LegoCraft: Transforming 2D Instructions into Interactive 3D Mixed Reality Building Guides

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Fig. 1. Mixing LEGO building with XR applications.

LegoCraft is a revolutionary project aimed at transforming the way individuals engage with Lego building sets. This innovation introduces cutting-edge technology that seamlessly converts conventional 2D Lego building instructions into captivating 3D mixed reality guides, enhancing the building experience for users. The project integrates a user-friendly interface, fostering interactive assembly and elevating the joy of constructing Lego creations through the incorporation of immersive technology.

CCS Concepts: • **Human-centered computing** → *Visualization design and evaluation methods.*

Additional Key Words and Phrases: XR, Lego, Guides, 2D to 3D, Spatial Visualization

1 INTRODUCTION

Traditional 2D Lego building instructions often pose challenges for builders, hindering the understanding of spatial relationships and creating potential frustration during the assembly process. This limitation has been a longstanding obstacle for Lego enthusiasts, impacting their overall building experience. The problem lies in the lack of depth and interactivity within the instruction manuals, hindering users from realizing the full potential of their Lego sets.

2 MOTIVATION

The motivation behind LegoCraft stems from a deep understanding of the intrinsic value that Lego building brings to individuals. Lego enthusiasts invest not only money but also time, effort, and emotional energy into their creations. By addressing the limitations of traditional 2D instructions, LegoCraft directly targets the enhancement of the building experience. This is not merely a convenience; it is a transformative leap towards optimizing health, as it reduces stress and frustration associated with challenging instructions and promotes happiness by unlocking the full creative potential of each Lego set.

The significance of the problem cannot be overstated. Users invest considerable amounts of time and money into Lego sets, seeking a fulfilling and enjoyable activity. The immersive 3D mixed reality guides provided by LegoCraft offer a solution that resonates with the core desires of Lego enthusiasts, ensuring a more enriching and satisfying building journey.

3 RELATED WORKS

The integration of mixed reality (MR) technologies into instructional tools has seen significant growth, driven by its potential to enhance educational and experiential learning.This section reviews pivotal studies and technological advancements that frame and support our work.

3.1 Augmented and Virtual Reality in Instructional Settings

Research has shown that both AR and VR can significantly enrich educational experiences. [2] discuss how AR can facilitate learning through its unique ability to merge digital and real-world elements. Similarly, [8] explore comprehensive VR applications in educational settings, highlighting the immersive experiences that significantly enhance student engagement and learning outcomes.

3.2 Mixed Reality for Practical Skills Development

In the context of skills development, MR applications have demonstrated substantial benefits in practical and technical education. [6] provide evidence that MR environments improve cognitive and psychomotor skills, essential in educational settings. Additionally, [1] review how MR can be effectively used to teach complex tasks, thereby reducing cognitive load and improving learning efficiency.

3.3 Interactive 3D Modeling Tools

The role of 3D modeling in education has been explored extensively. [5] discuss the effectiveness of 3D interactive models in enhancing understanding of spatial structures, which is critical in fields such as architecture and engineering. Furthermore, [7] provide a comprehensive review of empirical studies on the use of educational virtual environments over a decade, highlighting the educational benefits of immersive 3D technologies. These technologies not only aid in visualizing complex structures and concepts but also significantly enhance learner engagement and interaction.

3.4 Comparative Studies in Instructional Technologies

Comparative research highlights the advantages of MR over traditional educational methods. [4] found that MR tools could lead to better learning outcomes by providing more engaging and interactive learning experiences. Further, [3] illustrate that AR applications offer significant educational benefits over conventional methods, including higher motivation and better conceptual understanding.

By situating Legocraft within this body of research, we align our project with current innovations aimed at transforming educational methodologies. The literature not only guides our development strategy but also frames our contributions within the broader context of technological advancement in education.

4 SOLUTION

The solution presented by LegoCraft is a pioneering approach that seamlessly converts traditional 2D Lego building instructions into immersive 3D mixed reality guides. Through the integration of this technology, users can now visualize each step of the assembly process in a three-dimensional space, gaining a deeper understanding of the spatial relationships between Lego bricks. The user-friendly interface promotes interactive assembly, allowing users to engage with the building process in a way that was previously unattainable.

In essence, LegoCraft aligns seamlessly with the identified problem by providing a solution that transforms the Lego building experience. By marrying innovative technology with the timeless joy of Lego construction, this project opens new avenues for individuals to explore, create, and derive unparalleled satisfaction from their Lego sets.

4.1 Methodology

- `Research and Analysis`: Conduct an in-depth analysis of the challenges faced by users with traditional 2D Lego building instructions. Understand user pain points, frustrations, and limitations.
- `Technology Integration`: Develop a robust system for seamlessly converting 2D instructions into 3D mixed reality guides.
- `Interface Design`: Develop a user-friendly interface that allows for interactive assembly, ensuring ease of use and accessibility for builders of all skill levels.
- `Prototyping`: Create prototypes of the LegoCraft system to test functionality, user experience, and overall effectiveness in addressing the identified problem.
- `User Testing`: Conduct extensive user testing to gather feedback and refine the system based on user input. Iterate on the design and functionality to enhance the overall user experience.
- `Integration with Lego Sets`: Ensure compatibility and integration with a variety of Lego sets, addressing the diverse needs and preferences of the Lego enthusiast community.
- `Quality Assurance`: Conduct thorough quality assurance testing to identify and rectify any potential issues, ensuring a seamless and reliable experience for users

5 SYSTEM DESCRIPTION

An idea is only as good as its implementation, and bringing LegoCraft to reality requires a robust system for users to be able to visualize 2D paper instructions in 3D space. A Unity XR application was created to allow for the user to be able to interact with 3D models of each step of the Lego building process. Initially, a 3D model of a fully assembled Lego Police car was created using BrickLink Studio 2.0, a free-to-use software that allows users to create custom Lego models of their own design.

The 3D model was exported to Unity, and custom building instructions were created according to which the model was broken down into 15 steps to build the vehicle from start to finish. A user interface is created that allows users to iterate through 3D models of each step, and to rotate the models about a fixed point - so they may be able to visualize what a completed step looks like from all angles. The 3D model of each step is also accompanied by models of all the pieces required in each step. Alongside the 3D steps is also an AR representation of the PDF instructions in floating space, which the users can also simultaneously flip through the pages of. This was implemented for testing purposes so that users could use it as a comparator before filling out the questionnaires.

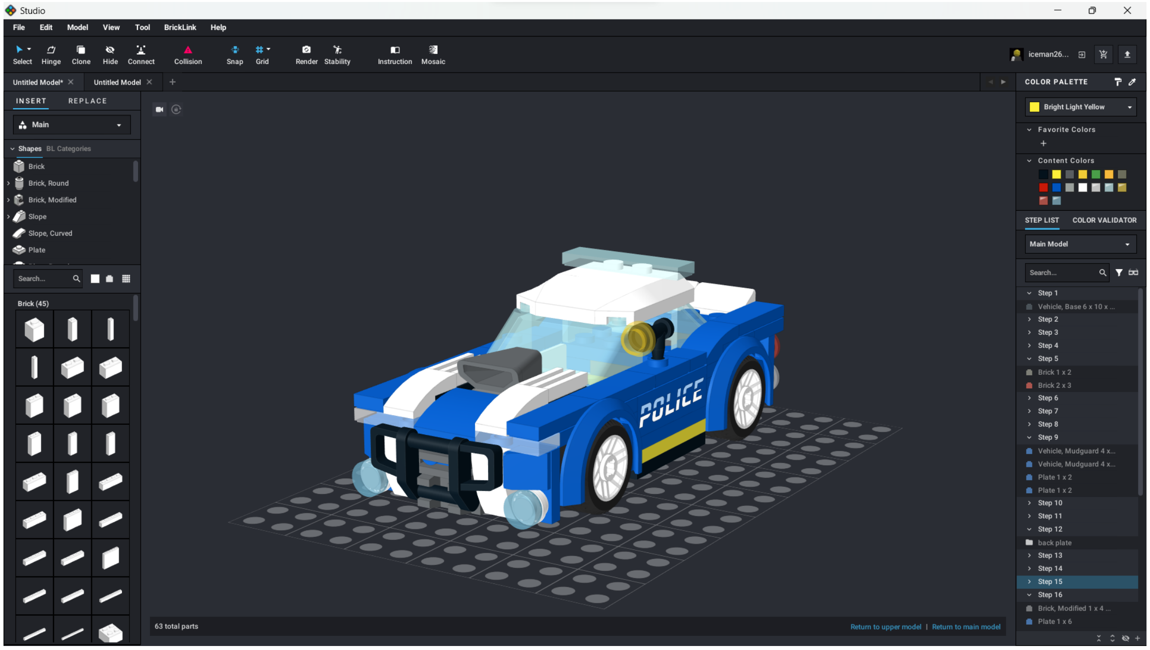

Fig. 2. Using Studio 2.0 to model our Lego set in 3D

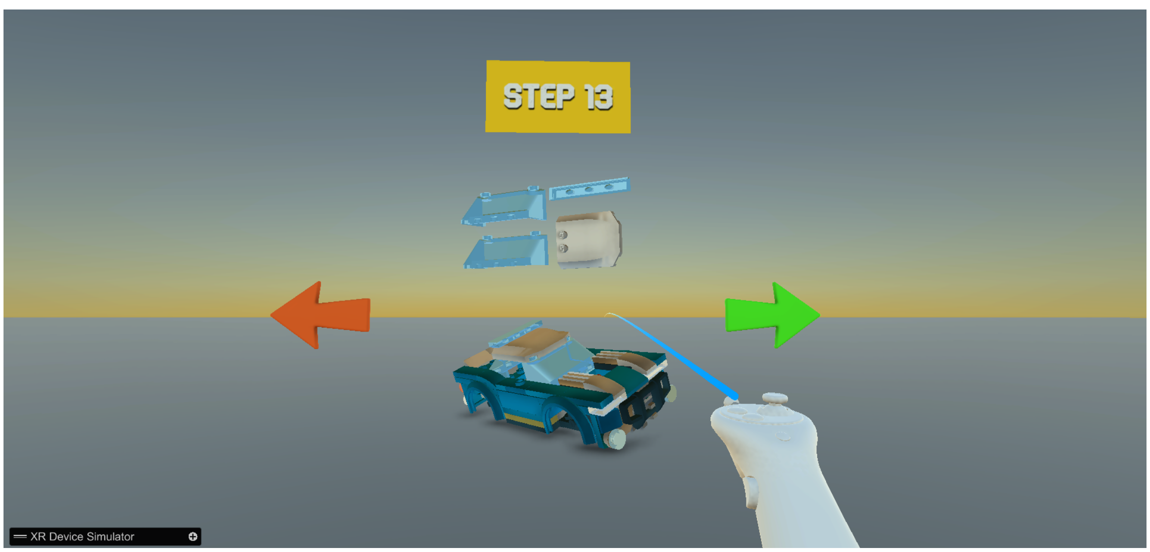

Fig. 3. 3D interactable model used for testing in simulator

6 EVALUATION AND RESULTS

In our evaluation of the Legocraft system, we engaged a group of eight participants, chosen from our circle of friends. None had prior experience with mixed reality, making them ideal candidates for testing the intuitiveness and accessibility

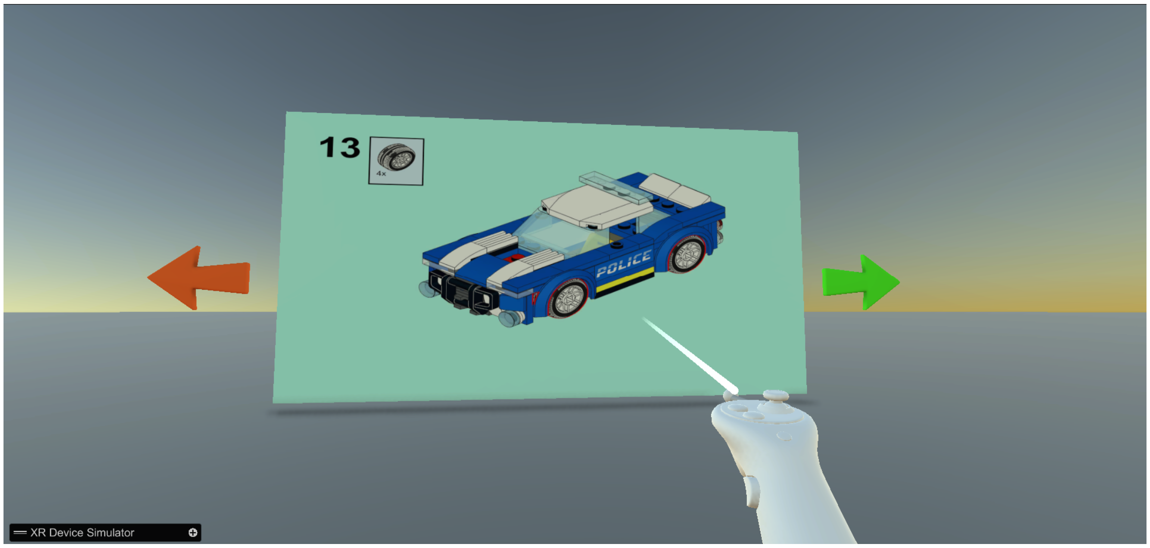

Fig. 4. A simulation of the 2D PDF instructions provided for comparison

of our new system. Each participant used the Legocraft system for a ten-minute session, followed by a comprehensive survey to capture their feedback and insights.

6.1 User Interface and Experience

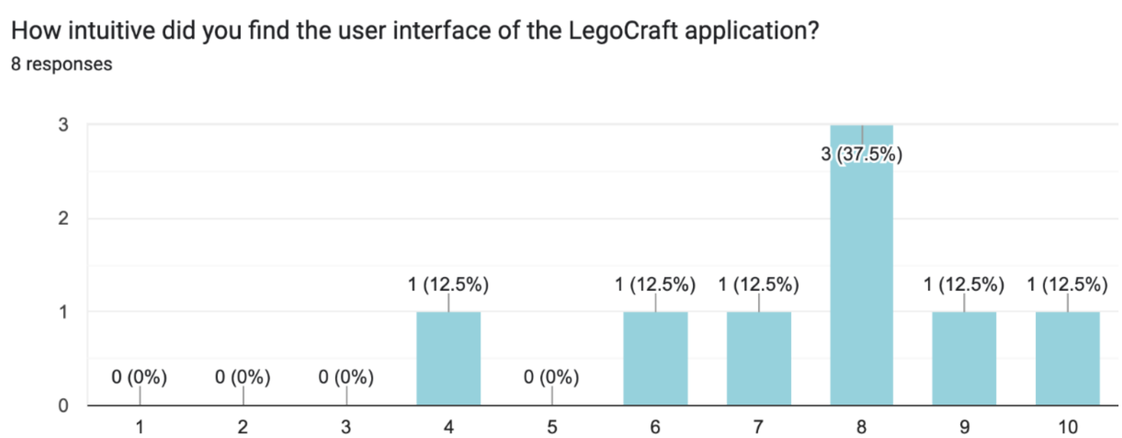

Fig. 5. Interface Intuitiveness feedback

The user interface of Legocraft was rated highly for its intuitiveness, with a majority of participants scoring it between 7 and 10 on a scale of 10, indicating a generally positive user experience. Key feedback highlighted the seamless transition from 2D to 3D instructions, which significantly improved the building process. This transition was helpful to all participants, enhancing their understanding and interaction with the model.

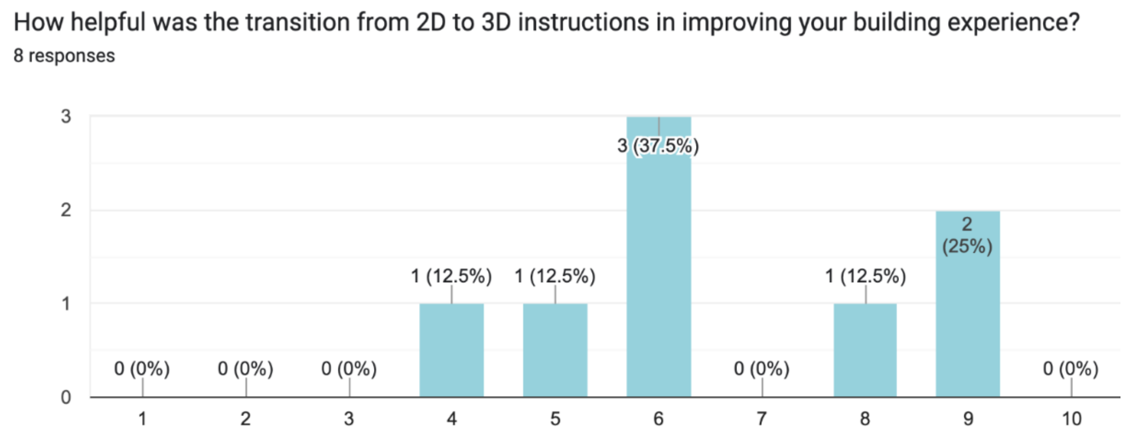

Fig. 6. 2D to 3D Transition Feedback

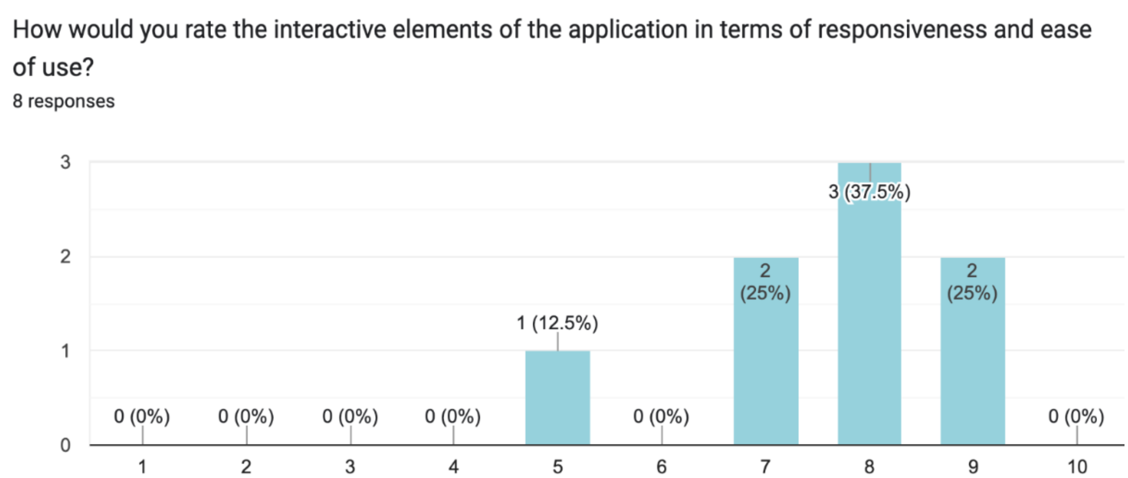

Fig. 7. Responsiveness feedback

6.2 Responsiveness and Interactive Elements

The responsiveness of the interactive elements within the application received mixed reviews. While some users found the controls to be intuitive, noting the application felt like playing a video game, others encountered technical issues such as bugs with trigger functions and cursor misalignment. These technical challenges underscored the need for ongoing refinement of the interface.

6.3 Future use and Recommendation

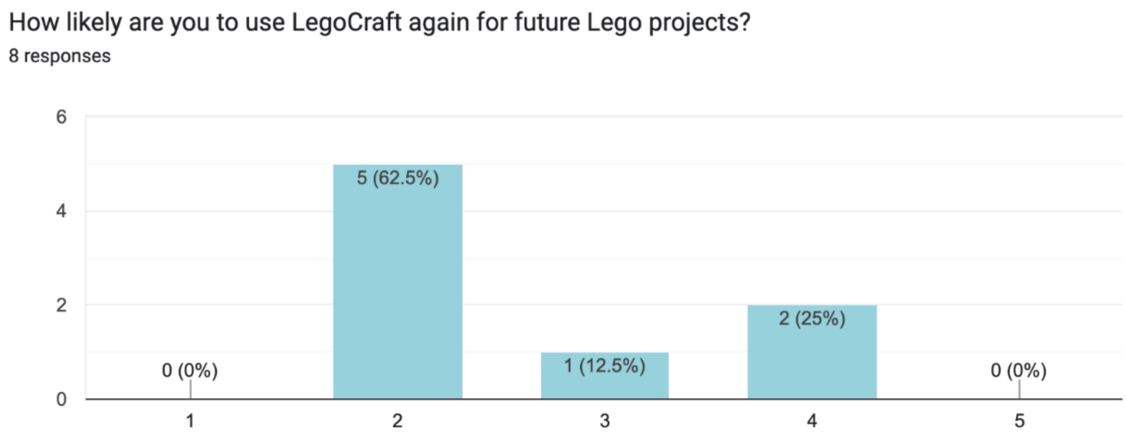

Fig. 8. Likelihood of using the system again

Despite some technical hiccups, the overall sentiment towards future use was optimistic. Approximately 87.5% of participants expressed a likelihood of using Legocraft for future projects, and a similar percentage would recommend it to other Lego enthusiasts. The immersive 3D view and the ability to manipulate the model were particularly appreciated, as they provided a perspective that traditional 2D instructions could not offer.

6.4 Technical Issues and Improvements

Several participants reported specific technical problems, such as objects getting stuck and trigger malfunctions. These issues highlight areas for technical improvements. Participants suggested enhancements including more intuitive VR integration, better alignment of manual and model steps, and improved navigation controls, which could make the experience more user-friendly and enjoyable.

6.5 Overall Satisfaction

Overall, participants rated their experience with Legocraft positively. The ability to visualize the assembly in 3D not only made the building process more engaging but also allowed for a better appreciation of the structural complexities of Lego models. This feedback is invaluable as we continue to refine Legocraft, aiming to make it the go-to tool for Lego enthusiasts seeking a more interactive building experience.

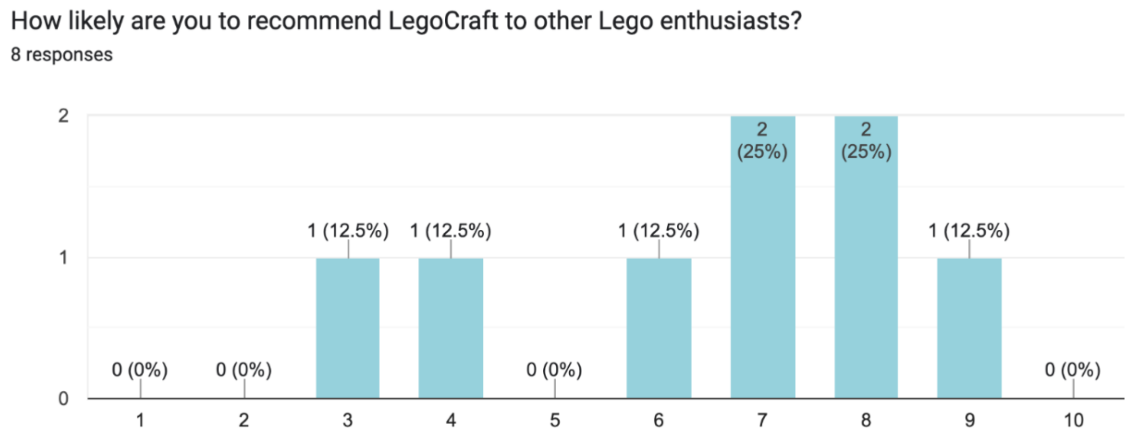

Fig. 9. Likelihood of Recommendation to friends

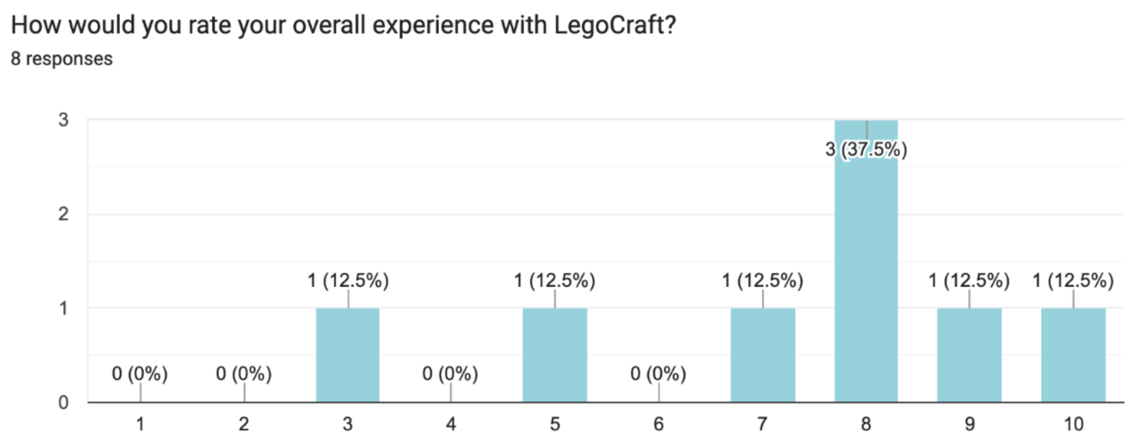

Fig. 10. Overall feedback

7 DISCUSSION, FUTURE WORK

Moving forward, several areas have been identified for further development and enhancement in the Legocraft system:

- `Improved Interaction Design`: Simplifying the interaction model to reduce the learning curve and enhance the naturalness of the interface. This could involve integrating more gesture-based controls or employing advanced VR/AR capabilities for a more immersive experience.

- `Technical Issue Resolution`: Prioritizing the identification and resolution of technical issues that users encountered during the testing phase. This includes enhancing cursor control precision and ensuring consistent functionality of interactive elements.
- `Enhanced 3D Visualization`: Developing more sophisticated 3D models that can offer better visual feedback and interaction, such as highlighting specific assembly steps or enabling dynamic viewing angles without loss of detail or clarity.
- `User Customization Features`: Allowing users to personalize their experience, such as adjustable difficulty settings for instructions, or preferences for manual versus automatic step progression.
- `Extended Testing and Feedback Integration`: Conducting further evaluations with a broader user base to collect a wider array of data and feedback. This would help refine the system based on diverse user experiences and promote more generalized conclusions about its effectiveness.
- `Scalability and Broader Application`: Exploring the scalability of the Legocraft system to support a wider range of Lego sets and potentially other types of assembly-based educational and recreational activities.
- `Sustainability and Accessibility Considerations`: Ensuring that future developments are sustainable and accessible to a wide audience, including considerations for economic and physical accessibility.

By addressing these areas, Legocraft can move closer to its goal of revolutionizing the way individuals engage with Lego building projects, making the process more interactive, intuitive, and enjoyable. This continual evolution will also contribute to the broader field of educational technology by demonstrating the effective integration of mixed reality into learning and recreational activities.

8 CONCLUSION

In conclusion, the evaluation of Legocraft has demonstrated its potential to transform Lego building into a more intuitive and engaging activity through mixed reality. While there are areas for improvement, particularly in the technical execution of the interface, the positive responses regarding its usability and innovative approach are encouraging. We are committed to addressing these feedback points to enhance the user experience in future updates.

9 ACKNOWLEDGMENTS

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