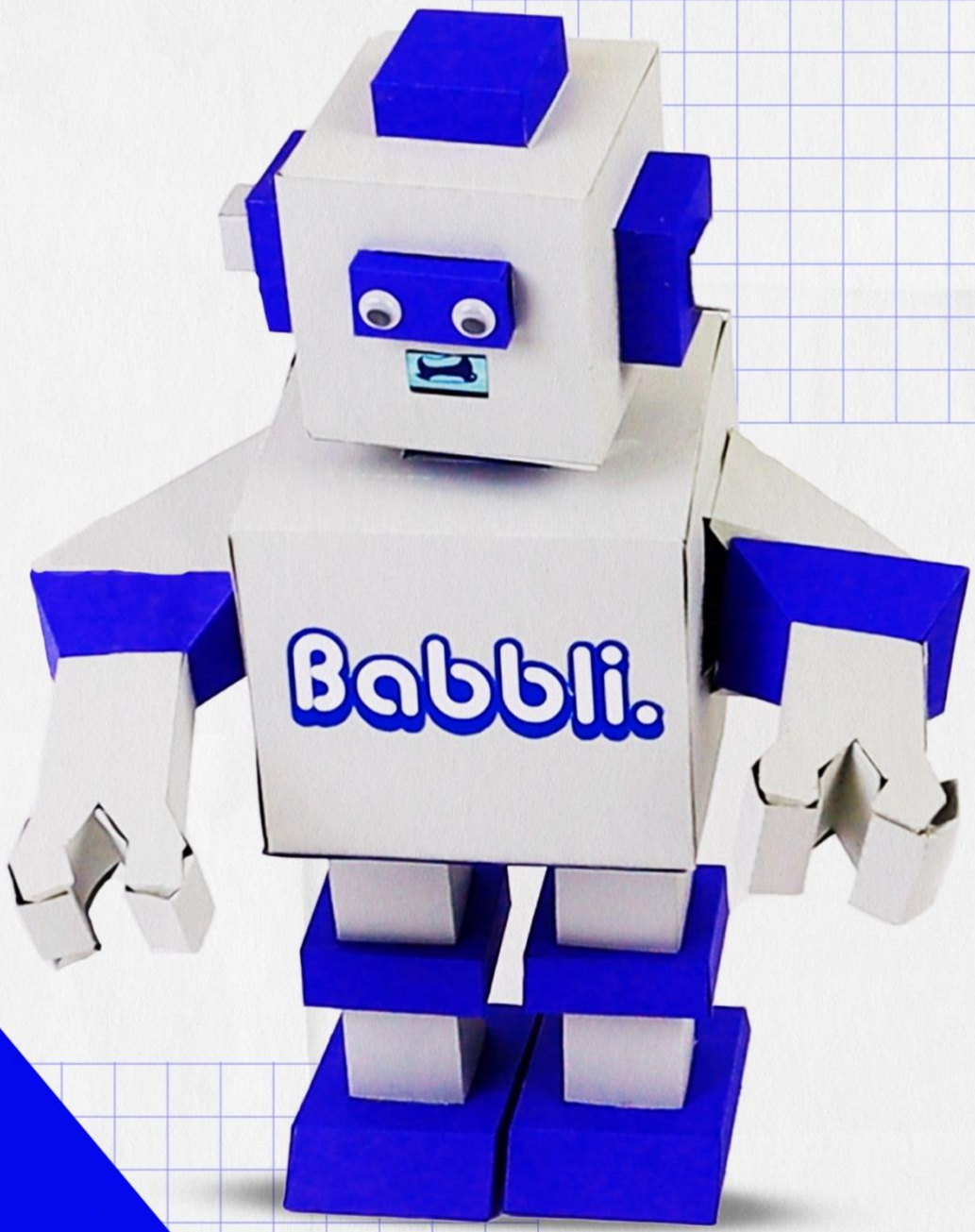
BABBLI

an LLM storytelling toy
for language development



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Creative Computing Institute

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1.Explanation of the idea for a wider audience

Babbli is a large language model (LLM) powered storytelling toy that dynamically creates stories in two languages, adapting the narrative based on the child's input. This innovative toy is designed to support children in second language acquisition, offering a unique, interactive experience that is both educational and entertaining. The story changes depending on the child's input, allowing endless possibilities to feed their imagination. These creative and interactive stories allow the child to feel like a part of the story's adventure, taking them on a journey of language acquisition.

The toy first asks the child what they would like the story to be about and generates a short introduction in two languages. After this, it continues the narrative by asking a follow-up question in both languages, which informs the LLM to continue the story based on the answer. The child can input in either language and encourages them to repeat key words.

With the advancement of LLM'S and with the right prompting, it is now possible to create endless stories that are enriching and entertaining for children. Until the development of modern LLM's, it has never been feasible to make an infinite storyteller that was coherent. Babbli uses this advancement in technology to enhance second language acquisition in children in a playful and interactive way.

2.Research and context

Storytelling is one of the oldest forms of human communication and has historically served as a popular way to pass knowledge from one generation to another. It has also been proven effective as a tool in language development in both first and second language development. Storybook reading is a well-researched tool that enhances preschoolers' reading, speaking, and listening abilities (Isbell et al., 2004). Moreover, storytelling extends beyond vocabulary enrichment to fostering imaginative capabilities in children. Story reading as opposed to storytelling, comes with illustrations to preempt the child's imagination. Storytelling requires the child to engage more actively, utilizing their visual imagination and enhancing their listening skills through participation (Isbell et al., 2004). This distinction highlights why storytelling, especially without supporting images, is particularly potent in developing robust language skills.

Storytelling for second language development has also been proven to be beneficial to second language learners as examined by Lucareveschi (2016) who analyzed two influential empirical studies by Kim (2010), and Atta-Alla (2012). For instance, the first study observed that storytelling significantly improved language skills among ESL learners (English as a Second Language) who showed an active interest and engagement in storytelling activities. However, it was noted that the benefits were not uniform across all participants; individuals who did not enjoy storytelling saw modest improvement, suggesting that learner engagement plays a critical role in the success of storytelling as a pedagogical tool (Kim, 2010). Similarly, the second study explored storytelling's impact on ESL learners, finding that engaging with various stories, including folktales with repeated patterns, enhanced the four key language skills: reading, writing, speaking, and listening. These findings

underscore the capacity of storytelling to enrich language learning by providing learners with comprehensive, enjoyable, and interactive experiences that support both receptive and productive language skills (Atta-Alla, 2012).

In recent years, the integration of new technologies into educational systems has grown globally, driven by the accessibility of smartphones, personal computers, tablets, and user-friendly software. This has redefined the way we tell stories and has shown the emergence of many storytelling technologies. The Digital Storytelling Association (2011) defines it as a "modern expression of the ancient art of storytelling," highlighting the use of multimedia tools to craft compelling stories (Lambert, 2009).

Digital storytelling aligns with various learning theories, notably constructivism, which advocates that students learn best through active engagement and building their own understanding from hands-on experiences and interactions with their environment (Wilson, 1996; Anderson, 2008). Digital storytelling, serves as an effective constructivist tool, enabling learners to explore and internalize knowledge through narrative construction. This constructivist approach is supported by empirical research indicating that digital storytelling significantly enhances motivation and facilitates a deeper engagement with learning material (Smeda, et. al. 2014). This echoes back to the previously mentioned (Kim, 2010), that found storytelling beneficial in ESL learners if they were engaged with the stories. Digital storytelling can be a beneficial alternative, as it boosts engagement and motivation in the classroom dynamically and interactively (Smeda, et. al. 2014).

In determining the target age group for the project, the "Critical Period Hypothesis" originally proposed by Penfield and Roberts (1959) and later popularized by Lennenberg (1967), became particularly relevant. The idea of the *critical period* explains that there is an optimal window during early childhood and before adolescence when language learning processes are most receptive. Notably, from ages two to four, children transition from 'baby talk' to more mature speech patterns. The capacity for imitation is at its peak between the ages of four and eight. By the age of three, children can possess a vocabulary of about 1000 words, with approximately 80% of their utterances being intelligible even to strangers. This insight directly influences the age focus of the proposed storytelling toy, emphasizing the ages 3 to 8 as critical for fostering imitative learning, a core component of the toy's functionality (Lennenberg, 1967).

In terms of second language acquisition in children exposed to two languages, bilingualism is best supported when a second language is introduced before the age of eight, suggesting that early introduction of a second language does not interfere with the development of the native language, but rather, enhances linguistic capacity (Penfield & Roberts, 1959). Moreover, research by Birdsong (2006) and Moyer (2004) suggests that early bilinguals activate different brain areas compared to those who learn a second language later, which can lead to a more native-like proficiency. Moyer notes that early learners have neurological advantages that diminish with age, such as auditory and articulatory flexibility, crucial for acquiring a second language effectively. Conclusively, while there is a broad consensus supporting the efficacy of early language learning, there are individual variations. However, for this project, targeting children aged 3 to 8 aligns with the identified critical period for dual language development.

Building on the critical period hypothesis, further studies suggests that early engagement with language through storytelling can boost confidence when facing new language challenges, making the experience more familiar and manageable (Weisleder and Fernald, 2013). Storytelling is not merely an educational tool for improving language skills but also an influential factor in developing children's confidence as it provides a dynamic and engaging way to reduce anxiety and foster imagination, making it an ideal method for early childhood education (Warmansyah and Nirwana, 2023).

The relevance of these findings is corroborated by current market offerings such as the Toniebox, a storytelling toy that utilizes audio figures to activate pre-loaded stories and songs. Babbli and Toniebox represent distinct approaches within this innovative category. The Toniebox targets children above the age of three, and employs figurines, called Tonies, which when placed on a specially designed 5-inch cube, trigger audio playback ranging from 30 minutes to an hour of stories or songs. These Tonies feature a range of characters from popular franchises such as Disney and Sesame Street (Kallisch et al., 2016).

Another toy in the market that is worth mentioning is Codi, an AI-enabled storytelling robot designed for children aged 12 months and older. Unlike Toniebox's fixed interactions, Codi offers dynamic interaction with its audience through a library of over 200 curated songs and stories. Codi's AI technology learns from a child's reactions and play patterns to customize future interactions. It does not, however, change the stories themselves. The personalization of the interactions helps tailor its functionalities to better suit the preferences of each child (Pillar Learning, 2019).

Babbli introduces yet another layer of innovation by focusing on bilingual language development by creating stories that adapt in real-time to the child's input, supporting language learning in two languages. This feature not only entertains but educates, making Babbli a particularly valuable tool for families looking to immerse their children in bilingual environments from a young age. Moreover, Babbli's potential use of cost-effective materials like cardboard could make it more accessible than both Toniebox and Codi which are around 100 USD each (subject to market), appealing to a broader demographic by lowering economic barriers to educational technology.

3. Beneficiaries

The primary beneficiaries of Babbli are the children who will be using it. Bilingual children, in particular, would find this tool valuable as it would enhance their language skills, helping them maintain proficiency in both their native and second languages. This is essential not only for cognitive development but also for maintaining cultural ties. For non-bilingual kids, Babbli serves as a gateway to new languages, potentially sparking an interest in further language learning and enhancing their communicative abilities at an early age.

Parents and family members indirectly benefit from Babbli. Parents, while not interacting directly with the toy, can observe improvements in their children's language skills and cultural awareness. This support reduces educational pressures, particularly for non-bilingual parents, and fosters stronger family bonds through shared cultural and educational activities. Extended family members, such as grandparents, may also experience enhanced communication with the child if they

speak one of the languages being taught. Moreover, Babbli promotes activities that involve language learning, thus fostering a closer familial bond through shared educational activities.

Organizational beneficiaries include schools and charities. Schools can integrate Babbli into classrooms, making it easier for teachers to manage students with diverse linguistic backgrounds and incorporate bilingual education more seamlessly, at the same time it could be introduced as a playful tool within the national curriculum through different subjects. In the UK for example, from an early age children must engage with at least one foreign language like French or Spanish. Charities and NGOs (non-governmental organizations), such as Refugees International or Save the Children, might use Babbli in settings like refugee camps or hospitals where it serves as a cost-effective, portable tool for storytelling and education. For instance, Doctors Without Borders could employ Babbli to help bridge communication gaps among children in their care, making it a tool for both education and psychological comfort.

At a societal level, the UK can serve as a case study for the broader benefits of Babbli. Government and educational authorities benefit from fostering bilingual education and cultural retention amongst immigrant children, supporting integration and education goals. This contributes to societal benefits as these children grow into adults who can act as cultural and linguistic bridges within the community. Additionally, helping immigrant children maintain their native culture and language promotes multicultural understanding and cohesion, providing a foundation for these children to maintain cultural ties with their native countries or communities.

Babbli not only transforms individual language learning experiences but also supports families, educational institutions, and societal integration efforts, making it a versatile tool in fostering a more interconnected and culturally aware society.

4. User research

While the primary users of Babbli are the children, the consumers are their guardians who make the purchasing decisions. Understanding the motivations, challenges and opportunities of both groups is essential for developing a product that meets the needs of its young users while appealing to their caregivers. The personas created for this research help illustrate these dynamics and guide the design process.

	*Pablito* An English-speaking Child in an English-speaking country
Characteristics	Age: 4 years old Language: His family moved from a Spanish-speaking country to an English one when Pablito was 6 months old. He mostly speaks English. Learning Style: Kinesthetic learner who loves music and drawing
Goals	Pablito is eager to learn and wants to speak Spanish with his Abuelita

UX Needs	Interactive, minimal text, and highly engaging content
Frustrations	Finds apps like Duolingo boring, dislikes reading textbooks, prefers learning through play.
Personality	High energy, loves to laugh.

	*Abuelita Milagri* Pablito's Grandmother
Characteristics	Age: 77 years old Language: Only speaks Spanish
Goals	Wants to communicate effectively with Pablito
UX Needs	Product must be easily explainable, not too expensive, and suitable as a gift.
Frustrations	Sadness over the communication barrier with Pablito, whose busy parents and limited Spanish education at school hinder their conversations

Personality	Wise and helpful

	*Soo Ji* A Korean-speaking Child in an English-speaking Environment
Characteristics	Age: 6 years old Learning Style: Auditory learner, interested in insects and animals Language: She is still learning English, as she just moved to an English-speaking country a year ago.
Goals	Wants to better understand English to enjoy nature documentaries she watches with her eomma.
UX Needs	Interactive content focused on her interests, supportive learning environment
Frustrations	She has entered a mute phase at school, as she still feels new and doesn't fully understand. She would like somewhere where she could practice English without the social pressures of class.

Personality	Inquisitive, curious, and adventurous

The study of these personas directly informs and enhances the design of Babbli in the following ways:

Pablito’s kinesthetic learning style and preference for interactive play influenced Babbli's design to include dynamic, interactive storytelling. By asking Pablito what he wants the story to be about and generating a short introduction in both languages, Babbli engages him from the start. The follow-up questions in both languages ensure that Pablito remains interested and motivated, providing a playful learning environment that aligns with his high energy and love for laughter.

The need for an easily explainable product for Milagri led to the creation of a user-friendly interface with clear instructions. Babbli’s ability to generate coherent, bilingual stories makes it an ideal tool for bridging the communication gap between Milagri and Pablito. The toy’s affordability and suitability as a gift make it accessible, ensuring that Milagri can provide Pablito with a meaningful and educational present that enhances their relationship through shared storytelling experiences. As the input can be in English or Spanish, they can play together and share special moments.

Soo Ji’s inquisitive nature and auditory learning preference influenced Babbli to be able to tell stories about themes related to her interests in nature and animals. By allowing her to input story elements based on her preferences, Babbli creates an engaging and supportive learning environment. The pressure-free space for

practicing English helps Soo Ji gain confidence, making the process enjoyable and effective. The interactive elements cater to her learning style, ensuring that she remains curious and adventurous.

The design of Babbli has been deeply influenced by the personas created from this user research. By understanding the specific characteristics, goals, and frustrations of children like Pablito and Soo Ji, and their caregivers, Babbli has been tailored to meet their unique needs. The result is a product that not only supports language learning through engaging and interactive methods but also bridges communication gaps and fosters a love for learning among young users.

5. Time management

In the planning and execution of any successful project, clearly defined objectives are crucial. For the development of Babbli, I have employed the SMART goals framework to establish and communicate these objectives effectively. This framework ensures that each goal is Specific, Measurable, Attainable, Relevant, and Time-based, providing a robust structure for monitoring progress and achieving results. These goals guide every phase of the project, from initial research to final testing, ensuring that each step is purpose-driven.

Specific: I intend to create an interactive language development toy for children ages 3 to 8, that uses a large language model like GPT. It would be a storytelling toy that uses voice input, and transforms the input into an interactive story in two languages. My initial intention is for it to be a physical

toy, but will define this after some research if a software version would be better.
Measurability: I will know if the project is accomplished if the design decisions made are supported by the user research I have done. If the project successfully can detect voice input and transform it to create an interactive story in two languages.
Attainability: In order to attain this goal I will need to research second language development and storytelling for second language development in children 3 to 8. I will also need to further familiarize myself with GPT's API, and learn how to integrate a direct translation tool to it. I then will also need to research the best way to structure the story. Finally I will need to connect the project to an Arduino.
Relevance: I believe this goal is relevant to my future plans as it involves children, a.i. and hardware, three topics that I have explored at my internship at LEGO and might continue exploring. It will also be relevant to my future plans as I want to apply at some point to the Media Lab at MIT. I believe this project perfectly encompasses what they're looking for. This project might be a good project to use in my portfolio when applying to them.
Time Based: This project is time sensitive not only for the deadline but as I might need extra time to order any hardware bits I am missing. I want to have a software version at least one month and a week before handing in, so I have a month to focus on the hardware aspect.

Table 1: SMART Goals

In addition to defining clear and structured objectives through the SMART framework, the MoSCoW method has been used to prioritize the various elements of Babbli. This method categorizes the project requirements into four groups: Must Have, Should Have, Could Have, and Will Not Have. This allows for an efficient allocation of resources and focused development.

Must Have: The must-have for this project is to have at least a software that creates GPT generated stories, detects voice input to make the stories interactive, and translates the stories. Child also should answer in second language and not just English.
Should Have: It could have a hardware interface/robot with an led screen that the child could interact with instead of just the software.
Could Have: I could make cardboard structure to hold the Arduino/RasPi
Will Not Have: An image display on the led screen other than the robot face. I was thinking it could display some drawings of key-words of the story, but I think it might be best to keep it just for facial expressions of the robot.

Table 2: MOSCOW Analysis

To effectively manage the project timeline, a Gantt chart has been developed. This visual tool is instrumental in planning and tracking the progress of the different project activities over time. The Gantt chart organizes the project into distinct phases. These phases include initial research, software development, hardware

integration, and final testing and documentation. Each task is aligned with the SMART goals and prioritized according to the MoSCoW method.

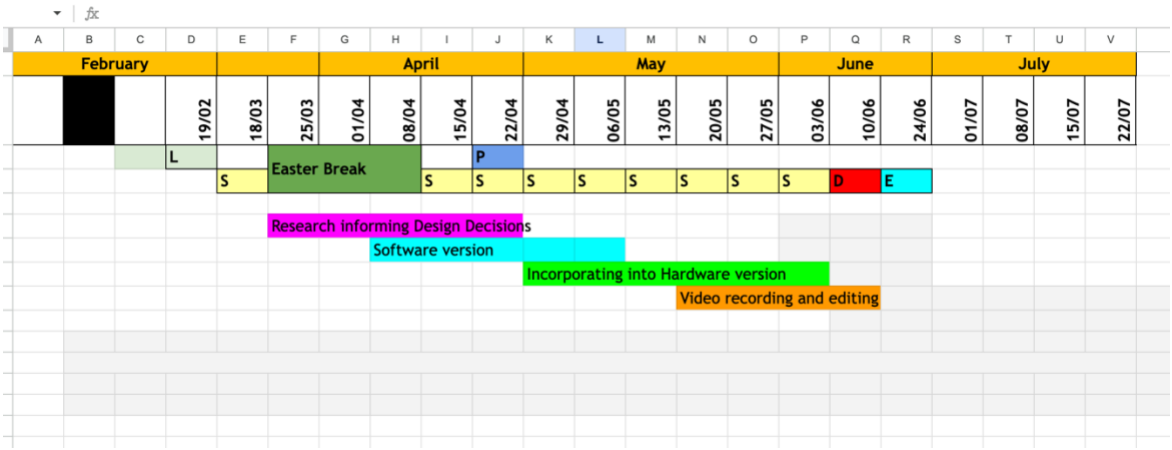

Figure 1: GANNT Chart

As the project unfolded, my adherence to the original Gantt chart was challenged by practical constraints and evolving insights into the project's demands. For instance, practical challenges needed an overlap of these tasks, like library issues, code bugs, and environment management.

Using the MoSCoW method as a framework, I successfully met all the categorized goals of the project. The successful completion of these goals under the MoSCoW framework demonstrates effective prioritization and resource allocation, allowing for focused development and adherence to the project's core requirements.

6. Design Process

The ideation phase for Babbli began with brainstorming sessions and sketching potential designs. The primary objective was to create an engaging character that

children could interact with, creating a sense of adventure and personal connection. After considering various names and character concepts, I decided on "Babbli," inspired by the Tower of Babel and the playful nature of children's babble when they are learning language.

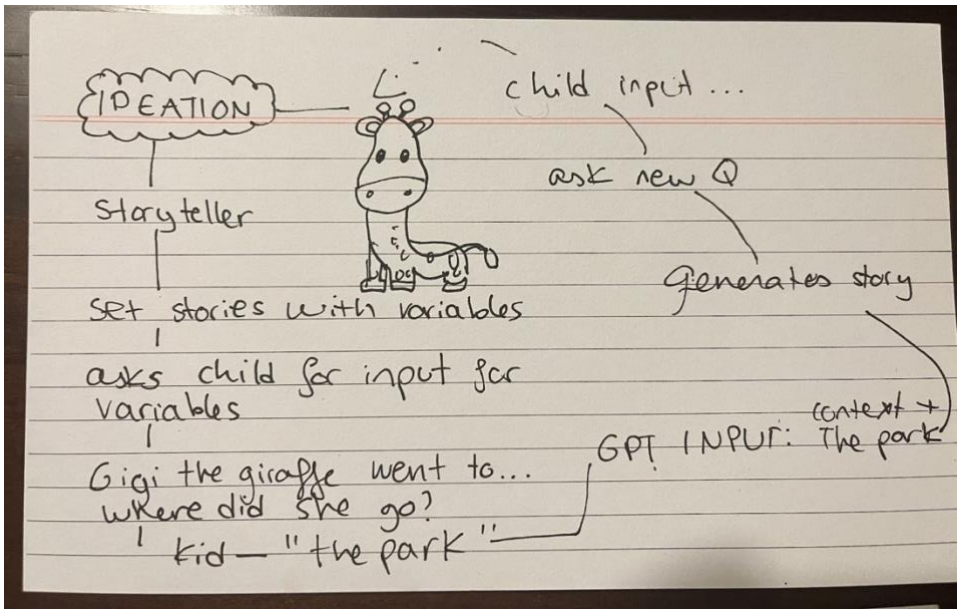

Figure 2: Ideation sketch

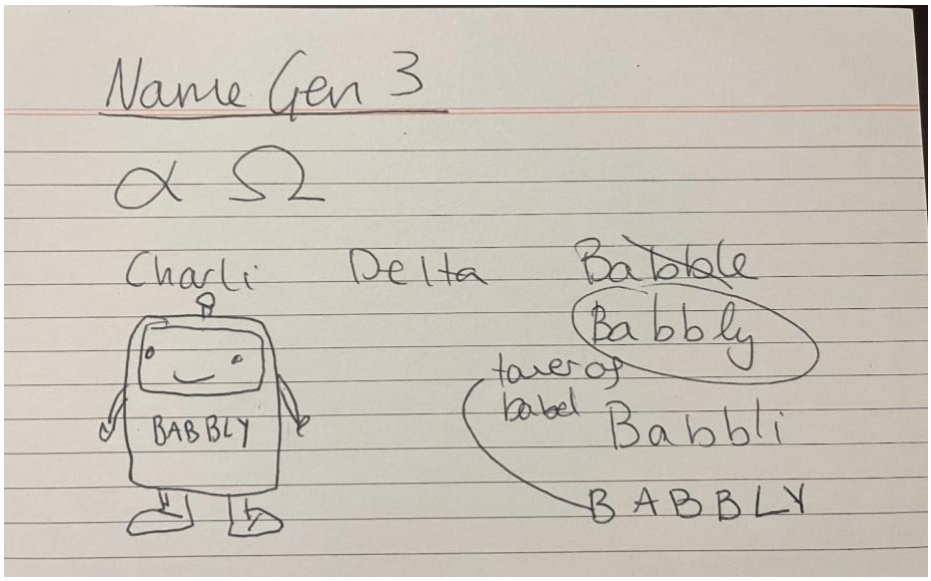

Figure 3: Name Gen 3 Sketch

Storytelling Functionality

The first step in bringing Babbli to life was to develop a basic version of the storytelling functionality using Python. The initial goal was to create a script that could convert speech to text and then use a GPT model to generate stories based on a that word input. The process began with following the documentation to set up speech-to-text conversion. However, this initial attempt was met with significant challenges, particularly with installing PyAudio, a crucial package for speech recognition.

Despite spending considerable time troubleshooting, the issue persisted. Eventually, I resolved the package issue by modifying the Python environment settings. I switched from Anaconda to a standard Python environment, ensuring that the correct version of Python was being used. This allowed me to successfully install the necessary packages and proceed with the development.

With the speech-to-text functionality working, I moved on to integrating the GPT model for story generation. The first version of Babbli could generate a short story in English and Spanish based on the input word. For instance, if the child said "Chicken," the system would produce a brief story involving a Chicken, followed by a question to encourage further interaction.

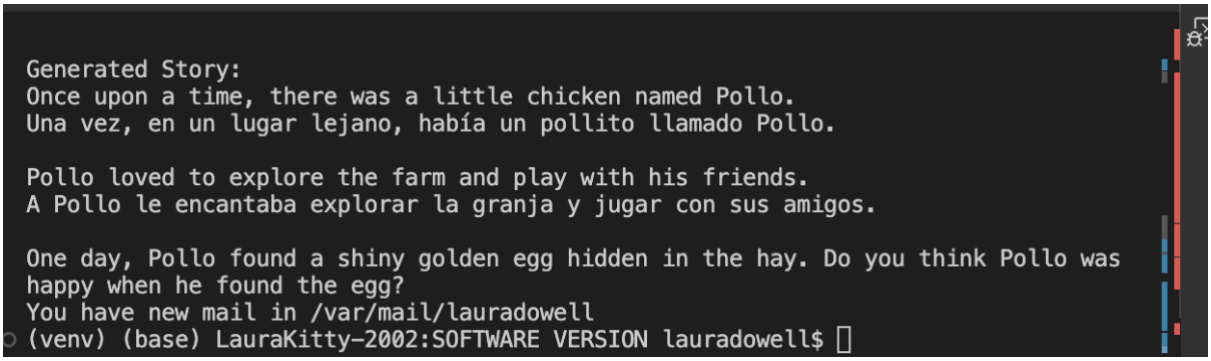

Figure 4: Example of story generated

The prompt given to the GPT model was carefully crafted to ensure the stories were age-appropriate, engaging, and educational. The initial prompt was:

"You are a children's storyteller for kids under 8 years old. You are creative and fun and take the children on an adventure in English and Spanish. You listen carefully to what the child wants a story about, and you tell them a story based on that word, repeating each sentence in both languages. Make the story no longer than three sentences. End the story by asking the child a question to follow up the story."

This version demonstrated the core concept of Babbli and provided the model valuable insights into user interaction. Based on feedback and further testing, I iterated on the design to improve functionality and usability. One of the key improvements was expanding language support. Initially, Babbli could generate stories in English and Spanish. However, I extended this capability to include French, and even Russian. This enhancement increased Babbli's educational value and appeal to a broader audience.

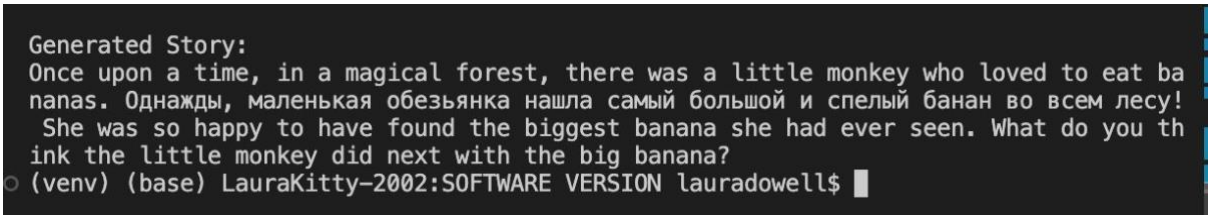

Figure 5: Example of generated story

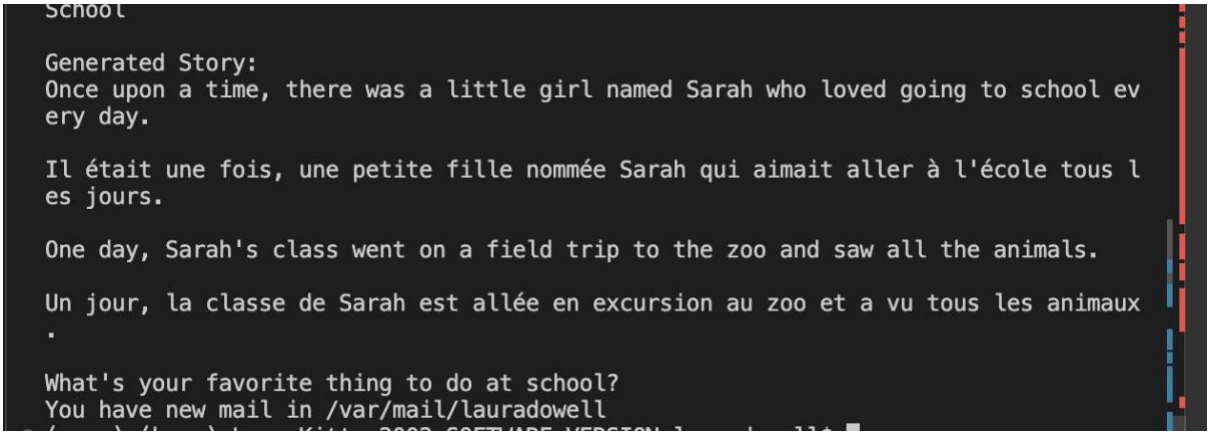

Figure 6: Example of generated story

Additionally, I refined the story generation process to include dynamic story expansion. Babbli asked the child follow-up questions after each story segment, allowing the story to evolve based on the child's responses. This interactive feature was essential for maintaining the child's engagement and making the storytelling experience more immersive.

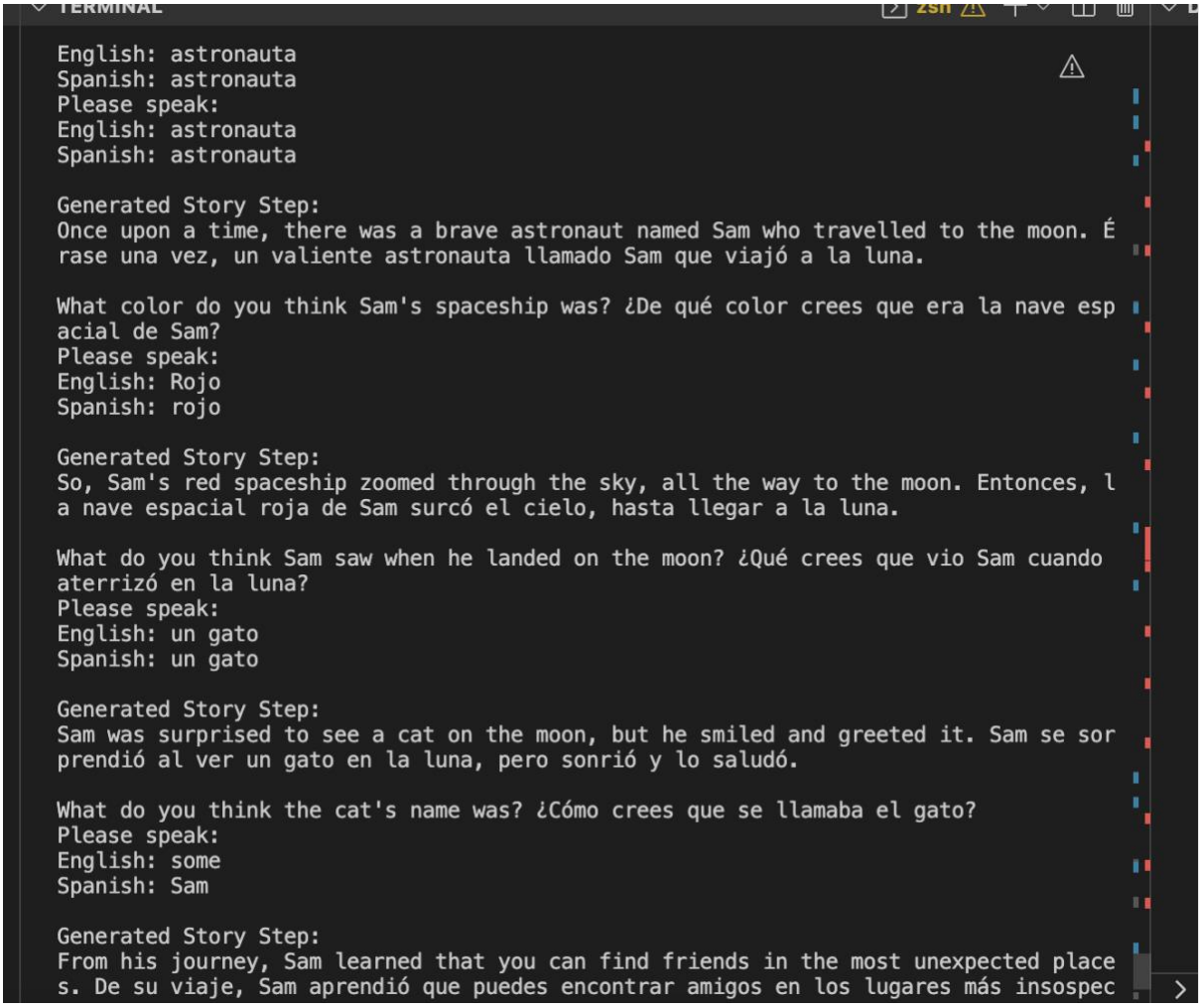

Figure 7: Example of full interaction

With infinite story generation comes the need to structure it to make sure the stories made sense and followed a narrative. This is why I incorporated different steps depending on how many interactions the child had had as seen below, based on a basic plot with an “exposition," "climax," and a "resolution" .

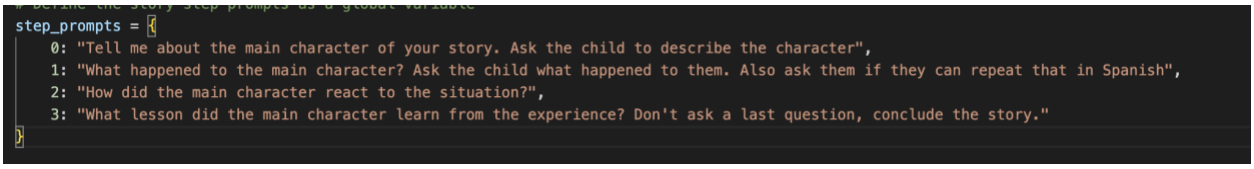

Figure 8: Steps of story generation

Integration of Hardware components

The next phase involved integrating hardware components to create a physical prototype of Babbli. The primary challenge here was making sure that the Arduino board could interface with the necessary components, such as microphones, speakers, and OLED screens. Initial attempts with an Arduino Leonardo revealed compatibility issues, particularly with connecting the OLED screen. I decided to switch to an Arduino UNO, which offered better documentation and easier setup.

While waiting for the new hardware components to arrive, I continued refining the software aspects of Babbli. This included improving the story generation prompts and testing different configurations to ensure robust performance. But after careful consideration and advice from the technicians I realized that Raspberry Pi would be more suitable for Babbli as it would allow me to not have to connect the toy to a laptop but be able to run the project entirely on the Raspberry Pi. Using a Raspberry Pi would allow me greater freedom and control over the functionalities and keep the elements all together in one system.

The initial phase involved executing the Python script on the Raspberry Pi and ensuring the installation of all requisite libraries and configurations. Additionally, I integrated the ElevenLabs text-to-speech API to provide realistic and engaging voice output for the stories. This integration added a crucial auditory component, enhancing the vividness and enjoyment of the stories for the children. Subsequently, I connected both a speaker and a microphone to the Raspberry Pi to facilitate auditory story generation.

Considering the potential for a more immersive experience, I conceptualized incorporating a moving mouth animation that would synchronize with the story's narration, thereby fostering a deeper connection between the child and the toy. To implement this, I connected an OLED screen and programmed an animated mouth, which I later edited to fit the screen. The Python code was modified to ensure the animation was synchronized with the audio output.

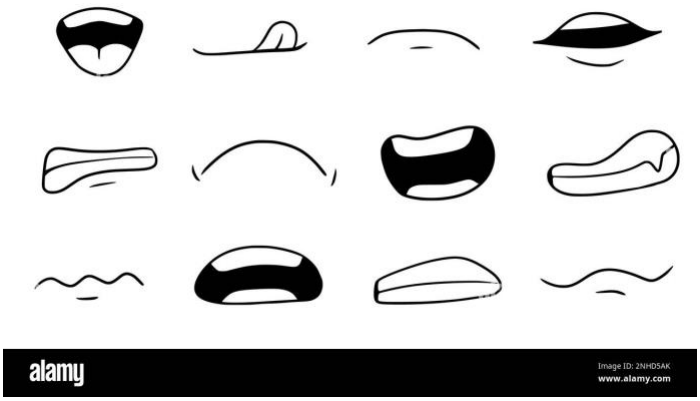

Figure 8: Mouth animation from alamy.com

However, the OLED screen initially displayed a yellow and blue color scheme. To resolve this, I bought new screens with appropriate color settings and integrated them successfully.

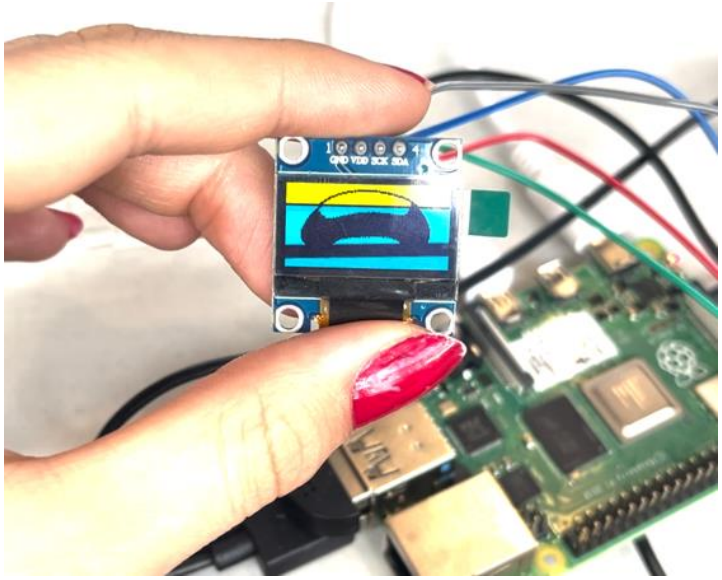

Figure 9: Duo tone OLED

Initial tests on the OLED were successful; however, the screen dimensions were too small. A replacement with a larger screen has been ordered to improve visual engagement.

I changed the code to synchronize the mouth animations with the auditory outputs from the story narration. This synchronization is crucial for providing a cohesive user experience.

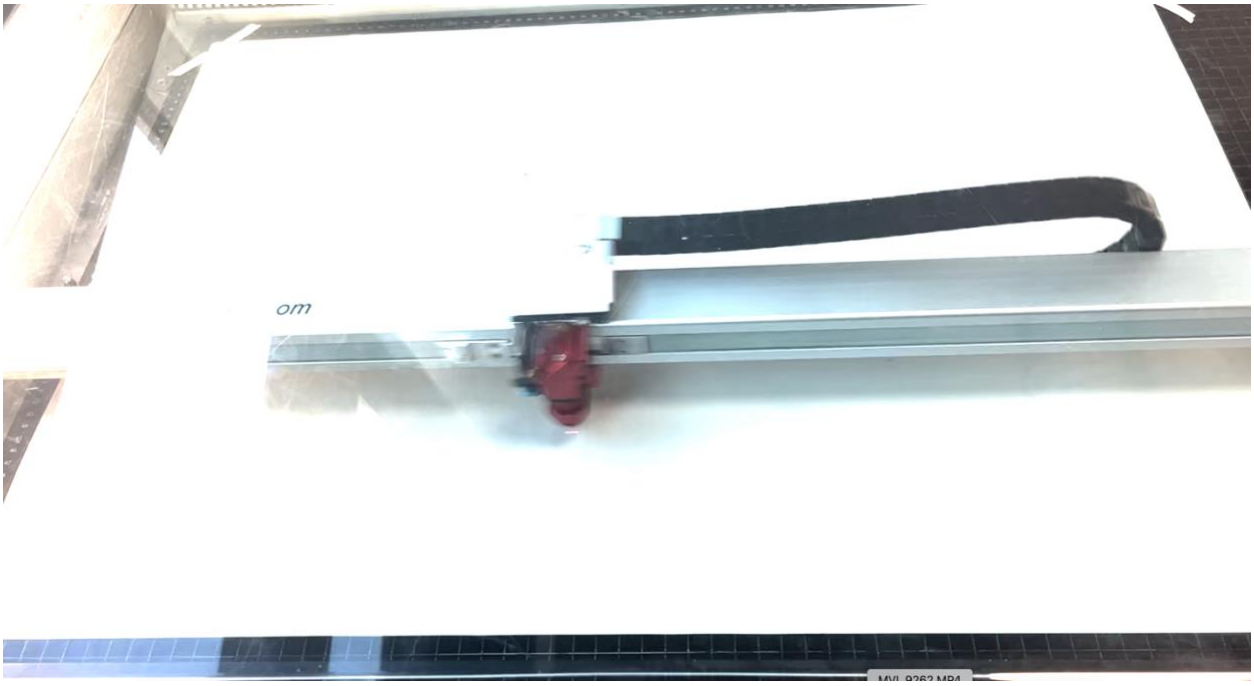

Figure 11: Laser cutting process

Figure 12: Cardboard Robot Assembly

The laser cutting process was conducted, focusing on cuts and etches as per the design converted from PDF to SVG format and edited to red and black to work with the laser cutter. The Robot design was found on Etsy by "KaBlackout" and is linked

in the references. Despite several challenges, including a malfunction in the laser cutter and imperfect cuts requiring manual intervention, the construction proceeded. Assembly was facilitated using a combination of glue stick and double-sided tape, the latter proving advantageous for its ease of use and cleanliness.

Finally, I designed a logo using the open-source Alba font. Interestingly, it turned out to be somewhat similar to the "Barbie" logo, which I noticed afterward. Moving forward, I plan to conduct more thorough research on existing designs to avoid unintended connotations in my future projects.

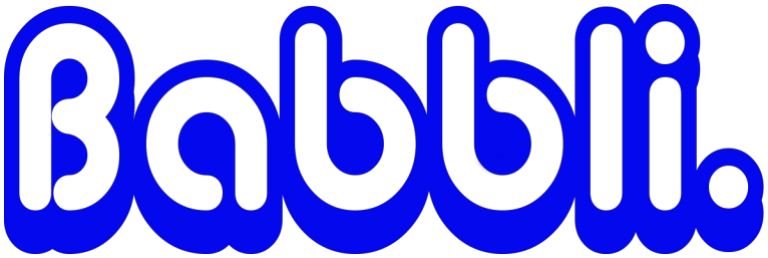

Figure 13: Babbli logo

Despite the setbacks, the project was completed on time. It aims to demonstrate the project's viability and the potential for further enhancements in future iterations.

7. Outcome

Figure 14: Babbli Interaction

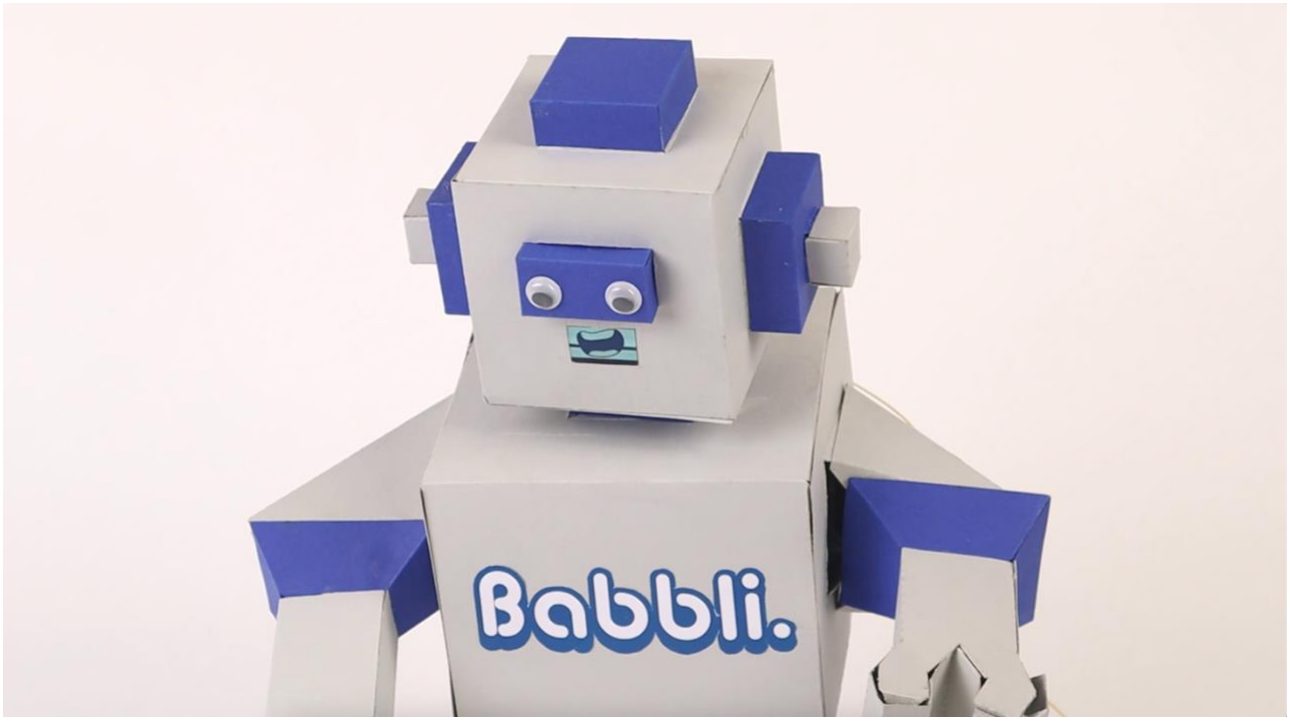

Figure 15: Babbli

Babbli is an innovative interactive storytelling toy designed to enhance dual language development in young children. It dynamically creates stories in two languages, responding in real-time to the child's inputs, making each story unique and tailored to the child's imagination. Central to Babbli's design is its dual-language capability, which supports linguistic skills in both the native and a second language. This prototype displays stories in Spanish-English, Russian-English, and French-English, but is potentially able to do the same in any other language. As a prototype, Babbli effectively demonstrates the potential of merging LLM-driven storytelling, and AI voice generation, with language learning, displaying significant educational benefits and setting the stage for future development to meet current educational trends.

The successful completion of Babbli was influenced by effectively employing project management methodologies, including the MoSCoW method, SMART goals, and Gantt chart. These tools collectively made sure that all development phases progressed according to a predefined timeline: focusing first on the must-haves, and later the could-haves allowed for time to complete them all on time.

Most importantly, the development of Babbli as a prototype has demonstrated the feasibility and educational potential of my concept. While this initial version has displayed the core idea, it also laid the foundation for future iterations that could transform Babbli into a fully-fledged product.

Moving forward, several enhancements are considered essential. The current cardboard structure, while cost-effective, was too delicate and flimsy for robust handling by young children. Exploring more durable materials such as a rigid polymer, using 3D printing, or changing the robot structure to a simpler shape could

provide the necessary robustness without compromising affordability. Introducing interchangeable models could also allow children to customize the appearance of their Babbli, further enhancing engagement and creativity.

Additionally, the response time of the device needs improvement; the current Raspberry Pi processor struggles with the quick generation of stories. This has been edited out in the video to facilitate understanding. Streaming the generated stories could be a potential solution for faster content delivery. Moreover, expanding the range of available languages to other combinations of languages like Italian-Spanish or Japanese-Spanish could significantly broaden the appeal and educational value of Babbli across diverse cultural contexts and avoid it seeming like just an English teaching tool. These changes will help refine Babbli's design and functionality, ensuring it meets the diverse needs and preferences of its users.

It is crucial to address the potential ethical concerns and the perception of technology-based toys for children. The integration of AI in children's toys, while innovative, brings with it a set of ethical considerations, particularly concerning privacy and data security. Ensuring that personal data, especially when sourced from minors, is handled with the utmost confidentiality and in compliance with stringent regulations is crucial for the future iterations of the project.

This prototype phase has been important in validating the design and function, providing a solid foundation for further development and refinement. As a result, Babbli currently serves its function well to display the intended idea and paves the way for potential advancements that could further its impact and reach in the educational toy market.

8. Reflection and possible ways forward

Reflecting on the development of Babbli, it has been an insightful and challenging journey. The initial goal was to make a toy that not only entertained but also educated, facilitating children's language acquisition through interactive storytelling in multiple languages.

Looking forward, the Babbli project presents numerous opportunities for expansion and application. As a prototype, Babbli has the potential to serve as a foundation for a larger-scale project that could be introduced into educational systems or used in language learning centers worldwide. Its adaptability makes it suitable for exhibitions or interactive installations in museums or educational expos, where it can provide hands-on learning experiences to a broader audience.

Moreover, the technology and methodology behind Babbli could be adapted for other educational purposes beyond language learning. For example, the interactive storytelling approach could be tailored to teach other subjects such as history or science, where engaging narratives can significantly enhance understanding and retention of complex concepts. The potential to include more languages and cultural content could also make Babbli a valuable tool in multicultural education, promoting diversity and inclusion from an early age.

In essence, Babbli not only represents a successful intersection of technology and education but also offers a foundation for future educational innovations. Its development from a simple concept to a functioning prototype highlights the transformative potential of integrating creative design with AI to enrich educational experiences for children globally.

Overall, the development of Babbli has highlighted the potential of integrating advanced technology with traditional educational methods to create new learning experiences. The journey has not only been about overcoming technical challenges but also about understanding the nuanced needs of children and continuously adapting the product to meet these needs in innovative ways.

References:

Afrilyasanti, R. and Basthomi, Y., 2011. Digital Storytelling: A Case Study on the Teaching of Speaking To Indonesian EFL Students. Language in India, 11(2).

Ajibade, Y. and Ndububa, K., 2008. Effects of Word Games, Culturally Relevant Songs, and Stories on Students' Motivation in a Nigerian English Language Class. TESL Canada Journal, 25(2), pp.27-48.

Birdsong, D., 2006. Age and Second Language Acquisition and Processing: A Selective Overview. Language Learning, 56(1), pp.9-49. Available at: https://doi.org/10.1111/j.1467-9922.2006.00353.x.

Flege, J.E., Yeni-Komshian, G.H. and Liu, S., 1999. Age constraints on second-language acquisition. Journal of Memory and Language, 41(1), pp.78-104.

Grøver, V. et al., 2020. Shared Book Reading in Preschool Supports Bilingual Children's Second-Language Learning: A Cluster-Randomized Trial. Child Development, 91(6), Available at: https://doi.org/10.1111/cdev.13348.

Isbell, R., Sobol, J., Lindauer, L. and Lowrance, A., 2004. The effects of storytelling and story reading on the oral language complexity and story comprehension of young children. Early Childhood Education Journal, 32, pp.157-163.

KaBlackout, 2023. Robot Papercraft DIY Robot Template. Available at: https://www.etsy.com/listing/578634226/robot-papercraft-diy-robot-template [Accessed 13 May 2024].

Kallisch, K., Ramirez, I., Pischel, C., Best, S., Serman, M. and Serman, M., 2022. Bringing it all back home: remote evaluation of speech intelligibility with hearing aids during lockdown. Journal of Hearing Science, 12(1).

Lenneberg, E.H., 1967. Biological Foundations of Language. John Wiley & Sons.

Lucarevschi, C.R., 2016. The role of storytelling on language learning: A literature review. Working Papers of the Linguistics Circle, 26(1), pp.24-44.

Moyer, A., 2004. Age, Accent and Experience in Second Language Acquisition: An Integrated Approach to Critical Period Inquiry. Multilingual Matters.

Penfield, W. and Roberts, L., 1959. Speech and Brain-Mechanisms. Princeton Legacy Library.

Pillar Learning. (n.d.). Codi the Storytelling Robot. Available at: https://www.pillarlearning.com/products/codi.

Smeda, N., Dakich, E. and Sharda, N., 2014. The effectiveness of digital storytelling in the classrooms: a comprehensive study. Smart Learning Environments, 1(1). Available at: https://doi.org/10.1186/s40561-014-0006-3.

Ullman Design, 1991. Alba Font. [font] Available at: https://www.dafont.com/alba.font [Accessed 13 May 2024].

Warmansyah, J. and Nirwana, E.S., 2023. The Effect of Storytelling Methods and Self-Confidence Children's Expressive Language Skills. Ta'dib, 26(1), pp. 29–42. Available at: https://doi.org/10.31958/jt.v26i1.5927. Accessed 3 Dec. 2023.

Weisleder, A. and Fernald, A., 2013. Talking to Children Matters: Early Language Experience Strengthens Processing and Builds Vocabulary. Psychological Science, 24(11), pp.2143–2152. Available at: https://doi.org/10.1177/0956797613488145.