and properly centered internal components should be considered to improve battery life and reduce hand fatigue. The Arduino platform may also be upgraded to an ESP32-based IoT system with Wi-Fi or Bluetooth connectivity to support a centralized Smart Station approach.

The developed Whiteboard Marker Ink Refiller had limitations related to the airtight sealing of the marker cap, battery capacity, weight and distribution of internal components, and the need for careful marker insertion to avoid damaging the internal alignment mechanism. The prototype also used a basic Arduino platform without the Wi-Fi or Bluetooth connectivity proposed for a centralized Smart Station system.

5. Compliance with ethical standards

The authors declare no conflict of interest. This study received no external funding. The researchers acknowledge the faculty, staff, and students of Estado High School and the University of Southern Mindanao–Kidapawan City Campus for their participation and institutional support. Participation was voluntary, informed consent was obtained, and data were collected through non-invasive methods while maintaining confidentiality and ensuring that no identifying information was disclosed.

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