

# Development Of A Small Scaled Single-Handed Binary Typing Machine And Its Use As An Accessibility Feature

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**Abstract:** In the digital age, typing has become indispensable, yet individuals with physical disabilities often face barriers due to traditional keyboard designs. This study addresses this issue by exploring the feasibility of a small-scale, single-handed binary typing machine as an alternative accessibility solution. Employing the Design Thinking Process Framework, the research aims to design, develop, and evaluate a prototype that prioritizes ergonomics, efficiency, and ease of use. Drawing from insights gained through consultation with individuals experiencing typing challenges, the prototype utilizes an Arduino microcontroller and binary mapping to enable single-handed operation. Through iterative testing and refinement, the device demonstrates successful functionality, offering a promising solution to enhance keyboard accessibility for individuals with physical disabilities. The study's implications extend to sustainable development goals, particularly SDG 3 (Good Health and Well-being) and SDG 10 (Reduced Inequalities), by promoting quality of life and equal access to resources for individuals with disabilities. Recommendations include further refinement of the prototype, such as custom printed circuit boards and button labels, to enhance usability and accessibility. Ultimately, this research contributes to a more inclusive digital landscape, empowering individuals with physical disabilities to engage effectively in the digital world.

**Key Words:** Accessibility Keyboard; Arduino Communications; Binary Mapping

## 1. INTRODUCTION

### 1.1 Background of the Study

In this century of digital communication, typing has become a standard and essential skill. Traditional typing methods, such as the use of computer keyboards, often require the use of both hands and a certain level of dexterity. This poses a significant challenge for individuals with physical disabilities that limit the use of one of their hands or side of the body (*Typing to Communicate - Center on Disability and Inclusion - Syracuse University, n.d.*).

Existing solutions such as voice recognition software or specialized keyboards exist which come with their own limitations such as the accuracy of the translation and even the pricey nature of the specialized

keyboards. These specialty keyboards, like stenographs, are primarily designed for professional use, for instance court reporting or closed captioning rather than general typing. Additionally, ones that use specific codes and combinations of keys in order to form a word, have steep learning curves due to their unique shorthand typing system (Anderson et al., 2009).

However, there is a lack of efficient, small-scale, single-handed typing machines in the market. Most existing typing devices are either large-scale, expensive or not designed for single-handed use. This gap in the market presents an opportunity for the development of a small-scale, single-handed typing machine.

### 1.2 Statement of the Problem and Objectives

The purpose of this study is to explore the feasibility of an alternative technological solution to aid in giving accessibility options for keyboards. The objectives of the research project are:

1. To design a small-scaled binary typing machine that can be operated with a single hand, considering factors such as ergonomics, efficiency, and ease of use.
2. To develop a prototype of the single-handed binary typing machine using suitable materials and technologies.
3. To evaluate the potential of the binary typing machine as an accessibility feature for individuals with physical disabilities that limit the use of one or both hands.
4. To test the functionality and efficiency of the developed prototype under different conditions and use-cases.

### *1.3 Significance of the Study*

This study aims to design and develop a small-scale, single-handed binary typing machine and explore its potential as an accessibility feature for individuals with physical disabilities. The goal is to create a device that is not only functional and efficient but also affordable and easy to use. This could potentially revolutionize the way individuals with physical disabilities communicate in the digital world. The invention hopes to provide a better way of typing for handicapped people where ease and comfort are prioritized.

In making the invention, the researcher had the third and tenth Sustainable Development Goals, or SGD, in mind (United Nations, 2015). The intended use for the invention is to help improve the quality of life of the selected audience and people who are in need of the device in order to uphold the third SDG to uplift the wellbeing of people regardless of an emergency. In addition, the goal is to make an invention that is able to promote accessibility for every person regardless of the situation they are in, thus promoting the tenth SDG. The research then further expands on this goal by being affordable and attainable for anyone in need.

### *1.4 Scope, Limitations and Delimitations*

Since the project is in use of five bits as the input, the maximum number of characters that can be mapped to the binary combinations would be thirty two (32) characters. This limit is able to accommodate for the entire alphabet system, a space, and important punctuation marks such as period, comma, question

mark and exclamation point. Additionally, the binary for zero being '00000' was set to a 'NULL' or empty state considering the fact that the system has the zero output by default. The circuit also features an Arduino Nano as the main board of the system which would need it to be plugged into a laptop or device with the Arduino IDE application as a power source and in order to allow the device to output the symbols when used.

### *1.4 Review of Related Literature*

#### A. Binary Counting

Binary counting serves as the cornerstone of modern computing and digital electronics. At its essence, it operates on a simple premise: the representation of numbers using only two symbols, typically 0 and 1. This binary system mirrors the fundamental states of electronic components: off and on, or low and high voltage. As such, it serves as a backbone to all digital operations, from basic arithmetic in computer processors to the encoding of data in memory storage. Its simplicity enables complex computations and data manipulation through a series of binary operations. Beyond its foundational role in computing, binary counting finds applications across diverse domains. In simulation studies, binary counting facilitates the modeling of complex systems with discrete states. In data aggregation, it enables efficient storage and retrieval of information in databases (Alt et al., 2022). Moreover, statistical modeling often relies on binary representations for analyzing categorical data. Thus, binary counting stands as a fundamental pillar of digital technology, shaping the landscape of modern computation and information processing (Ezzalfani, M. et al., 2018).

#### B. Accessibility Keyboards

Accessibility keyboards are created for fostering inclusivity in the world of technology. Designed with the needs of individuals with disabilities in mind, these keyboards offer a range of features to enhance usability and accommodate diverse needs (Fernández-Batanero et al., 2022). Their larger keys and high-contrast color schemes cater to users with visual impairments, facilitating easier identification and operation. Customizable layouts enable personalized configurations tailored to specific motor limitations, ensuring a more comfortable and efficient typing experience. In educational settings, the integration of accessibility metadata holds promise for enhancing the learning experience of students with disabilities (Akpan & Beard, 2013). By providing accessible educational resources, such as text-to-speech capabilities or alternative input methods, educators can empower

students to overcome barriers to learning and participate fully in academic activities.

### C. Stenography

Stenography, or shorthand writing, is a system designed for rapid writing and note-taking. Rooted in the principles of shorthand writing, it offers a rapid means of capturing spoken language with efficiency (Giauque, 1976). Traditionally employed in professions such as journalism and court reporting, stenography has evolved in tandem with advancements in technology. In recent years, its relevance has extended to academic contexts (Tabé & Materechera, 2024), where scholars explore its impact on students' writing proficiency and its potential for fostering secure communication channels. By condensing complex language into concise symbols or abbreviations, stenography promotes fluency and brevity in written communication. This skill holds particular value in domains where time is of the essence, such as real-time transcription or data entry. Moreover, the encrypted nature of stenographic systems renders them well-suited for confidential communication, offering a layer of security in sensitive exchanges.

### D. Handheld Translators

Handheld translators represent a breakthrough in the realm of language translation, offering instant access to linguistic resources in a compact, portable form. Benefiting from the computational power of mobile devices, these applications provide instant translations for a wide range of languages, bridging communication barriers and facilitating cross-cultural exchange. Studies have always remarked their efficacy in enhancing the performance of translation students, serving as valuable aids in vocabulary acquisition and grammatical comprehension. One notable area of impact lies in the translation of collocations—word combinations with idiomatic meanings (Alotaibi & Salamah, 2023)—where handheld translators excel in providing contextually accurate renditions. Beyond individual use cases, handheld translators hold promise for fostering global connectivity and understanding in an increasingly interconnected world.

### E. Arduino Communication System

The Arduino platform has emerged as a versatile toolkit for innovation in electronics and interactive systems, empowering enthusiasts and professionals alike to bring their ideas to life. Among its myriad applications, Arduino finds use in developing secure communication systems through the integration of multi-directional multi-scroll chaotic oscillators (MMCOs). These oscillators generate complex,

unpredictable signals that form the basis of cryptographic communication protocols, ensuring confidentiality and integrity in data transmission. By harnessing the principles of chaos theory (Pano-Azucena, A.D., et al., 2016), Arduino-based communication systems offer robust defenses against eavesdropping and tampering, making them suitable for sensitive applications such as IoT (Internet of Things) networks (James et al., 2021). Through open-source collaboration and experimentation, developers continue to refine and expand the capabilities of Arduino-based communication systems, unlocking new possibilities for secure, decentralized communication infrastructures.

## 2. METHODOLOGY

The study employed the five (5) stages in the nonlinear Design Thinking Process Framework: Empathize, Define, Ideate, Prototype, and Test (Dam, 2023).

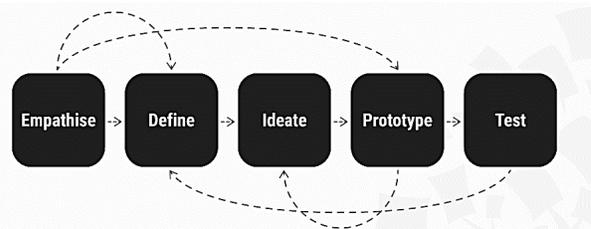


Fig. 1. Design Thinking Process Framework from (Dam, 2023)

### 2.1 Phase 1: Empathize

Empathize stage highlights the need to engage with people and to immerse with the environment to obtain significant insights on human experiences and motivations and to gain a deeper understanding of certain issues involved (Dam, 2023). The researcher consulted his parent, who had difficulty with using their right hand due to a stroke, and peers to obtain significant experiences.

During the consultation periods, the researcher was able to initialize a concept mockup of the proposed keyboard idea in which the consulted peers were able to help by suggesting improvements on the code and logical reasoning for the technology that will be used. During the consultation, it was realized that a certain positioning of the buttons were ideal for the comfort and usability of the handheld keyboard. The mother of the researcher then aided in giving insightful reviews of what can be added for comfort and functionality.

### 2.2 Phase 2: Define

Feasibility of the project, purchasing of the materials and creation of the prototype were the three identified research problems. Feasibility of the project was the first to be questioned. The researcher solved this with days of experimenting on binary projects until a code with a functioning output was created. Next was purchasing materials. The researcher solved this by finding a supplier who was able to supply the student with the Arduino devices. Last was the creation of the prototype. The researcher solved this by making a blueprint for the invention and planned the implementation of the circuit.

### 2.3 Phase 3: Ideate

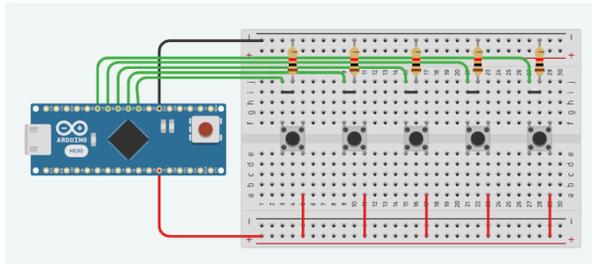


Fig. 2. Tinkercad Circuit Simulation

Designing the device, an Arduino Nano was used due to the board being one of the smaller and compact boards available to make data receiving and interpreting easier due to the built-in USB connector. Following that, the materials used for the experiment are: One Arduino Nano, One Arduino Uno, Five (5) 10K Ohm Resistors, Five (5) push buttons, One device with Arduino IDE, One set of jumper wires, One digital voltmeter and One breadboard.

For the device, it was intended to serve as a single-handed keyboard designed for accessibility. Considering the situation, the circuit was adjusted to be small and would fit the palm of the user thus requiring smaller parts. Additionally, larger buttons, than that in Figure 4, were then chosen to give the user more tactile buttons for ease upon use.

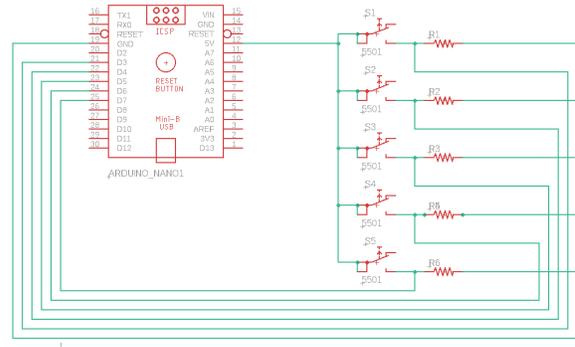


Fig. 3. EAGLE Circuit Diagram

### 2.4 Phase 4: Prototype

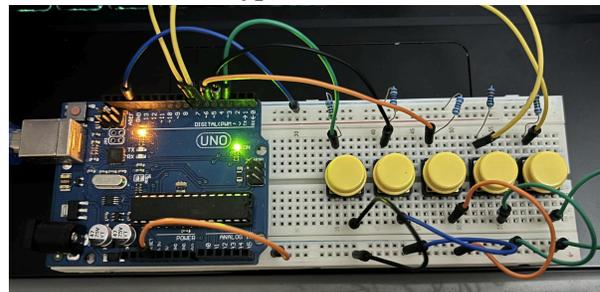


Fig. 4. Implemented Breadboard Circuit

First, the components were gathered and tested individually for continuity using a digital voltmeter. Second, each of the components were then attached to the breadboard according to the sequence of the circuit diagrams. A major difference between the implemented circuit and the simulated circuit is the use of an Arduino Uno as the breadboard's microcontroller in order to properly test the circuit prior to requiring the need of soldering parts together. Third, the pins of the Arduino were then connected to the components on the breadboard using the jumper wires with the five different buttons occupying digital pins D3 to D7 respectively. Additionally, the 5V pin and GND pin of the Arduino were connected to the power rails of the breadboard in order to supply power to the buttons. Fourth, using the Arduino IDE application, a sketch of the code was created with the use of the pins D3 to D7 as logic inputs appended to each other in an array to simulate a sequence of bits. The different bits were then mapped to the letters 'A' to 'Z' from logic '00001' to '11010' respectively. The succeeding logic from '11011' to '11110' were then assigned important punctuation marks and '11111' which would function as the space bar.

### 2.5 Phase 5: Test

Once all components of the invention were assembled, the testing phase began. The device was connected to the laptop with the Arduino IDE and code opened. The code was then uploaded into the Arduino Uno and the serial monitor was then used as a sample typing space. Once ready, the different binary combinations were then sequenced through individually in order to test the output of the circuit. The character data were then recorded.

## 3. RESULTS AND DISCUSSION

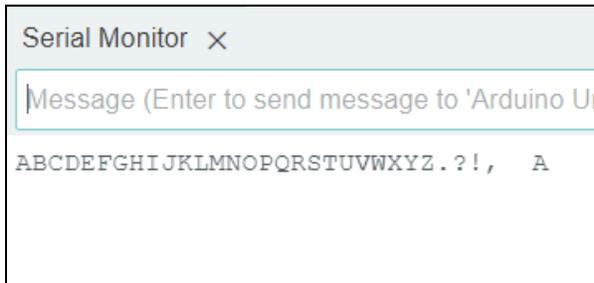


Fig. 5. Serial Monitor Output

The data obtained from the invention were as intended with all the mapped characters and symbols successfully being output by the Arduino board. Additionally, the delay implemented in between each of the letters served as a way for the input bits to be properly pressed before having an output of a letter.

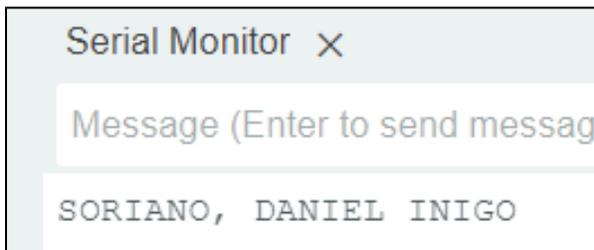


Fig. 6. Researcher's Name in Serial Monitor

Similarly, tests were conducted with the formation of other words and names. The second test was done with the use of the researcher's name. The letters were created with the use of the binary equivalent of the letters' position in the alphabet, example of which would be the letter 'A' with it being the first letter thus translating to a binary of '00001'. An example of the process of 'typing' by the user in Figure 6 showcases the letter 'C' being typed with the binary for

the number three '00011' being pressed. Table below shows each of the mapped characters as well as the binary required to be input for the letter to be typed.

Table 1. Character to Binary Conversion

Character	Binary
A	00001
B	00010
C	00011
D	00100
E	00101
F	00110
G	00111
H	01000
I	01001
J	01010
K	01011
L	01100
M	01101
N	01110
O	01111
P	10000
Q	10001
R	10010
S	10011
T	10100
U	10101
V	10110
W	10111
X	11000
Y	11001
Z	11010
.	11011
?	11100
!	11101
,	11110

SPACE

11111

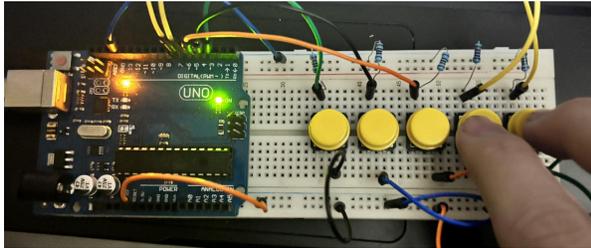


Fig. 7. Letter 'C' as Input

## 4. CONCLUSIONS

### 4.1 Summary of the Study

In the experiment, the researcher planned and designed the creation of a binary-based keyboard for accessibility for people in need. The research utilizes the Design Thinking Process Framework, involving stages such as Empathize, Define, Ideate, Prototype, and Test. Through consultation with a person experiencing this issue, a concept for the proposed keyboard was developed, emphasizing comfort and usability. A circuit using an Arduino microcontroller and binary mapping was then designed and tested, giving successful results. The invention was created to usher in a revolutionized era of accessibility to promote the quality of life and equality of individuals.

In conclusion, this study presents a significant step forward in addressing the accessibility challenges faced by individuals with physical disabilities in digital communication. By designing and developing a small-scale, single-handed binary typing machine, the research offers a promising solution to enhance keyboard accessibility. Through the utilization of the Design Thinking Process Framework and consultation with individuals with physical disabilities, a functional prototype was created, demonstrating the feasibility and potential of the device. As technology continues to evolve, initiatives like this contribute to a more inclusive digital landscape, where individuals with physical disabilities can communicate and engage effectively, regardless of their limitations. Moving forward, further refinement and testing of the prototype could lead to widespread adoption, ultimately empowering individuals with physical disabilities to participate more fully in the digital world.

### 4.2 Implications on Sustainable Development

The Invention made by the researcher was brought to life by the use of today's technology to make

a device that a lot of people can use in the future. The researcher made use of different items to be able to make the invention. The researcher made their own codes while making use of the tools they had in hand to make an innovative device such as the inclusion of binary language. This invention not only contributes to the advancement of technology but also aligns with the principles of the third and tenth Sustainable Development Goals (SDGs).

Primarily, the development of this device represents the essence of the third SDG by promoting quality of life for individuals with physical disabilities. By offering a practical solution to typing challenges, the invention empowers people with limited dexterity, facilitating their active participation in digital communication and societal engagement. Moreover, the basis behind the device signifies progress towards the tenth SDG, which aims to reduce inequalities by ensuring equal access to resources and opportunities for all individuals, irrespective of their physical abilities.

### 4.3 Recommendations

The researcher recommends the use of a custom printed circuit board for the final circuit. The use of this would aid in the positioning and final design of the handheld device with the casing already created. Another recommendation would be the use of labels for the buttons in order to guide the user and to serve as 'shortcuts' along the alphabet. Additionally, the implementation of the 'Keyboard.write()' function of the Arduino language must be done in order to be able to have the keyboard write outside of the Serial Monitor of the Arduino IDE. Lastly, once the circuit is properly implemented on a PCB, a test with the intended audience must be conducted. This is to ensure that the circuit's logic and comfort still carry to the PCB form.

## 5. ACKNOWLEDGMENTS

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## 7. APPENDIX

```
// DEFINE THE BUTTON PINS
INT BUTTONPINS[5] = {3, 4, 5, 6, 7};

VOID SETUP() {
  // INITIALIZE THE BUTTONS AS INPUTS
  FOR (INT I = 0; I < 5; I++) {
    PINMODE(BUTTONPINS[I], INPUT);
  }
}
```

```
// BEGIN SERIAL COMMUNICATION
SERIAL.BEGIN(9600);
}

VOID LOOP() {
  // READ THE BUTTON STATES
  DELAY(1000);
  INT BUTTONSTATES[5];
  FOR (INT I = 0; I < 5; I++) {
    BUTTONSTATES[I] =
DIGITALREAD(BUTTONPINS[I]);
  }

  // CONVERT THE BUTTON STATES TO A BINARY
NUMBER
  INT BINARY = 0;
  FOR (INT I = 0; I < 5; I++) {
    BINARY = BINARY * 2 + BUTTONSTATES[I];
  }

  // MAP THE BINARY NUMBER TO A LETTER
  IF (BINARY >= 1 && BINARY <= 26) {
    CHAR LETTER = 'A' + BINARY - 1;
    SERIAL.PRINT(LETTER);
    DELAY(1000);
  }
  ELSE {
    IF (BINARY == 27){
      SERIAL.PRINT(".");
      DELAY(1000);
    }
    ELSE IF (BINARY == 28){
      SERIAL.PRINT("?");
      DELAY(1000);
    }
    ELSE IF (BINARY == 29){
      SERIAL.PRINT("!");
      DELAY(1000);
    }
  }
}
```

```
ELSE IF (BINARY == 30){
  SERIAL.PRINT(",");
  DELAY(1000);
}
ELSE IF (BINARY == 31){
  SERIAL.PRINT(" ");
  DELAY(1000);
}
}
}
```