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Arith-O-Matic: An Arithmetic Interactive Machine

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Abstract

This study focused on the design, development, and acceptability evaluation of Arith-O-Matic: An Arithmetic Interactive Machine, an instructional device intended to support Grade 2 pupils in learning basic arithmetic operations through virtual manipulatives, immediate feedback, and a reward-dispensing mechanism. The study was anchored on learning principles and theories such as experiential learning, situated learning, reflective learning, constructivism, inquiry-based and discovery learning, and task-technology fit. It employed a descriptive-developmental research design involving the planning, fabrication, testing, revision, and evaluation of the device. The respondents were thirty elementary teachers teaching Mathematics in key stage one from President Roxas Central District, selected through simple random sampling. A survey questionnaire was used to evaluate the acceptability of the device, and the data were analyzed using frequency count and mode. Findings showed that Arith-O-Matic was rated Highly Acceptable across all indicators, including question generation, display clarity, user-friendliness, calculation accuracy, feedback indicators, reward dispensing, mobility, safety features, and overall operation. The device was found useful as an instructional material for demonstrating addition, subtraction, multiplication, and division; however, overheating after prolonged use was identified as a technical limitation. The study recommends improving the monitor size, virtual manipulative features, feedback display, speaker volume, and ventilation system. The study supports SDG 4 – Quality Education and SDG 9 – Industry, Innovation and Infrastructure by promoting technology-enhanced Mathematics instruction. Its sustainability impact lies in strengthening educational, technological, and institutional support for early-grade numeracy development.

Keywords: Acceptability, Arithmetic, Educational Technology, Instructional Materials, Mathematics Instruction, Numeracy, Reward Mechanism, Virtual Manipulatives

1. Introduction

This study focuses on the development and acceptability evaluation of Arith-O-Matic: An Arithmetic Interactive Machine, an instructional technology designed to support Grade 2 pupils in learning basic arithmetic through virtual manipulatives, immediate feedback, and a reward-dispensing mechanism. The study responds to the continuing challenge of limited instructional materials in early-grade Mathematics, particularly in helping learners visualize and understand addition, subtraction, multiplication, and division. Grounded in K-12 Mathematics competencies, learning theories, technology integration, and task-technology fit, the study positions Arith-O-Matic as a learner-centered instructional device intended to improve engagement, conceptual understanding, numeracy practice, and teacher support in Mathematics instruction.

Mathematics in the early grades provides the foundation for understanding fundamental concepts and developing problem-solving, critical thinking, and logical reasoning skills. Olivia (2013) stated that in the K-12 Curriculum Mathematics is a crucial subject that is relevant not only in school, but also, beyond the classroom. It emphasizes key mathematical domains such as Numbers and Number Sense, Patterns, Algebra, Geometry, Measurement, Probability and Statistics. However, the researcher observed a lack of instructional materials in teaching Mathematics among Grade 2 pupils, resulting in continued reliance on traditional materials such as worksheets and practice problems. This situation may contribute to pupils' difficulty in retaining mathematical concepts throughout the school year and may affect their performance in the Rapid Math Assessment. Rachmawati et. al. (2023) found that students believe Mathematics as a hard and boring because they have limited comprehension on it, which reduces their motivation and engagement with the subject. In response to these challenges, the study developed Arith-O-Matic: An Arithmetic Interactive Machine, an instructional device that integrates a calculator-like operational system, virtual manipulatives, immediate audio and visual feedback, and a reward system. The device generates mathematical questions based on the user's chosen operation and allows pupils to manipulate visual representations of arithmetic concepts. This aligns with the view that educational technology and manipulatives may support mathematical learning, as Hajj and Harb (2023) stated that the integration of educational technology has transformed teaching and learning process and expecting it to evolve, while Zain (2020) noted that manipulatives can effectively demonstrate and illustrate mathematical concepts. Kissane (2017) also indicated that the intelligent use of calculators at different levels of education gives many chances for pupils to build a thorough understanding of key areas of Mathematics through their own activities.

The literature emphasizes that Mathematics education in the K-12 curriculum is intended to develop critical thinking, problem-solving, accuracy, creativity, perseverance, objectivity, and productivity. Oliva (2013) stated that in the K-12 Curriculum, Mathematics is emphasized as a crucial subject with relevance beyond the classroom, highlighting its importance throughout life. Oliva (2013) further emphasized that the K-12 curriculum framework encompasses five core content areas: Numbers and Number Sense, Geometry, Measurement, Patterns, Algebra, Statistics and Probability. These content areas are supported by instructional resources such as manipulatives, measuring instruments, calculators, tablets, computers, smartphones, and internet resources. The study is also aligned with the K-12 Mathematics competencies for Grade 2, particularly the visualization and representation of addition, subtraction, multiplication, and division. These competencies require learners to represent addition of numbers with sums up to 1000, subtract 2- to 3-digit numbers with minuends up to 999, visualize multiplication involving factors from 1 to 10, and represent division involving numbers up to 100. Since these skills require conceptual understanding, the use of interactive manipulatives becomes relevant in helping pupils move from abstract concepts to concrete representations. Several studies also highlight the importance of addressing mathematical difficulty through engaging instructional strategies. Rachmawati, et al. (2023) stated that students' limited comprehension of Mathematics begun from the assumptions among them that Mathematics is hard and boring. These difficulties include struggles in understanding concepts, acquiring skills, and solving problems. In this context, tangible learning aids, increased practice, engaging instruction, and collaboration with parents are identified as ways to ease mathematical learning difficulties. Manipulatives are strongly supported in the literature as instructional tools for Mathematics. Zain (2020) emphasized that manipulative media can enhance children's ability to grasp numerical concepts. Yeatts (2012) indicated that manipulative materials are tangible objects that engage multiple senses, allowing students to feel, touch, handle, and manipulate them. Durmus and Karakirik (2006) define virtual manipulatives as interactive, web-based visual tools that offer opportunities to learn mathematical concepts. These insights support the use of Arith-O-Matic because the device uses virtual manipulatives to help pupils visualize arithmetic operations and receive immediate feedback. Technology integration also serves as a major theme in the study. Hajj and Harb (2023) cited that the integration of educational technology has transformed the teaching and learning process in numerous ways. Technology supports interaction, feedback, and innovation in teaching strategies. The use of technology in K–12 education is emphasized by both educators and learners, and various technologies are integrated into Mathematics classrooms to support different teaching and learning goals (Ozel et al., 2008). Technology also supports interaction among students, teachers, and digital tools while contributing to conceptual, procedural, and metacognitive mathematical knowledge (Ball & Barzel, 2018). Herrera (2023) also observed the effect of technology, after implementing one-to-one devices for a two-year period, students' academic ability in Mathematics and reading improved noticeably.

The literature also supports the careful use of calculators and digital instructional tools in Mathematics learning. Nguyen & Nguyen (2023) noted that calculators can support conceptual approaches to problem resolution and knowledge discovery, although concerns remain regarding possible effects on computation and reasoning. Padmi (2020) asserted that students' attitudes on the use of calculators to learn Mathematics have significantly improved. Meanwhile, calculators should not be viewed merely as answering devices because their intelligent use can support learners' understanding of Mathematics through active engagement (Barry, 2017). Arith-O-Matic also draws support from literature on interactive media and programmable technology. Electronic interactive media allows users to manipulate and control media formats such as text, sound, video, graphics, and animation (Britannica, 2023). According to Bush (2015), React Javascript supports user interface development through declarative programming. Programmable devices operate by executing commands or code to complete intended actions (Navabi, 2024). ESP 8266 is described as a low-cost, small-size Internet of Things device with integrated Wi-Fi capability and low power requirements (Thakur, 2016). These technological foundations are relevant to the development of Arith-O-Matic because the device combines React JS software, virtual manipulatives, touchscreen interaction, audio-visual feedback, and an ESP 8266-based reward-dispensing mechanism.

Locally, the study responds to the observed instructional needs of Grade 2 pupils and Mathematics teachers, particularly the lack of interactive instructional materials for arithmetic learning. The Rapid Math Assessment is a diagnostic tool used to measure learners' mathematical skills based on grade-level competencies, especially among key stage 1 learners. According to the Division Memo No.201 s.2023, all schools under DepEd Cotabato Division must administer RMA at the beginning of school year. The study notes that Grade 2 pupils in F. Cajelo Elementary School showed low RMA results in the past two years, with many learners falling under the intervention level. At the national level, the study is aligned with the K-12 Mathematics curriculum, which emphasizes problem-solving, critical thinking, and the development of mathematical competencies. It also supports the broader goal of integrating technology and instructional resources into teaching and learning. In the Philippine educational context, where teachers often balance limited resources with the demand for improved learner performance, interactive instructional devices such as Arith-O-Matic may provide practical support for classroom instruction. Globally, the study reflects wider educational trends involving technology-enhanced learning, digital manipulatives, interactive media, and learner-centered instructional design. The literature on technology integration, virtual manipulatives, programmable devices, and interactive instructional materials indicates that Mathematics education is increasingly shaped by digital tools that support engagement, feedback, conceptual visualization, and active learning. The prior arts discussed in the manuscript, including symbol manipulation systems, interactive Mathematics instructional tools, and arcade-style reward-based machines, show that the development of Arith-O-Matic belongs to a broader field of educational innovation combining physical and digital interaction.

This study was grounded in several learning principles and theories, including Experiential and Situated Learning, Constructivism, Reflective Learning, Inquiry-Based and Discovery Learning, and Task-Technology Fit. Experiential Learning, as outlined by David Kolb (1984, as cited in Cherry, 2018), emphasizes learning through direct everyday experiences wherein knowledge is created through the transformation of these experiences. This supports Arith-O-Matic because pupils actively interact with arithmetic problems through virtual manipulatives. Situated Learning, according to Lave and Wenger (1991, as cited in Egbert and Roe, 2020), emphasizes learning that takes place within the context where concepts and theories are actively applied. This is relevant because Arith-O-Matic provides a practical environment where pupils can apply arithmetic concepts through guided interaction. Reflective Learning by Schön (1983, cited in Third, 2022) involves processing experiences to derive deeper understanding and meaning, which is supported by the device's immediate correct or incorrect feedback. Constructivism holds that knowledge is built as learners relate new concepts to ideas drawn from their own experiences (Piaget, 1964 cited in Miller and Manderfeld, 2024). Arith-O-Matic supports this by allowing learners to manipulate representations and construct understanding through active exploration. Discovery and Inquiry-Based Learning, as described by Bruner (1966, cited in McLeon, 2024), emphasizes learning through firsthand experiences, allowing students to identify facts, connections, and ideas independently. This aligns with the learner-centered design of the device, where pupils solve problems through interaction and discovery. Finally, Marikyan and Papagiannidis (2023), stated that Task-Technology Fit Model by Goodhue and Thompson (1995), assesses if the technology fits to the task that the user requires and how acceptable the performance of technology in assisting an individual. Similarly, Task-Technology Fit Model by Goodhue and Thompson (1995, cited in Marikyan and Papagiannidis, 2023), assesses whether the technology fits to the task that the user requires and how acceptable the performance of technology in assisting an individual. This theory supports the acceptability evaluation of Arith-O-Matic by examining whether its design, usability, compatibility, reliability, and performance are appropriate for Grade 2 arithmetic instruction. Conceptually, the study follows an input-process-output structure. The inputs include ideas from related literature, drawing, materials, tools and equipment, labor, and cost. The process involves planning, designing, fabricating, testing, revising, and evaluating. The output is the Arith-O-Matic: An Arithmetic Interactive Machine and its teacher's operational manual.

The study is justified by the continuing need for interactive, technology-supported, and developmentally appropriate instructional materials in early-grade Mathematics. Although teachers may use television, PowerPoint presentations, worksheets, and practice problems, these tools may not be sufficient to sustain learners' engagement, promote conceptual retention, or provide immediate interactive feedback. The recurring low RMA performance among Grade 2 pupils further supports the need for instructional innovation. Existing literature supports the use of manipulatives, technology, calculators, interactive media, and programmable devices in Mathematics education; however, the study addresses a practical gap by designing a localized instructional machine that combines these elements into one device. Arith-O-Matic integrates generated arithmetic questions, virtual manipulatives, audio-visual feedback, and a reward-dispensing mechanism to support addition, subtraction, multiplication, and division practice. The study therefore aimed to design and develop Arith-O-Matic: An Arithmetic Interactive Machine and evaluate its acceptability among thirty (30) public elementary school teachers teaching Mathematics key stage one.

This study is most directly aligned with SDG 4 – Quality Education because it focuses on improving Mathematics instruction through an interactive instructional device that supports numeracy, conceptual understanding, learner engagement, and teacher assistance. The study contributes to educational quality by addressing the shortage of instructional materials and by offering a technology-enhanced tool for practicing Grade 2 arithmetic competencies. The study also aligns with SDG 9 – Industry, Innovation and Infrastructure because it involves the design and development of an instructional machine using React JS software, virtual manipulatives, touchscreen interaction, and an ESP 8266 programmable device. Its innovation lies in combining educational software, interactive media, and programmable reward dispensing into a localized Mathematics learning device. The study may also be linked to SDG 8 – Decent Work and Economic Growth in an indirect educational sense because it emphasizes foundational Mathematics skills that may help learners develop competencies useful for future academic and employment pathways, especially in Mathematics-related fields. However, this contribution is indirect and should be understood as part of long-term human capital development rather than an immediate employment outcome.

The study contributes to educational sustainability by developing a reusable instructional material that may help teachers improve early-grade Mathematics instruction and support pupils' long-term numeracy development. It also contributes to technological sustainability by demonstrating how locally designed educational technology can be integrated into classroom practice through software, programmable devices, and virtual manipulatives. In addition, the study supports institutional sustainability by offering schools a tool that may help improve Mathematics practice, learner engagement, and performance in assessments such as the Rapid Math Assessment and National Achievement Test in Mathematics. From a socio-economic sustainability perspective, the study recognizes that strong foundational Mathematics learning may help learners build competencies needed for future academic and career opportunities. It also has innovation and digital sustainability value because it presents a localized, interactive, and technology-based response to a classroom problem. Overall, Arith-O-Matic represents a multidisciplinary instructional innovation that connects Mathematics education, technology development, learner motivation, school performance, and sustainable educational improvement.

2. Material and methods

2.1 Research Design

The study employed a descriptive-developmental research design. The developmental component focused on the planning, designing, fabrication, testing, revision, and production of Arith-O-Matic as an instructional machine for Grade 2 Mathematics. The device was developed to assist teachers in teaching basic arithmetic concepts and to help address the shortage of instructional materials for key stage one Mathematics learners. The descriptive component involved evaluating the acceptability of the developed machine based on the responses of selected elementary teachers. The project was constructed using locally available materials and electronic components. Its instructional system included React JavaScript software for the virtual manipulatives, a touchscreen laptop for user interaction, and an ESP 8266 programmable device for activating the reward mechanism after three consecutive correct answers. The structure was made of white-painted ply board edged with counter nosing and equipped with caster wheels for easier movement and positioning. During the development process, the researcher revised the design based on actual parts used, replaced the unavailable touchscreen monitor with a touchscreen laptop, adjusted the virtual manipulatives for regrouping in addition and subtraction, and shifted the software use from offline to online access through a cellphone hotspot due to device limitations.

2.2 Locale of the Study

The study was conducted in President Roxas Central District, located in the municipality of President Roxas, Cotabato. The district consists of ten elementary schools and served as the research setting for evaluating the acceptability of the Arith-O-Matic instructional machine.

2.3 Respondents of the Study

The respondents of the study were elementary teachers from President Roxas Central District. Specifically, the study involved thirty (30) teachers who were teaching Mathematics in key stage one. These teachers evaluated the acceptability of Arith-O-Matic after being introduced to the device and guided on its operation.

2.4 Sample and Sampling Procedure

The study used simple random sampling to select the thirty (30) elementary teacher-respondents from President Roxas Central District. This sampling method was used to provide the selected teachers an equal chance of participating in the evaluation of the developed instructional machine.

2.5 Research Instrument

The primary research instrument was a survey questionnaire designed to evaluate the acceptability of Arith-O-Matic: An Arithmetic Interactive Machine. The developed device itself served as the instructional material to be assessed by the respondents. The teachers were also guided by the operational manual prepared by the researcher to help them understand and operate the machine during the evaluation.

2.6 Data Gathering Procedure

The researcher first prepared a letter requesting permission from the Schools Division Office of Cotabato to conduct the study. After approval was granted, the researcher coordinated with the school principals for the administration of the instrument. The Arith-O-Matic was introduced to the respondents, and its operation was demonstrated using the operational manual. The respondents were then allowed to use and assess the machine before answering the survey questionnaire. The researcher personally managed the assessment process and facilitated verification from the respondents to ensure that the data were properly collected.

2.7 Data Analysis Techniques

The data gathered from the survey questionnaire were analyzed using frequency count and mode. Frequency count was used to determine the number of responses for each acceptability indicator, while mode was used to identify the most frequently occurring response. These statistical tools were applied to describe the level of acceptability of Arith-O-Matic: An Arithmetic Interactive Machine based on the evaluation of the teacher-respondents.

3. Results and Discussion

3.1 Design, Development, and Operation of Arith-O-Matic

3.1.1 Design and Functional Components of the Device

The Arith-O-Matic was developed as an instructional material intended to help teachers present arithmetic concepts interactively and easily to early-grade learners. It used React JavaScript software that allowed users to manipulate virtual manipulatives through a touchscreen laptop monitor. The device allowed users to select among addition, subtraction, multiplication, and division. It generated arithmetic problems based on the selected operation and provided visual, audio, and reward-based feedback after successful completion of learning tasks. The reward system was connected to an ESP 8266 programmable device, which activated the vending machine motor and dispensed rewards through the vending machine spring. The result shows that the device combined digital interaction and physical reinforcement to support arithmetic practice. Its use of virtual manipulatives allowed pupils to visualize and represent mathematical concepts, while the audio-visual feedback and reward mechanism provided immediate response to learner performance. This supports the idea that technology-integrated instructional materials can enhance Mathematics teaching by making abstract concepts more concrete and engaging.

3.1.2 Arithmetic Interaction and Learning Process

The device had two main users: the teacher and the pupil. The teacher explained the mathematical concepts, introduced the device, and turned it on, while the pupil used the machine to practice arithmetic. After choosing an operation, the pupil answered automatically generated problems from level one to level three. In addition, the pupil used blocks representing hundreds, tens, and ones, which automatically joined together to demonstrate regrouping. In subtraction, the pupil used a hammer feature to break parts apart for problems with or without regrouping. In multiplication, the device provided boxes for the multiplicand, while the pupil dragged shapes representing the multiplier to show the product. In division, the dividend was shown above boxes representing the divisor, and the pupil distributed objects into the boxes to identify the quotient. These findings indicate that Arith-O-Matic supported different forms of arithmetic visualization and representation. The interaction process allowed pupils to solve problems through direct manipulation of virtual objects rather than relying only on written computation. This design is consistent with the purpose of using manipulatives in Mathematics instruction because it helps learners connect concrete or visual representations with abstract numerical operations.

3.1.3 Reward System, Structure, and Technical Observation

After three consecutive correct answers from level one to level three, the machine tallied the answers and allowed the pupil to select a reward. The reward was dispensed through the reward exit, after which the pupil could either continue using the machine or return to the homepage. The physical structure of Arith-O-Matic was made of white-painted ply board edged with counter nosing. It measured three feet and four inches in height, two feet and two and one-fourth inches in width, and one foot and one and five-eighth inches in thickness. The reward was designed to be eight centimeters in height and three centimeters in thickness, ideally in the form of chocolate or biscuits. The device was also equipped with caster wheels for convenient transport and positioning. During testing, however, the machine was observed to overheat after one hour of use because the laptop keyboard compartment was covered, indicating the need for ventilation and a fan or blower. The results suggest that the device was generally functional and portable, but the testing process also identified a technical limitation that must be addressed for longer use. The overheating issue does not remove the instructional value of the machine, but it shows that proper ventilation is necessary to improve its durability, safety, and usability during classroom implementation.

3.2 Acceptability of Arith-O-Matic

3.2.1 Teacher Ratings Across Acceptability Indicators

The acceptability evaluation showed that all thirty respondents rated the device as highly acceptable in generating questions based on the user's chosen mathematical operation. For display clarity, twenty-nine respondents rated it highly acceptable, while one rated it very acceptable. For user-friendliness of the virtual manipulative tool, twenty-three respondents rated it highly acceptable and seven rated it very acceptable. For calculation accuracy, twenty-nine respondents rated it highly acceptable and one rated it very acceptable. For use with or without teacher supervision, eighteen respondents rated it highly acceptable, ten rated it very acceptable, and two rated it acceptable. For operational feedback indicators, twenty-eight respondents rated it highly acceptable and two rated it very acceptable. For the locking system that secures electrical connections, twenty-six respondents rated it highly acceptable, two rated it very acceptable, and two rated it acceptable. For reward dispensing after three consecutive points, twenty-six respondents rated it highly acceptable and four rated it very acceptable. For mobility, twenty-seven respondents rated it highly acceptable, two rated it very acceptable, and one rated it acceptable. For overall operation, twenty-nine respondents rated it highly acceptable and one rated it very acceptable. The general mode across all indicators was 5, indicating that the device was generally perceived as highly acceptable. The results indicate that the teacher-respondents accepted Arith-O-Matic as an instructional aid for teaching Mathematics. The consistently high ratings suggest that the device was perceived as functional, clear, accurate, interactive, mobile, and useful for classroom instruction. Its positive evaluation also implies that teachers recognized its potential to help pupils understand arithmetic concepts through technology-supported practice and immediate feedback.

3.2.2 Overall Acceptability and Instructional Implications

Overall, the findings showed that Arith-O-Matic was highly acceptable as an instructional material for Grade 2 Mathematics. The respondents' ratings suggest that the device has potential to help pupils enhance numeracy skills and understand mathematical concepts through interactive engagement. The use of generated arithmetic problems, virtual manipulatives, correct-or-incorrect feedback, and reward dispensing contributed to its acceptability as a classroom tool. This finding supports the role of technology integration in Mathematics instruction. As what Hajj and Harb (2023) noted, it is true that technology integration in Math classes is not only vital to advance aspects of daily life, but also, to emphasize that school should highly consider the use of technology as a necessary component of a curriculum. Through this, the students could have a lifelong learning and help them remember mathematical concepts throughout the school year that may lead to higher results of Rapid Math Assessment (RMA). In support to the idea of Zain (2020) manipulatives enhance comprehension of numerical concepts and motivates both the children and teachers. Comprehending in mathematical concept is challenging since concepts are often abstract but with the use of manipulative media, students can easily grasp mathematical concepts that could help enhance the teaching and learning process.

4. Conclusion & Recommendations

The study successfully designed and developed Arith-O-Matic: An Arithmetic Interactive Machine as an instructional device that uses virtual manipulatives to demonstrate basic arithmetic operations, particularly addition, subtraction, multiplication, and division. Based on the evaluation of thirty elementary Mathematics teachers from President Roxas Central District, the device was rated as Highly Acceptable, indicating its potential usefulness as instructional equipment for Grade 2 Mathematics. The findings suggest that Arith-O-Matic may support teachers in presenting arithmetic concepts more interactively and may help pupils improve their understanding of basic mathematical operations.

Based on the findings and observations during the development and evaluation of the device, it is recommended that future improvement of Arith-O-Matic include the use of a larger touchscreen monitor to accommodate bigger virtual manipulatives, revision of the addition feature so users can manually join the box of algorithm instead of relying on automatic joining, enlargement of the correct-or-incorrect feedback display, use of a louder speaker for audio feedback, enlargement of virtual manipulative boxes for easier handling, and installation of a fan, blower, or proper ventilation in the laptop keyboard compartment to prevent overheating.

The study was limited to the design, development, and acceptability evaluation of Arith-O-Matic as an instructional machine for Grade 2 arithmetic competencies. Its evaluation was based only on the responses of thirty elementary teachers teaching Mathematics key stage one in President Roxas Central District; therefore, the findings focused on teacher acceptability rather than direct measurement of pupils' learning performance or long-term improvement in arithmetic achievement.

Compliance with ethical standards

The study was conducted in accordance with institutional ethical standards, with proper permission secured before data gathering. Participation was voluntary, informed consent was observed, and all respondent information was treated with confidentiality. The authors declare no conflict of interest, acknowledge all contributions and sources used in the study, and retain responsibility for the originality, accuracy, and copyright compliance of the research.

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